WTE TReX

IoT, TELEMETRY, MESSAGING I/O TRANSCEIVER + PLC

User Manual

Table of Contents

Introduction

Thank you for choosing the TReX.

The TReX is a high power transceiver, suitable for commercial, industrial, remotely managed control/monitoring and autonomous control applications.

The TReX can be used to:

- Automate processes using the integrated ladder logic PLC, with remotely located IO expansion.
- Transmit and receive POCSAG paging messages.
- Send DMR text messages.
- Operate as a secure IoT gateway allowing control and monitoring from devices supporting the MQTT protocol.
- Connect to third party SCADA control and monitoring systems using Modbus protocols.
- Log messages to internal memory to meet auditing requirements.
- Mirror analog and digital inputs to a remote unit.
- Inspect potential site interference using the integrated spectrum analyser.
- Report system and installation errors, such as loss of communications, and battery states.
- Detect antenna faults during normal operation.
- Transmit and receive secure serial and telemetry data at high data rates and over a very long range.
- Act as a repeater for forwarding telemetry and paging messages in poor coverage areas.

TReX Features

- Up to 4W power output, operating from 421MHz to 480MHz.
- DIN rail mountable aluminium enclosure that also allows simple mounting from top, bottom or sides.
- Data transmit rates from 512 baud to 32K baud. Supported channel spacing of 25kHz, 12.5kHz and 6.25kHz.
- Secure AES encryption options for both TCP connections and messages sent across RF links.
- Ability to receive AES encrypted secure paging messages and securely control outputs across existing national and local area paging networks.
- Optional Ladder Logic programmable PLC with radio extensions, allowing user programmable automation.
- Support for an unlimited number of IoT devices to publish to a MQTT broker service.
- Support for **two-way** paging. Provides receipt of delivery and optionally receipt for accepted jobs.

- Supports 512, 1200, 2400, 4800 and 9600 baud POCSAG paging messages.
- Transmits DMR Tier 1 text messages (optional).
- Receives 1600 baud 2 level FLEX™ paging messages.
- Modbus RTU and TCP support for easy SCADA system integration.
- Paging store and forward repeater operation with configurable duplicate reject.
- 8 digital inputs and outputs.
- Two 0-10V/4-20mA analog outputs
- Two 0-10V analog inputs.
- Integrated spectrum analyser (optional).
- Simple to configure back to back mirroring and monitoring of analog and digital IO.
- Extended SCADA system expansion supporting up to 11 wirelessly connected units per system (optional).
- Optional logging to SD card of all received and transmitted messages.
- Graphics display shows all radio activity including I/O state.
- Multi language support (English and Spanish) and additional languages available on request.
- Fully configurable via front panel without the need for an external PC connection.
- Configurable via serial port, direct USB connection or Ethernet.
- RS232, RS422 and RS485 (both 4 and 2 wire) support.
- USB connection allows downloading of message logs or direct access to configuration files.
- Configured inputs can be programmed to output messages when triggered.
- Configured digital and analog outputs can be controlled via received messages.
- Any output can be assigned to indicate:
    - Channel busy. The channel busy output level is configurable.
    - Filtered match of message payload.
    - Reception of any message.
    - Comms link fail.
    - Antenna fault.
    - Low output power.
    - High temperature.
    - Low RF output.
    - Low low supply voltage.
    - Change in any input state.
- Periodic message support to ensure radio link integrity.
- Low battery messaging.
- Support for additional protocols upon request and negotiation.
- Firmware upgradable.
- High stability oscillator ensuring a maximum of 80Hz drift (at 160MHz) over the entire specified temperature range.

- Antenna mismatch detection capability.
- High sensitivity receiver.
- Internal real time clock.
- Long-life design uses no moving or electromechanical parts. No limited life components such as electrolytic capacitors.

TReX Versions

TReX I/O Connection Variants

The TReX can be supplied as different models with different input and output connections.

- **TReX-460 i8o1**
  - 8 digital inputs
  - 2 analog inputs
  - 7 digital (open drain) outputs
  - 2 analog outputs (1-10V or 4-20mA)
  - 1 relay output (normally closed contact)

- **TReX-460 i8o8**
  - 8 digital inputs
  - 2 analog inputs
  - 8 relay outputs (normally open contacts)
  - 2 analog outputs (1-10V or 4-20mA)

For more information on these TReX I/O variations please refer to the **Installation section** on this manual.

Safety Information

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it.

The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

! This is the safety alert symbol. It is used to alert to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

!WARNING
WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

!CAUTION
CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury

NOTICE
NOTICE is used to address practices not related to physical injury.

!CAUTION

HAZARD OF THERMAL BURNS

High operating temperature possible when transmitting continuously for extended periods.
- Avoid direct contact with device while in operation.
- Install device in a restricted access location to avoid unintentional contact.

Failure to follow these instructions can result in minor injury.

!CAUTION

HAZARD OF RADIO FREQUENCY (RF) BURNS

Ensure that a matching load or antenna is attached to the RF port prior to applying power to the device.
The TReX operates at a moderately high power level. RF energy has the potential to cause burns.

Failure to follow these instructions can result in moderate injury.

!WARNING

LOSS OF CONTROL
- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical control functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop and over travel stop.
- Separate or redundant control paths must be provided for critical control functions.
- System control paths may include communication links. Consideration must be given to the implications of anticipated transmission delays or failures of the link.

Failure to follow these instructions can result in death or serious injury

!WARNING

HAZARD OF DEATH OR SERIOUS INJURY

To comply with both **FCC RF Exposure** requirements in section 1.1310 of the FCC Rules and EN50383, antennas used with this device must be installed to provide a separation distance of at least 55 cm from all persons to satisfy RF exposure compliance.

DO NOT:

- Operate the transmitter when someone is within 55cm of the antenna. EN50383 regulatory limits have deemed that 55cm is a safe clearance distance from this product while operating at full power.
- Operate the transmitter unless all RF connectors are secure and any open connectors are properly terminated.
- Use within 1m of sensitive electronic devices and medical equipment while operating at full power.
- Operate the equipment near electrical blasting caps or in an explosive atmosphere. All equipment must be properly grounded for safe operations.

All equipment should be installed only by a qualified technician or engineer.

Failure to follow these instructions can result in death or serious injury

!WARNING

THIS EQUIPMENT IS NOT INTENDED FOR MAINS VOLTAGES

- The TReX was **NOT** designed to operate and/or be connected directly to live main voltages. The TReX must be connected to a certified, suitably rated low voltage DC supply.

Failure to follow these instructions can result in death or serious injury

NOTICE

HAZARD OF EQUIPMENT DAMAGE

- This product is not chemical resistant, detergent, alcohol, aerosol sprays, and/or petroleum products may damage the front panel. Clean using a soft cloth moistened in water.
- The radio can be damaged if there is any potential difference between the chassis-ground, Serial signal ground, power (-) input, or antenna coaxial shield. Before connecting any wiring, ensure that all components are earthed to a common ground point.
- The antenna port will be damaged if signals greater than 13 dBm are injected/received.
- Do not connect any other transmitter to the RF connector or share the antenna with any other device.
- Extreme Heat or High temperatures can damage TReX components. DO NOT expose or operate the unit in extreme heat (above 70 degrees Celsius) or leave in direct sunlight or any other UV source.
- Although this product is designed to be rugged, it will not survive excessive shock or vibration abuse. The TReX is intended to be mounted permanently either in a land based location or in a vehicle. When fitting in a vehicle, vibration damping mounts may be required.
- The TReX IP rating is IP-51. This product is not waterproof or dustproof. DO NOT directly expose to rain or use in a condensation forming environment.
- When antennas are co-located on a community (shared) site the correct site engineering must be performed to ensure that RF exposure limits are met.

NOTICE

CARE REQUIRED WHEN TRANSPORTING

Safety and care must be taken when transporting, handling, installing and/or replacing radio equipment.

- Packaging should be adequate to ensure connectors are not damaged
- Store and handle the radio equipment in dry, clean safe environment
- Handle the equipment with care
- Avoid intrusion of any object/material into the radio case
- Care when stacking TReX boxes must be taken to not damage part of the radio, such as connectors.

NOTICE introduction of foreign object into the TReX radio enclosure will void warranty.

FCC NOTICE

This device complies with Part 15.247 of the FCC Rules.

Operation is subject to the following two conditions:

1. This device may not cause harmful interference and
2. This device must accept any interference received, including interference that may cause undesired operation.

This device must be operated as supplied by the equipment supplier. Any changes or modifications made to the device without the written consent of the equipment supplier may void the user's authority to operate the device.

End user products that have this device embedded must be installed by experienced radio and antenna personnel, or supplied with non-standard antenna connectors, and antennas available from vendors specified by the equipment supplier. Please contact the equipment supplier for end user antenna and connector recommendations.

Exposure to RF energy is an important safety consideration. The FCC has adopted a safety standard for human exposure to radio frequency electromagnetic energy emitted by FCC regulated equipment as a result of its actions in General Docket 79-144 on March 13, 1996.

This equipment complies with the FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 43cm between the radiator and any part of your body

NOTICE

This symbol on the product or its packaging indicates that this product must not be disposed of with other waste.
Instead, it is your responsibility to dispose of your waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment.

The separate collection and recycling of waste equipment at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For more information regarding recycling, contact the dealer where the product was originally purchased.

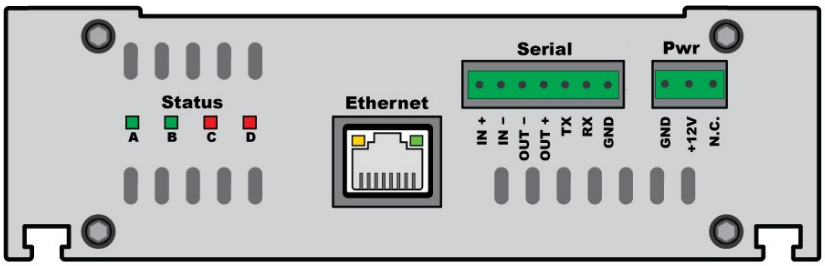
Operation

Once a 13.8V source has been connected to the power connector the TReX start-up status is displayed on the LCD.

When the TReX is operating normally, the two green status LEDs flash briefly once every second.

When decoding messages, the "A" green LED is held on for approximately one second.

The "C" red LED is held on for the duration of a transmission, while processing TCP data, Modbus protocol commands and decoding received messages. Both the "C" and 'D' red LEDs light while starting. The 'D' red LED remains lit if no IP configuration has been enabled.



On start-up under normal operation there is a message sent out the serial port. The message indicates the firmware revision, serial number other software related information.

After finishing the start-up procedure and loading of configuration settings the TReX enters its receive and decode mode of operation. The TReX now waits for commands to be entered serially for processing or inputs to be triggered. These may be either protocol messages to be processed or commands related to the configuration of the device. Serial messages may arrive on any serial port, or may also arrive through a TCP connection.

When messages are received and decoded, they are immediately sent out the serial port in the format of the configured protocol in use.

Messages are transmitted as per the input configuration when inputs change state. Please refer to **Input Output Hardware Connection** or **Input Handling** sections on this manual for further information.

The TReX outputs are driven high or low, or for a particular period of time depending on configuration. The outputs are controlled via the **WTE Output Control Protocol** message received and decoded. Each output can be configured to operate under various error states (Refer to **Outputs**).

Buttons

MENU/BACK:

When on the MAIN SCREENS used to enter the MENU. When inside the MENU, used to return back one level from within the MENU, until returning back to the MAIN SCREENS.

UP:

When on the MAIN SCREENS used to cycle between sub-screens. When in the MENU used to navigate or alter selected configuration items.

DOWN:

When on file related screens of the MAIN SCREENS shifts between entries. When in the MENU used to navigate or alter selected configuration items.

RIGHT:

When on the MAIN SCREENS used to cycle between main screen. Within the MENU used to enter sub MENU items or select items for configuration.

ENTER:

Used to select file related items from within the MAIN SCREENS. When in the PLC configuration menus, this button allows the currently edited PLC ladder program page to be viewed.

Main Screens

The TReX top icon bar provides information about the display screen and operating status. The far right text indicates the selected main screen. This is either “IO” (inputs and outputs), “PL” (PLC), “TX” (transmit) or “RX” (receive).

The time in the middle is the current RTC time (MENU->SYSTEM->TIME).
The “S” letter indicates that the master or slave SCADA telemetry modes are in operation.
The “M” letter, when present indicates that a Modbus telemetry request packet has been processed within the last 2 seconds.

The “Incoming” down arrow indicates that the TReX is in receiving (absent when RX is DISABLED). The “Outgoing” up arrow indicates that the TReX is transmitting. The “B” icon indicates that the TReX is waiting to transmit but the channel is currently busy.

The Icon “T” below indicates the TReX has been configured for telemetry stand-alone “Back-to-Back Mirror Mode”.

The back to back arrows indicate the unit is operating in “Serial Link” Telemetry mode.

The RJ45 connector icon is used to indicated when the TReX is TCP connected. Flashes to the padlock icon when TLS security is enabled and in use..

The chain link icon indicates when there is an active link to another device. Each time a message is received this icon is shown. This icon is also present immediately after start to ensure a link fail alert is not immediately raised after startup.

The “X” indicates a loss of an active link. This occurs when there has been no messages received for a configured period of time. The “link-fail” output if enabled will operate when this icon is shown.

The bell icon is shown when there is an alert that has been raised. This may operate an output if configured.

The padlock icon indicates that transmissions are AES encrypted.

The icon “P” indicates that the PLC is operational and controlling outputs as programmed.

IO Screens

Screens that relate to inputs and outputs.

IO (1):

All input and output states. Each IO highlighted state changes if the IO level is HIGH or LOW. There is a small line above each input or output if HIGH, and a line below if LOW. All ADCs (analog inputs) and DACs (analog outputs) show a bar graph as a proportion of full scale and display a raw count from 0-1023. When scaling has been applied to an analog output, the DAC value shown is the unscaled value.

In the middle, shown in larger text is “01”. The number“01” in this case is the telemetry UNIT ID. When TELEMETRY->MODE is configured to MASTER a small down arrow may be visible if the TELEMETRY->REMOTES have been configured to be more than 0. Pressing the down arrow (when configured as a MASTER) allows the UNIT ID to be cycled to view the IO of each remote slave in the system – allowing a possible system of up to 88 digital IO, 22 ADCs and 22 DACs to be viewed.

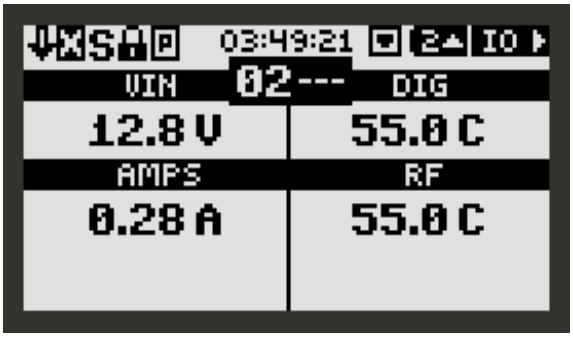
Next to the UNIT ID is the smaller number “123”. Each TReX resets this number to the LINK FAIL TIME each time a message is decoded. This “link count” reduces, and if reaches 0, the link fail output can be operated.

MASTER TReX units allow the “link count” to be viewed for all remote TReX SLAVE units.

IO (2):

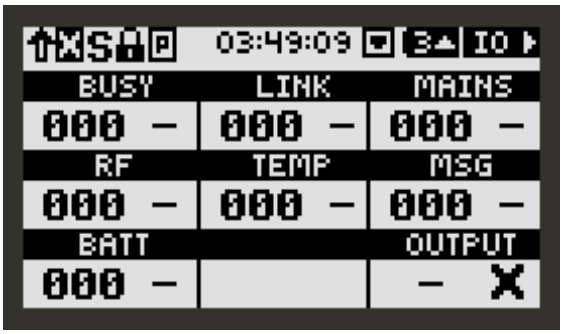
System voltage, current and internal operating temperature. RF is the temperature read directly next to the RF power stage and will be higher than than the DIG board temperature while the TReX is transmitting (not applicable for receiver only TReX units). Temperatures of the RF power stage may reach 100 degrees Celsius under normal long term operation. These temperatures are not the ambient temperature. The case of the TReX will NOT reach these temperatures.

As with the previous IO screen, systems voltages and temperatures of all SLAVE TReX units (up to 9 SLAVE units) can be viewed by pressing the down button if the TReX is configured to be a MASTER.



IO (3):

This is the ALERT summary screen. This screen shows which alerting function is enabled and active. There are many alerting functions possible such as link fail, RF fault, over temperature and others. The screen shows through the bell icon in the top bar how many alerts have been triggered since last cleared. The 3 digit count shows the total number of alerts raised for each alert type. The large tick icon indicates that a particular alert is enabled. The bell icon for each alert shows if there are new alerts that have been raised. See **Alert Handling** for details on alert configuration.

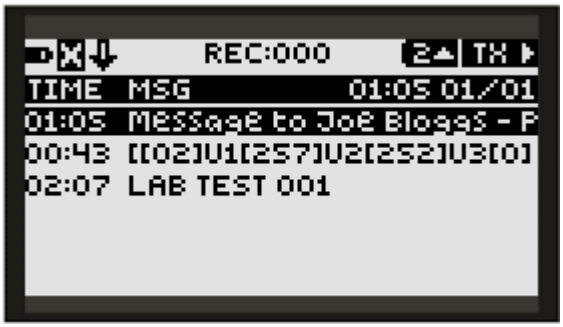


TX Screens

Screens that relate to messages transmitted.

TX (1):

Last message transmitted. Includes the time the message was transmitted, message RIC (radio identifying code/CAP Code) and level (0-3). To the right the modulation type and rate is displayed also with the transmit frequency.



TX (2):

List of all time-stamped messages retrieved from internal storage. Most recent message displayed at top. Next sub-screen can only be selected when top entry is displayed. Note that messages are only available here when TX logging has been enabled (MENU->TX->MSG LOG).

When an entry is selected pressing the UP/DOWN buttons, pressing the ENTER button displays the entire message.

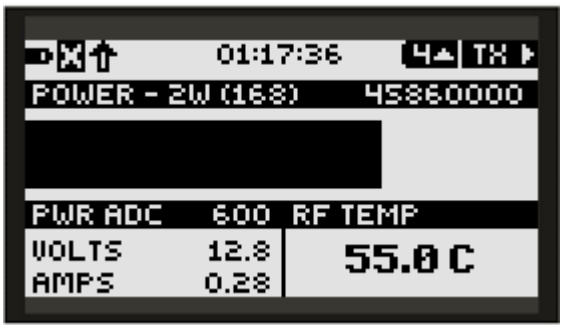
TX (3):

Displays the last transmitted message in large font. If the message exceeds the screen size, the DOWN button allows scrolling.

TX (4):

A TX power bar graph is displayed as a proportion of full power during a message transmission. Above the power bar is the text "POWER – 2W (168)". "2W" relates to the power setting in use. In brackets is the power amplifier DAC setting which is for factory use only.

The POWER ADC count is used to indicate forward power. RF TEMP relates to the RF amplifier temperature (not ambient) in degrees Celsius. VOLTS is the supply voltage and AMPS is the total supply current.



RX Screens

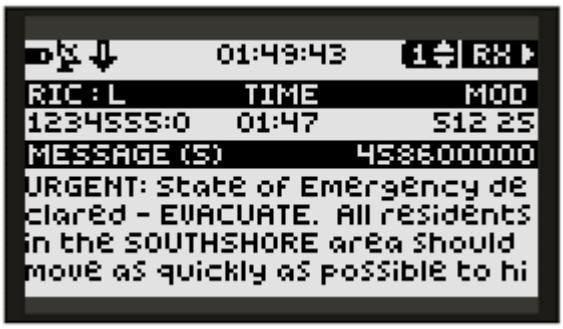
Screens that relate to messages received. Note, when messages are received, additional icons may be displayed in the top bar.

The second left icon changes from the "X" icon to the satellite icon when a message has been received. This indicates that the receiver is operational.

When the "BELL" icon is displayed with a following number, this means that there is an ALERT active. See **Alert Handling** for configuration and operation.

RX (1):

Basic summary of last received message. If the message is too large to fit on the screen the DOWN arrow will be visible in the title bar. Pressing the DOWN button will now scroll through the rest of the message.



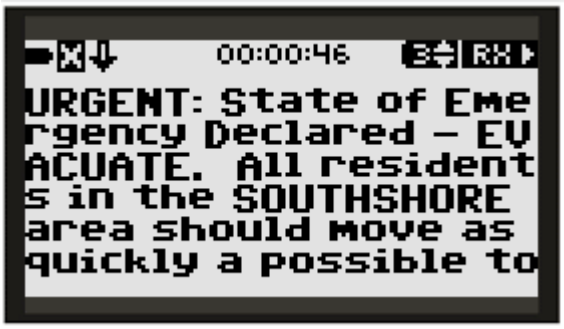
RX (2):

List of all time-stamped received messages retrieved from internal storage. Most recent message displayed at top. Next sub-screen can only be selected when top entry is displayed. Note that messages are only available here when RX logging has been enabled (MENU->RX->MSG LOG).

Messages starting with "*" are messages that met the ALERT filter requirements, and were eligible to operate the ALERT output when logged.

RX (3):

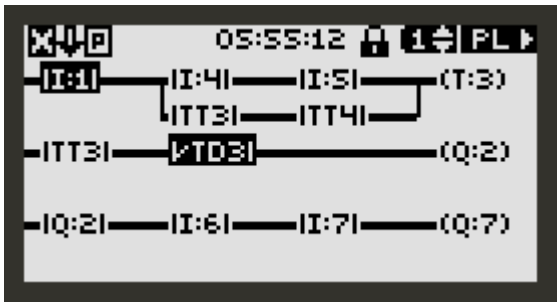
Displays the last received message in large font. If the message exceeds the screen size, the DOWN button allows scrolling.



RX (4):

Displays the signal strength of the configured channel in real time. Displays signal strength from -128dBm to 0dBm.

PLC Screens



The PL screen is a main screen of the TReX-460 that displays the currently configured ladders in groups of six lines. Further lines can be reached by pressing the DOWN button on the front of the device. Each line is displayed with it's corresponding inputs and their current states as well as the output of the line and it's current state.

When an input is displayed as **black text on a white background**, it is **open (or inactive)**. If displayed as **white text on a black background**, it is **closed (or active)**. Like a standard ladder logic display, **normally closed** inputs are preceded by a slash character ("/").

The number displayed in the top right corner indicates which page is currently displayed, with the first six lines displayed on page one and following lines displayed on subsequent pages.

The order of ladder program execution starts at the top of page 1 and proceeds downwards through subsequent pages. Each rung supports up to three inputs.

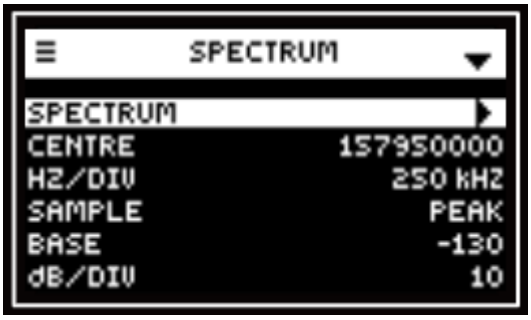
The "P" top left icon indicates that the PLC program is running and outputs are being controlled.

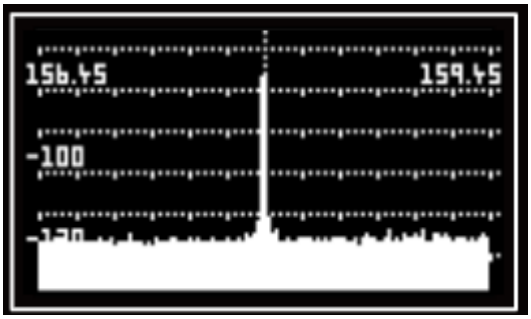
Site Configuration Tools

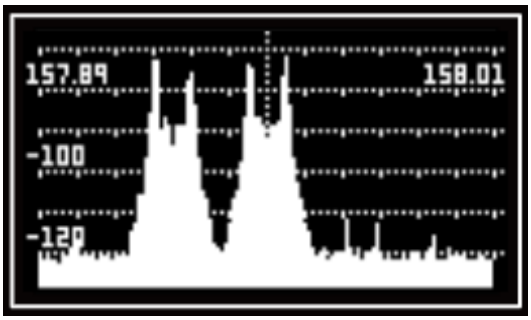
The TReX includes tools to ensure suitability for use at the current location and quality of the installation.

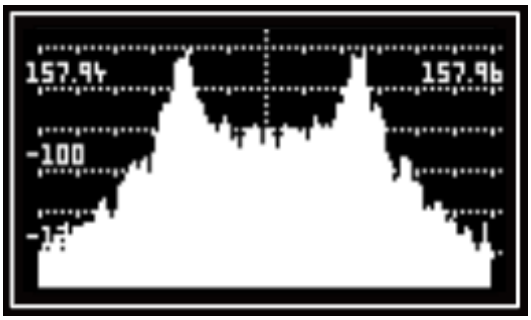
Spectrum Analyser

The optional spectrum analyser is a very simple to use tool that provides a span of either 3MHz, 120kHz or 24kHz around a configured test frequency. The receive bandwidth down to 500Hz is suitable for inspection of potentially interfering adjacent channel signals. The analyser can display signals as low as -125dBm making and is suitable for site inspection. This is an optional feature that requires a feature key to be purchased.



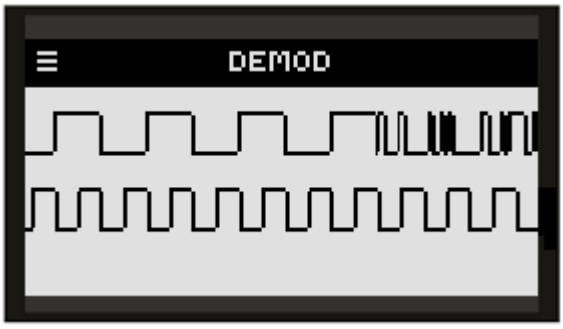






Demodulated Signal Viewer

The demodulated signal viewer allows inspection of raw demodulated data and the recovered clock from that data. This is useful for viewing channel activity. This facility is available for 2 level modulation modes of operation. 4 level modulation modes will display as straight lines.



Radio Link Encryption

Radio Links

The TReX can be configured to use industry leading AES 256-bit, block chained encryption for all used radio data links. This means messaging between WTE TReX radios cannot be intercepted without sharing of a key between devices.

A unique, non repeating timestamp is transmitted with every packet, ensuring that same content messages are not repeated, and also allows for protection against replay attacks. Historic messages with older time stamps can be rejected, protecting against malicious "record and playback".

In Telemetry and Modbus modes of operation outputs can be controlled with confidence, safely and securely. When RS232 serial link options are selected, full encryption options are available.

Secure Nationwide or Local Paging

One of the greatest shortcoming of public network paging is that unintended users with a standard paging receiver can intercept and read messages. In some countries paging is still used for emergency services and private information is transmitted. Some users still use paging networks to control devices, where the interception of these messages may allow device "hacking" and dangerous unintended behaviour.

The TReX can AES-256 encrypt standard paging messages and allow theses messages to be supplied to nationwide paging services. Messages transmitted are now completely secure, only able to be decrypted using a TReX receiver with a matching encryption key.

Emergency services can securely send encrypted messages across wide areas without the need for changes to infrastructure in order to meet privacy requirements.

Secure applications may include:

- Turning on fire station sirens/lights.
- Sending messages to local regions for decrypted retransmission.
- Enabling tsunami alarms across different parts of a country.

Note: In this application, the TReX may not need to be required to be used as a transmitter, only as a receiver. The AES encrypted message is obtained through serial output from a TReX unit, that is then supplied to an existing nationwide POCSAG or FLEX paging service provider.

See RF **Security** for usage and configuration details.

DMR Messaging

The TReX supports the transmission of short Digital Mobile Radio text messages, allowing direct messaging to DMR radios. This is an optional feature.

The TReX has a partial implementation of the ETSI TS 102 361-1 DMR standard allowing for DMR "Tier 1" messaging and therefore cannot be used in systems that have repeaters.

This is not a full implementation, and as a result has the following restrictions:

- Messages are limited to a maximum length of 70 characters.

DMR messages can be sent when an input is triggered or through use of the WT protocol in a similar manner as sending POCSAG paging messages. Refer to WT Protocol for usage information.

The TReX concurrently supports POCSAG and DMR messaging, allowing an input to send messages to both legacy paging systems and newer DMR radios. Additionally a POCSAG and separate DMR database is provided allowing a message to be transmitted to many POCSAG and DMR devices from the same serial protocol message. DMR transmissions may be on different frequency than POCSAG transmissions.

Different DMR manufacturers have interoperability limitations. The TReX is similar in this regard. Please refer to the Specification section for a list of tested DMR radios. The TReX WT protocol allows for switching between supported radio types to allow support for Hytera, Kirisun, Motorola and other brands.

All protocols implemented support direct DMR messaging. In order for a protocol to transmit directly to a DMR radio the DMR_DB database should be configured with group IDs, together with colour code, radio type and DMR radio frequency.

Programmable Logic Controller

An optional feature of the TReX-460 is a telemetry-optimised PLC. This allows automated control of outputs and transmissions based on configurable inputs, serial input, received messages, counters, comparators and timers. This PLC utility uses a ladder logic programming similar to other commercially available PLC devices.

Key Advantages of the TReX PLC:

- Can be configured on the unit itself, through the menu, without the need for an external PC or programmer.
- Ladder logic program may downloaded, and configured externally in a familiar ladder logic format using any text editor.
- Can be used with remote TReX units, separated wirelessly over significant distance, and use the input and output state of remote units to control the PLC program flow on the local unit.
- Each remotely accessed TReX can operate it's own PLC program.
- Live PLC operation can be viewed on the screen showing up to 6 rungs operating at the same time.
- Supports weekly, daily or hourly alarms.
- Allows macros to be executed as a rung output. This enables any user configurable message to be processed such as transmission of message or execution of TReX configuration commands.
- Allows timestamped logging to internal SD card of any PLC physical output change.
- Can match on configurable serial input, and use this to control program flow and serial output. If desired, simple serial protocols can be supported or converted.

See **PLC Screens**, **PLC Commands** and **PLC Support** sections for usage and configuration details.

Two-Way Paging

The TReX supports two-way paging. The TReX can return responses via serial or TCP connections. Transmitter capable TReX units can additionally respond at high power across the air.

Not only can acknowledgements be returned from the TReX, but confirmation of job acceptance receipts can be returned. This means that messages can be sent to single or multiple TReX units and clear details can be returned to notify if a message has been read or an action is being performed.

Applications for this feature include:

- sending messages to a fleet of vehicles (e.g. ambulance or taxi) for one of many to respond.
- use in a muster station type scenario, where in the case of emergency, a warden can notify when an area is safe or all personnel are present.

Example:

An emergency dispatch system may send a paging message to a group of ambulances for attendance at an emergency. The message will be displayed on a TReX unit within the ambulance with prompt to attend if possible. Accepting the job can be performed with a simple keypress that will send receipt to the dispatch system that the vehicle is on-route.

See **WTE Ack and Confirm Protocol** for usage details.

With a single keypress, key messages can be responded to. Details of the responder are returned and logged.

Configuration Methods

There are several methods to configure the TReX unit, such as:

- Directly from the front panel
- Via a web browser
- Via Serial terminal over the RS232, RS422 and or RS485.
- Via a TCP terminal (either client or server).
- USB connection and editing of the WTE_CONF.INI configuration file.

Configuration Backup and Restoration

Once the TReX has been configured using any of these methods, the configuration may be copied, backed up and restored if required. Using the method below, any number of TReX units can be quickly configured to behave identically.

To Backup Configuration:

1. Connect a USB lead from a computer to the TReX.
2. Wait for the TReX to appear as a mass storage device.
3. Copy the file WTE_CONF.INI to any location for backup.

To Restore Configuration:

1. Connect a USB lead from a computer to the TReX.
2. Wait for the TReX to appear as a mass storage device.
3. Copy the backed up file WTE_CONF.INI to the TReX, replacing the existing file.
4. Restart the TReX.

Front Panel Menu Configuration

All typical configuration items are accessible and configurable via the on-board menu system. This includes the ability to configure input messages. Through the use of the menu system the TReX is able to be set up and configured without any PC connection.

While inside the MENU transmit features are disabled to ensure that safe operating clearances are maintained. The TReX will continue to operate normally and transmit if required immediately on leaving the menu.

To enter the menu, press the MENU button. The top line icon bar shows when the DOWN button can be used when the DOWN arrow is visible. When scrolling down and the DOWN arrow disappears, then the end of the menu section has been reached. The UP arrow will be visible when navigation in the up direction is permissible. The RIGHT arrow indicates that the RIGHT button can be pressed to enter a MENU category when highlighted.

Pressing the MENU button again moves back one level, until the top is reached, and then the TReX leaves the MENU mode. If any change has been made, changes will only be written to internal storage when leaving the MENU mode.

To edit any field, first move to the item, press RIGHT to select the field. Once highlighted, the UP/DOWN arrows change the field. On completion, pressing RIGHT again will deselect the field.

Some fields are text that can be edited. There is a built-in text editor. Fields that are edited by the text editor are presented with the title “EDIT TEXT”. This may be suitable for minor changes where other configuration means are not available.

Each character can be selected by pressing the RIGHT button. The selected character is inverted. Pressing the UP/DOWN buttons allows the character to be changed to any printable character. Characters can now be selected via the text input screen.

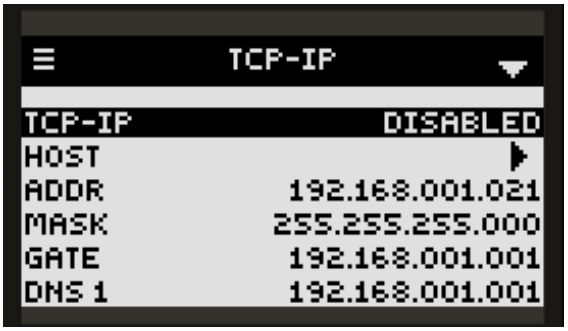
Once a character has been selected, pressing the ENTER button accepts the change.

The BACK arrow indicates the end of the text. This arrow is not part of the actual text but present as a marker. To make the text longer, highlight the BACK arrow and change the character using the UP/DOWN buttons. To make the text shorter or to delete a character, highlight the BACK arrow and press the ENTER button. Press the BACK button to exit the editor.

Web Browser Configuration

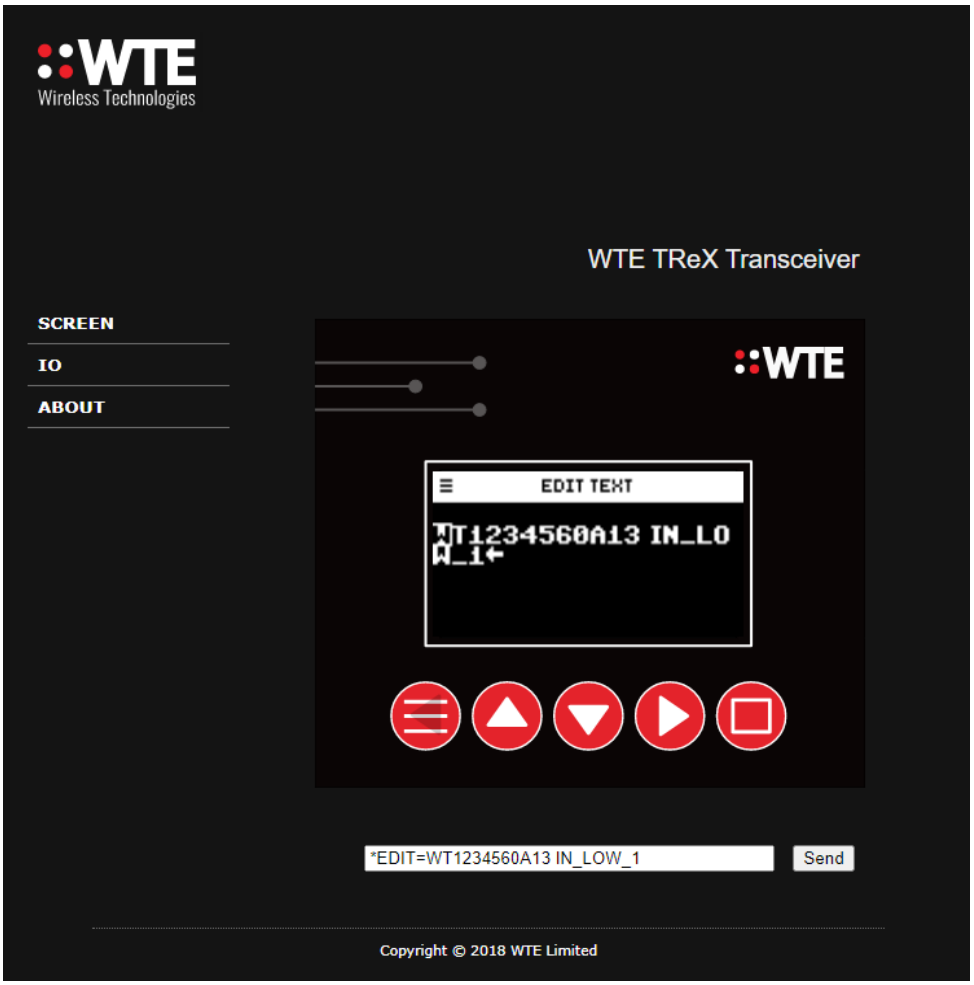
For web browser configuration to be possible (using browsers that support SVG such as "Chrome", "Firefox" etc.), the Ethernet/IP must be ENABLED via the menu (ENABLED by default). This is located in SYSTEM->IP. In this menu section network parameters can be configured such as the IP, Mask and gateway.

Only a single connection to the TReX should be allowed. Multiple connections will result in impaired responsiveness.



After the unit has been enabled to be use over the web, a web browser address matching the configured IP should be used. e.g.
http://192.168.1.21

This IP address is shown as a pop-up each time the TReX starts up.



Using the web browser the TReX can be remotely configured. When moving to a text field, the text box at the bottom of the browser is automatically loaded. Changes can now be made and committed by pressing the SEND button. This text box can also be used to transmit messages for a configured protocol.

Serial Command Configuration

Parameters can be changed using any common serial terminal (available on request if required) program using the RS232 or RS422/485 ports.
Start-up baud rate is determined by the baud rate as configured through the MENU.

All configuration commands always start with the asterisk '*' character.
All messages that do not start with the * character are processed by the protocol decoder.
All messages are terminated by a Carriage Return character, shown in this manual as <CR>
All commands that accept a value, can have that value read back by using the '?' suffix.
Typical usage:

**RX_FREQ?*

Typical response:

**RX_FREQ=160000000*

There are some commands that support multiple entries (such as the same command but for different ranges). In this case the question mark can be followed by the parameter to be interrogated. E.g.

**RX_RANGE?<CR>*

Returns (lists all ranges)

**RX_RANGE=1:8,2000000*
**RX_RANGE=2:0,0*
**RX_RANGE=3:0,0*
**RX_RANGE=4:0,0*
**RX_RANGE=5:0,0*
**RX_RANGE=6:0,0*
**RX_RANGE=7:0,0*
**RX_RANGE=8:0,0*

To find the first range only:
Usage:

**RX_RANGE?1<CR>*

Response:

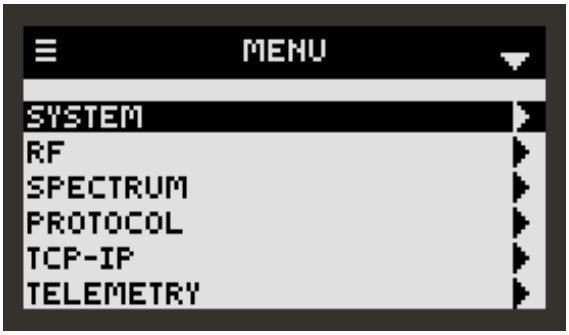
**RX_RANGE=1:8,2000000*

In order for any configuration changes made via serial to be saved the command **SAVE<CR>* must be sent to the TReX before removing power or restarting.

Note: Although most configuration changes are applied immediately, it is a good practice to

restart the unit after changing configuration. This can be achieved by removing power to the unit or sending the **REBOOT<CR>* command.

MENU Configuration



SYSTEM
Configures language, backlight, screen contrast, time, unit ID, sound, baud rates, factory test, main operating screens and menu lockout.

RF
Transmitter and receiver configuration items. Includes frequency, baud rates and logging settings.

SPECTRUM
Configures and allows access to the spectrum analyser.

PROTOCOL
Control of the handling and formatting for incoming and outgoing messages.

TCP-IP
Control of all aspects of internet connectivity. Allows remote configuration and operation through the use of the “Chrome” or “Firefox” web browser, TCP client or TCP server.

TELEMETRY
Determines if operation is on a controlled protocol basis, or autonomously operating input states to a remote TReX device.

STORE FWD
Configuration of the paging store and forward repeater operation including duplicate reject.

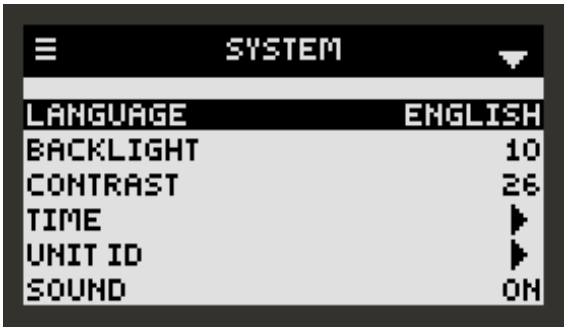
PLC
Configuration of programmable controller ladder logic program.

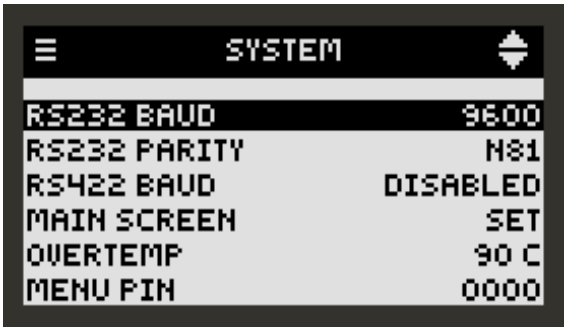
INPUTS
Configuration of all inputs.

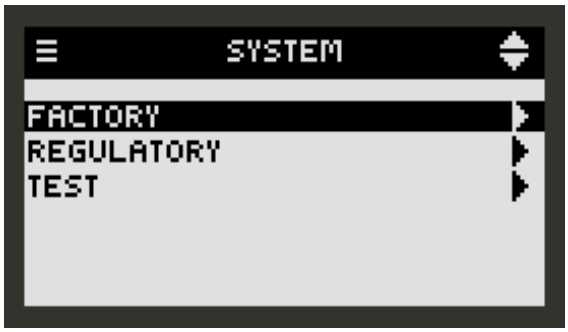
OUTPUTS
Configuration of all outputs.

ALERTS
Configuration of all alerts.

SYSTEM Menu







LANGUAGE
Items ENGLISH plus others can be selected. To incorporate specific language support please contact WTE Limited directly.

BACKLIGHT
The backlight setting is how long in seconds the backlight is lit after each key press and also when a message is received. Setting to 0 disables the backlight completely.

CONTRAST
The screen contrast setting. Although the display is temperature compensated across the TReX operating range, at times improved viewing is possible through this contrast adjustment.

Default value is 32.

TIME
Sets the internal clock.

UNIT ID
This is the unit ID that is used by the WTE output control protocol. This can be any number or alpha numeric description. e.g. “01” or “Unit-A”

SOUND
Allows control of system sounds that may be heard on an ALERT and also key beeps.
Items ON and OFF can be selected.

RS232 BAUD
Allows configuration of the RS232 port baud rate. All settings are N:8:1. Available rates are: 2400, 4800, 9600, 19200, 38400, 57600 and 115200.

Note: that for the most efficient transmission, the serial baud rate should be higher than the transmit over the air baud rate.

RS232 PARITY
Allows configuration of the RS232 port parity setting. May be set to N:8:1 or E:8:1

RS422 BAUD
Allows configuration of the RS422 port baud rate. All settings are N:8:1. Available rates are: 2400, 4800, 9600, 38400, 57600 and 115200

Note: that for the most efficient transmission, the serial baud rate should be higher than the transmit over the air baud rate.

MAIN SCREEN
This allows any page on any main screen to be set as the default main screen. This results in this screen being the screen that is first seen when powering up the unit, or after any period of inactivity the TReX will automatically revert to this screen.
Setting to DEFAULT will unset the last custom set screen and will return to the factory default main screen. Setting to SET will set the screen to be the screen that was last used before entering the menu.

MENU PIN
When the MENU PIN is set to a non-zero value, the MENU will be prevented from opening until the PIN is entered. Prevents accidental or unauthorised misconfiguration. If the PIN is ever forgotten, the PIN is visible using the command *CONFIG or viewing the

WTE_CONF.INI file through a USB connection. Once the MENU is unlocked, it will remain unlocked until the unit is restarted.

FACTORY
Sub menu responsible for calibration screens and setting of feature unlock keys.

TEST
Test sub menu for generation of test messages and testing of outputs.

REGULATORY
Regulatory items such as FCC-ID*.

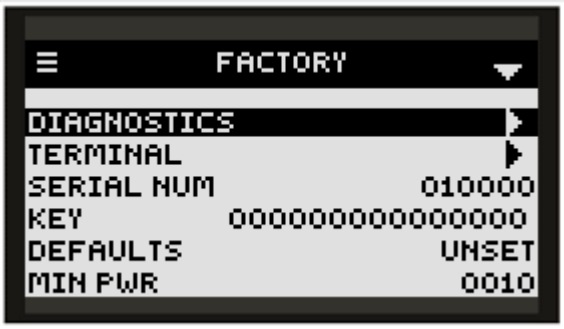
*Note: Publication number 784748-D02, FCC-Part 90 allows for devices with integrated display to not require a printed label on the device holding this information.

TEST Sub Menu

1-8
Digital output to test. Pressing up pulls the output to ground for 60 seconds. Pressing down releases the output.

FACTORY Sub Menu

This menu is typically for factory use only or to return the unit to a factory new state.



DIAGNOSTICS
Diagnostic information for factory use only.

TERMINAL
Basic serial analysis tool for factory use only.

SERIAL NUM
Read only unit serial number.

KEY
The key used to unlock unit features. If features are purchased after sale, a new key may be required to be entered here. They key is unique to the unit serial number. The TReX may only have a fixed number of key entry attempts before all features are disabled, requiring the unit to be returned to the factory.

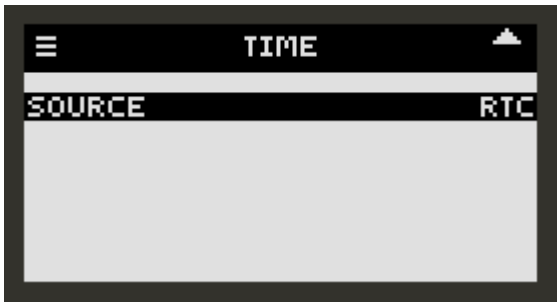
SET DEFAULTS
Used to set the TReX back to factory defaults. Calibration data is not cleared. This may be used at any time to restore the unit to a known starting point.

MIN PWR
Specifies the minimum power level as read from the forward power ADC during a transmission. If this minimum level is not reached, there will be a transmit warning and the RF OUTPUT (Shared with the MISMATCH output) will operate if configured. This parameter should NOT be changed without instruction from WTE.

MAX PWR
Specifies the maximum power level as read from the forward ADC during a transmission. When this level is exceeded the RF OUTPUT will operate if configured. This parameter should NOT be changed without instruction from WTE.

MAX I (mA)
Specifies the max current that can be drawn during transmission. When there is an antenna mismatch the current will often be higher than under normal use. During transmission power ramp up the system current is examined limited to this value. If the limit defined here is reached, the RF OUTPUT will operate to indicate a fault condition. This parameter should NOT be changed without instruction from WTE.

TIME Sub Menu

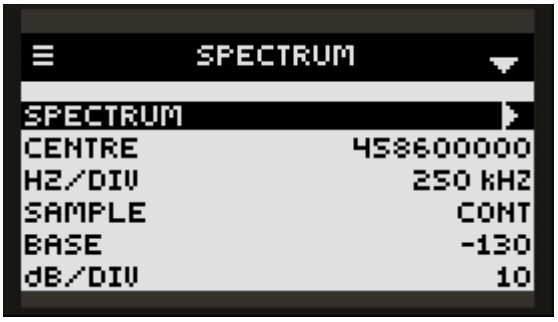


HOUR, MIN, DAY, WEEKDAY, MONTH and YEAR
Configuration of the real time clock.

SOURCE
Determines how time is maintained in the TReX.

- RTC uses the internal real time clock to keep time.
- FLEX takes the time from the FLEX transmission time details (if present).
- SEQ TEST takes the time from national paging network (used in N.Z. only).
- NONE only uses the internal processor clock. This will only be the time since last reset.

SPECTRUM Menu



SPECTRUM
Displays the radio spectrum using the settings in this menu. Signals between -128dBm and 0dBm can be displayed. **Power levels above 17dBm (50mW) will destroy the receiver input**.

CENTRE
Displays the centre frequency to be displayed on the screen.

HZ/DIV
Either 250kHz, 10kHz or 2kHz. The screen is 6 divisions wide in 120 steps.
The RBW (receiver bandwidth) and frequency span is automatically set when the Hz/Div changes.

HZ/DIV	RBW	Frequency Span
250kHz	25kHz	3MHz
10kHz	1kHz	120kHz
2kHz	500Hz	24kHz

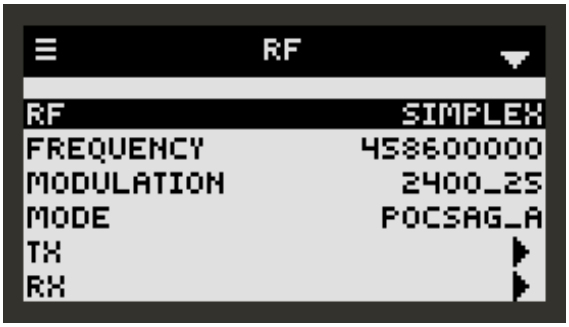
SAMPLE
When set to CONT the spectrum analyser screen will be updated with new values approximately twice a second. When set to PEAK only higher values will be written to the screen. At any time, the ENTER button can be pressed on the SCREEN to clear the screen and load new PEAK values.

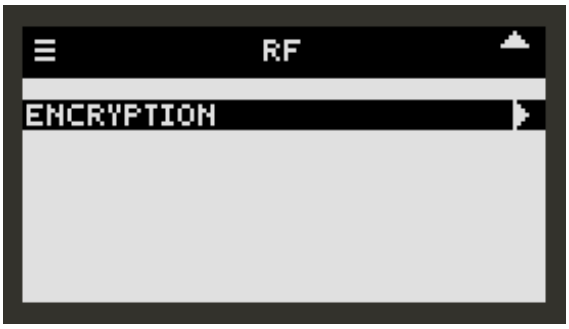
BASE
Defines the base signal level on the screen. When set to -100, only signals with a strength greater than -100 dBm will be displayed. Range is -130 dBm to -60 dBm.

dB/DIV
Scales the signal level displayed. Either 10 dB/DIV or 20 dB/DIV can be set. When 20 is set a dynamic range of 120 dB is possible.

RF Menu

!WARNING
CHANGING RF PARAMETERS WITHOUT AUTHORISATION MAY RESULT IN PROSECUTION AND AFFECT OTHER USERS. • The TReX can be configured to operate on many frequencies and at many power levels. Only use the TReX at power levels and frequencies legally permitted to do so at. If unaware of the restrictions of use for radio transmitters in the country of use, seek professional guidance. **Failure to follow these instructions can result in local body prosecution. Misuse may affect other radio users that may in return affect their safety when critical systems have been employed.**





RF
When SIMPLEX, the TReX receiver frequency, modulation and mode are used from this menu (common to TX). This allows common parameters to be easily changed in a single place. When DUPLEX the TReX receiver frequency, modulation and modes are used from within the RX menu. DUPLEX may be desired when forwarding onto another device in a different format (such as receiving in FLEX on one frequency and transmitting in POCSAG on another). RX_DISABLED disables all receiver functions. TX_DISABLED disables all transmitter functions. When RX_DISABLED is selected an operating current reduction of 50mA is typical.

FREQUENCY
Specifies the transmit and receive frequency in Hz (range limited to the variant of product). When RX is configured to DUPLEX, this setting may be independently configured for the receiver.

MODULATION
Specifies modulation parameters. This includes whether the modulation is 2 or 4 levels GFSK plus the channel width. 512_25 indicates 512 baud with 25kHz channel spacing (2 level GFSK). 4800-4L_6 indicates 4800 baud with a 6.25kHz channel spacing (4 level GFSK). Modulation rates from 512 baud to 32K baud can be set.

When RF is configured to DUPLEX, this setting may be independently configured for the receiver.

MODE
Specifies the transport mode of the transmitter and receiver (how the information is received over the air).

- **POCSAG_A** must be used in order to receive alphanumeric messages.
- **POCSAG_N** must be used in order to receive numeric messages.
- **POCSAG_T** should be used in order to receive tone only messages.
- **WTE_EN** must be used in order to receive 8 bit characters (POCSAG_A transmits 7 bit characters only).

When RF is configured to DUPLEX, this setting may be independently configured for the receiver.

TX
Transmitter configuration items. Includes output power level, power limits and other TX only parameters.

RX
Receiver configuration items. Includes RIC ranges, alerting options plus RF parameters such as frequency when RF has been configured to be DUPLEX.

ENCRYPTION Sub-Menu

Allows RF link configuration items to be set. See **RF Security** and **Radio Link Encryption** for more details.

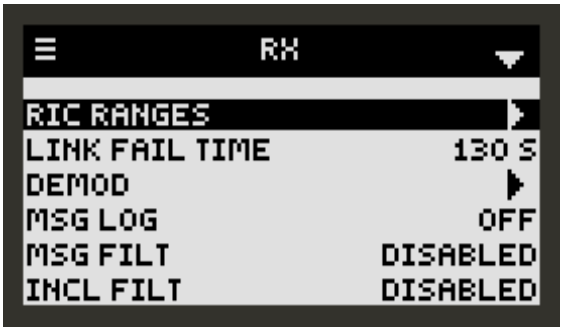
ENCRYPTION
When ENABLED, the configured key set by the *RF_KEY command may be applied to transmitted and received data.

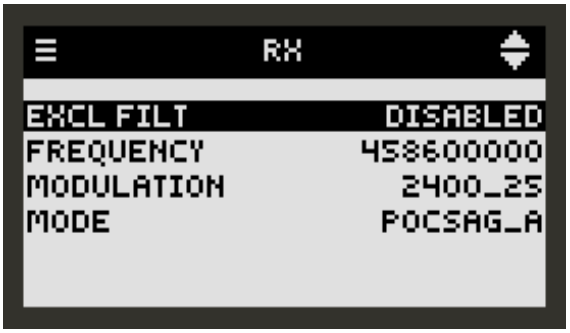
KEY TYPE
Allows the encryption method to be selected. AES 128-bit or AES 256-bit may be set. AES-256 is more secure, at the expense more processing time. Both types produce the same length encrypted messages.

DUPL REJECT
If enabled, the receiving TReX will determine from the encrypted time stamp if the message is the same age or older than a previous message from a TReX transmitting with a matching **LOCAL ID**.

LOCAL ID
This is the **TELEMETRY->LOCAL ID**, and must be unique for every TReX transmitting in a system.

RX Menu





RIC RANGES
Specifies up to 8 RIC RX ranges for decoding. Messages received with RIC codes not allowed with the RX_RANGE will be discarded by the receiver.

Note: When configuring the RIC RANGE, the LOW RIC must not be higher than the HIGH RIC and the HIGH RIC must not be lower than the LOW. Any attempt to configure illegally will reset the RIC RANGE to ensure these rules are not broken. Any RIC RANGE with a LOW RIC set to 0000000 will NOT be used.

LINK FAIL TIME
This is the number of seconds (up to 240) that is allowed to pass in-between received messages without setting the LINK FAIL output (if LINK FAIL output is configured).

ALERT
Visual notification and repeating beep (at a configurable interval) when a message is received that meets the conditions for raising an alert. See **ALERT FILTER**.

If the ALERT output is enabled the configured output will also operate.

Can be configured from 0-250 seconds. When set to 0 the alert is disabled.

DEMOD
Access to the raw signal demodulation screen allowing raw data and recovered clock signals to be viewed in real time. Only used for 2 level demodulations.

MSG LOG
When ENABLED all received messages are written to RX-LOG.TXT on the SD card. Should be set to DISABLED in critical applications when the SD card cannot be allowed to completely filled (such as when unsupervised). Logging is disabled while connected to the USB port.

DISABLED:

Messages are not logged.

ENABLED:

All messages displayed are written to internal SD card and can be viewed on the message history screen.

CLEAR:

Setting to CLEAR will result in RX-LOG.TXT being deleted when exiting the menu.

FILTERS

The TReX supports the use of message filters. These filters inspect the content of incoming messages and then make decisions on whether to ignore or pay attention to these messages based on filter setting.

There are 3 types of supported filters:

- Include filters (messages must include one or more of the matching entries).
- Exclude filters (messages must NOT include any of the matching entries).
- Message filters (ALERT may be triggered for message with any of the matching entries - see **Alert Handling**)

Message filters take priority over Exclude filters. This means that if "PUKEKO" has been specified in MSG.TXT and "FIRE" is specified in EXCL.TXT then a message with "FIRE AT PUKEKO PLACE", although it would normally be excluded, could still operate an output and display the message.

Each of the filter matching entries are NOT case sensitive and can be part of a longer word or phrase.

Entries are allowed to be more than one word e.g.
THIS IS A TEST

This will match on "ThiS is a TEST" but not the single words in the entry, unless they have been added as separate match entries.

Up to 15 key words can be stored, each up to 20 characters in length. There must be no ASCII control characters within the key words used and each matching phrase must be on a new line.

MESSAGE FILTER
This filter option allows the use of a text file called "MSG.TXT" to be stored and modified on the SD card (accessible via the USB port). If the feature is enabled this file (if present) will be searched for key words. If any of these key words are found then the configured alert output is operated. If logging is ENABLED, all messages resulting in an output being operated will add a leading '*' to the message.

In all the following examples:
ALERTS->ALERT OUT set to 2.
ALERTS->MSG set to ENABLED.
OUTPUTS->2->MODE set to DISABLED (to ensure no other IO function shares output 2)

Example:

MENU->RF->RX->MSG FILT set to ENABLED:

A text file named MSG.TXT is added to the SD card root directory that has the following contents:

TSUNAMI

MAJOR EMERGENCY

All messages WITH these key words will result in OUTPUT 2 being operated and an alert being raised. These messages will be displayed and logged normally as per the system configuration.

All other messages will still be decoded and displayed based on RIC range settings.

MENU->RF->RX->MSG FILT set to DISABLED:

Messages are not filtered. All received messages will operate OUTPUT 2 and raise an alert.

If the ALERT is now disabled:

ALERTS->MSG set to DISABLED.

There will be no visual or audible alert (see **Alert Handling**)

NOTE: Restarting is required in order to load the MSG.TXT settings. This applies both when enabled via the serial port or from the menu.

INCL FILTER

This filter option allows the use of a text file called "INCL.TXT" to be stored and modified on the SD card (accessible via the USB port). If the feature is ENABLED, this file (if present) will be searched for key words. Any of these key words MUST be present in order for the message to be processed.

NOTE: messages received for filtering must still fall within configured RIC ranges.

Example:

A text file named INCL.TXT is added to the SD card root directory that has the following contents:

FIRE

EMERGENCY

All messages WITHOUT these key words WILL BE DISCARDED. Even though non matching messages are discarded, the receiver OK indicators and timers will continue to operate normally.

INCL FILT set to DISABLED:

Messages are not filtered

INCL FILT set to ENABLED:

Messages are filtered

EXCL FILTER
This filter option allows the use of a text file called "EXCL.TXT" to be stored and modified on the SD card (accessible via the USB port). If the feature is ENABLED, this file (if present) will be searched for key words. Any of these key words MUST NOT be present in order for the message to be processed.

Example:
A text file named EXCL.TXT is added to the SD card root directory that has the following contents:
THIS IS A TEST
DISCARD
All messages WITH these key words WILL BE DISCARDED. Even though non matching messages are discarded, the receiver OK indicators and timers will continue to operate normally.

EXCL FILT set to DISABLED:
Messages are not filtered
EXCL FILT set to ENABLED:
Messages are filtered

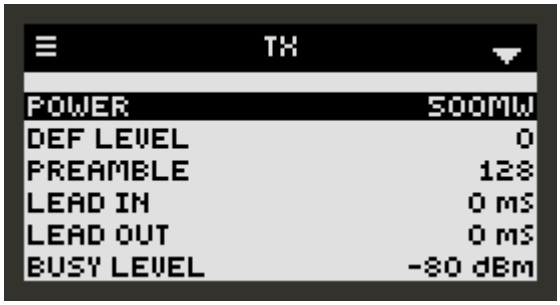
FREQUENCY
Specifies the receive frequency in Hz (range limited to the variant of product).
Applicable only when RX is DUPLEX.

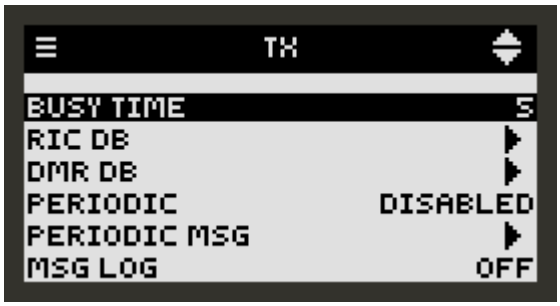
MODULATION
Specifies modulation parameters. This includes whether the modulation is 2 or 4 levels GFSK plus the channel width. 512_25 indicates 512 baud with 25kHz channel spacing (2 level GFSK). 9600-4L_6 indicates 9600 baud with a 6.25kHz channel spacing (4 level GFSK). Modulation rates from 512 baud to 48K baud can be set.
Applicable only when RX is DUPLEX.

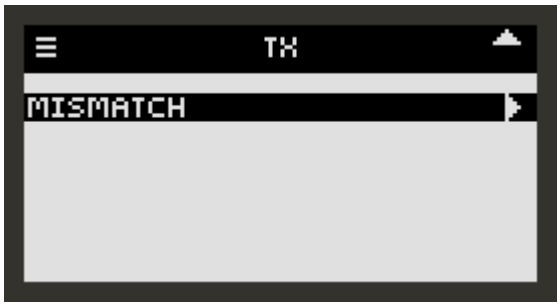
MODE
Specifies the transport mode of the receiver (how the information is received over the air). Applicable only when RX is DUPLEX.

- **POCSAG_A** must be used in order to receive alphanumeric messages.
- **POCSAG_N** must be used in order to receive numeric messages.
- **POCSAG_T** should be used in order to receive tone only messages ("TONE" displayed on screen for message payload, but not actually transmitted or received).
- **WTE_EN** must be used in order to receive 8 bit characters (POCSAG_A transmits 7 bit characters only).
- **FLEX** must be used in order to receive and decode 2 level 1600 baud FLEX messages.

TX Menu







POWER
Specifies the transmit power. Allows a maximum of 4W power to be set.

DEF LEVEL
Some protocols require a default message priority (or LEVEL) to be set when sending POCSAG messages. This level between 0 and 3 may be set here. WT protocol does not use this configuration item.

PREAMBLE
Set the transmitter preamble length (specified in bits). Short preambles allows the messages to be transmitted quickly.
Long preambles are typically used in conjunction with a matching receiver to save battery power when the receivers is in deep sleep mode.
The POCSAG standard uses a preamble of 576 bits. This very long preamble means that

paging receivers need only to wake once per second (at 512 baud) in order to check for an incoming message. If the receiver is always powered and receiving, then much shorter preambles can be used, and in some cases make significant reductions to channel activity.

LEAD IN
Sets the time in ms that the carrier is present BEFORE the START of a data stream. By default this is set to 0. Some receivers require a settling time before decoding. The lead-in time allows this to be managed, with a lead-in time up to 500ms.
LEAD OUT
Sets the time in ms that the carrier is present AFTER the END of a data stream. By default this is set to 0. A lead-out time up to 500ms can be configured.

BUSY LEVEL
Specifies the busy level for the configured channel.

The configured value is the signal level from 0 to -130 (in dBm). If the signal strength on the receiving channel is above this configured value, the channel will be considered to be busy. Transmissions will not be possible if the channel is considered to be busy. After the configured BUSY TIME period, the transmitter will transmit anyway.

Note: If the TReX continually reports BUSY serially or via 'B' icon, adjust the busy level appropriately or investigate the source of the channel interference.

BUSY TIME
Specifies the max period in seconds that a channel may be considered to be BUSY before transmitting anyway.

RIC DB
Some protocols do not need a RIC to be specified for each transmission. When the RIC DB is used, the RIC DB provides the destination RIC information. One or many RIC codes can be specified so that a message can be sent to many RIC codes at the same time.

DMR DB
When the DMR DB is used, the DMR DB provides the destination DMR group ID information for serial protocols. One or many DMR group IDs can be specified so that a message can be sent to many DMR radios at the same time. Inside this menu the DMR colour code and radio type can also be specified. The FREQUENCY specified allows all the DMR entries to be transmitted on a different frequency than POCSAG messages originating from other sources.

PERIODIC
If DISABLED the configured PERIODIC MSG is not transmitted. When not DISABLED, the value is the time in seconds between transmitting the PERIODIC MSG.

PERIODIC MSG

This message is transmitted periodically depending on PERIODIC setting. The message should match the used protocol. e.g “WT1234567A10 Periodic Message” should be configured if the WT protocol is selected.

MSG LOG

When ENABLED all transmitted messages are logged to “TX-LOG.TXT”. It should be noted that logging all messages to the SD card does slightly impair the performance of the transmitter. In some cases transmitting of batched messages may not be possible at high data rates. All messages will still be transmitted correctly, but in some cases less efficiently (through occasional resending of a preamble between messages). This means for some applications, especially when the TReX is not actively being managed (perhaps through being installed at a remote site), MSG LOG should be set to DISABLED. When the SD card is full, the message “SD CARD FULL” will be displayed until acknowledged. Operation will continue normally after the SD card is full.

DISABLED:

Messages are not logged.

ENABLED:

All messages displayed are written to internal SD card and can be viewed on the message history screen.

CLEAR:

Setting to CLEAR will result in TX-LOG.TXT being deleted when exiting the menu.

MISMATCH Sub-Menu

The MISMATCH feature allows for antenna mismatch conditions to be reported. Should the antenna become disconnected or damaged the antenna matching (in essence, how well power is transferred from the TReX to the antenna) may change. This feature is intended for use at the TReX 4W power setting from a fixed voltage power supply.

This mismatch may be observed by:

- An increase or decrease in drive to the RF amplifier in order to achieve the required output power.
- An increase or decrease in current flowing into the TReX.

This condition can be reported by raising an alert (see Alert Handling).

Every installation and antenna is different, therefore the MISMATCH feature must be calibrated for each unit after it has been installed. Even changing the length of coax to the antenna will affect the matching behaviour.

Calibration Process:

1. Complete TReX installation with antenna connected.
2. Complete configuration of the TReX including power level.
3. Select the MISMATCH output. If DISABLED, the MISMATCH feature will not operate.
4. Select RF->TX->MISMATCH->CAL and change to ENABLED. This will automatically calibrate the MISMATCH feature after the next transmission.
5. Exit the MENU.
6. Transmit any message, typically a short 512 or 1200 baud transmission. A pop-up message indicating that the MISMATCH feature has been calibrated will be displayed, and “CAL DONE” will be sent out the serial port.
7. Test the system by either changing or removing the antenna, then transmitting a message. Perform this test with care, and infrequently since this will place stress on the transmitter. The selected output will operate and pop-up will be seen.

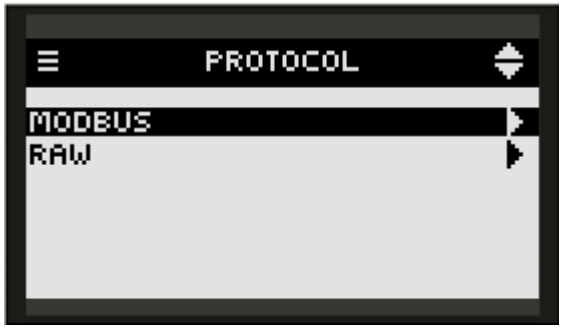
All parameters and calibration may also be controlled via MISMATCH serial commands.

CAL
Setting to ENABLED results in calibration of the MISMATCH feature after the next transmission.

DELTA DAC
This should not need to be changed. This is the permitted variation in drive to the power amplifier. Decreasing this value will result in higher rate of false MISMATCH alerts but greater sensitivity to small changes. Typically a value of 5 will be appropriate.

DELTA mA
This should not need to be changed. This is the permitted variation in transmit current. Decreasing this value will result in higher rate of false MISMATCH alerts but greater sensitivity to small changes. Typically a value of 50 will be appropriate.

PROTOCOL Menu



IN
Specifies the protocol to apply for serial input. Accepts WTE, CUSTOM, RAW, AUX and in some cases others as required or specified.

OUT
Specifies the protocol to apply for serial output. Accepts WTE, CUSTOM, RAW, AUX and in some cases others as required or specified.

SENT RESP
This the response out the serial port at the completion of each transmitted message. By default this is "Page Sent".

Note: The default overriding response for WT protocol is "WT[xxx]". To change the sent response to "Page Sent" a leading '' character must be used. e.g. "*Page Sent".*

REPEAT
When any serially controlled protocol is used and a message is transmitted, the REPEAT can be configured to result in additional transmissions. If the RIC_DB or DMR_DB is configured, the REPEAT will result in a retransmission to all entries in the populated databases. The REPEAT will not affect input, periodic or store and forward related transmissions. Setting to 0 will result in no repeating.

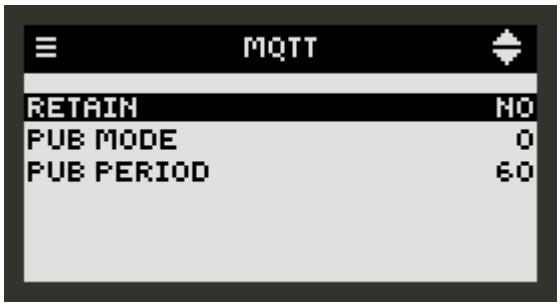
REPEAT DLY
Specifies the delay in seconds before any REPEAT transmission takes place. Max 60 seconds, min 1 second.

MQTT
Specifies parameters used for the “MQTT” protocol. This is a common “IoT” service protocol.

MODBUS
Specifies parameters used for the “MODBUS” protocol.

RAW
Specifies parameters used for the “RAW” protocol.

MQTT Sub-Menu



TCP-IP
Control of all aspects of internet connectivity. Allows remote configuration and operation through the use of the "Chrome" or "Firefox" web browser, TCP client or TCP server.

USER
Username to be used to log in to the broker. Not all brokers require this.

PASS
Password to be used to log in to the broker. Not all brokers require this.

UNIT ID
This is the unit ID that is used by the WTE output control protocol. This can be any number of alpha numeric description. e.g. "01" or "Unit-A". The UNIT ID is part of the published MQTT topic.

CLIENT ID
This is the MQTT client ID. This must be unique to an MQTT server. By default is set based on the TReX serial number. The CLIENT ID is part of the published MQTT topic.

QOS
The MQTT quality of service. When set to 0 there is no guarantee of delivery since there is no receipt of delivery. When set to 1, the delivery of any message is at least once (but there may

be unintended additional deliveries). When set to 2, there is exactly one delivery.

RETAIN
Sets messages to have retained flag set when configured to YES. The broker stores the last retained message and the corresponding QoS for all topics.

PUB MODE
0: All topics are published.
All TReX topics are typically republished after a configured period, unless there is an input change or message received, when the associated topic is published immediately.

1: Only **changed** topics are published.
After connection and initial publishing of all topics (all are "retained" by the server), only topics that change will be published. This option will significantly reduce sent data and may be desirable to reduce data usage costs.

2: Only digital IO topics are published. (**Di1-Di11** + **Do1-Do8**)
All Digital IO TReX topics are typically published after a configured period, unless there is an input change, when the associated topic is published immediately.

3: Only **changed** digital IO topics are published. (**Di1-Di11** + **Do1-Do8**)
Changed digital IO TReX topics are typically published after a configured period, unless there is an input change, when the associated topic is published immediately.

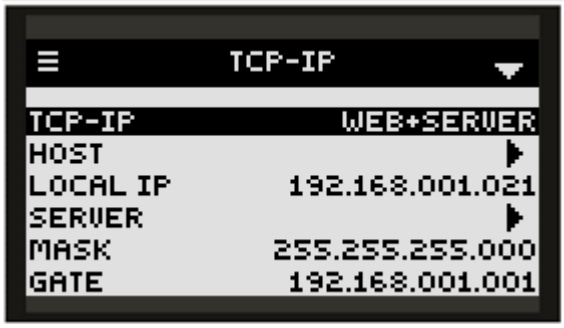
4: Only received radio messages are published, with history. (**MS** + **MO**xx)
Only the received messages as they arrive are published. There is no periodic publishing of any IO. MS is the ID topic of the last received message, MOXX is the message with ID suffix. e.g. if **MS** is 7, then the published message topic will be **MO07**. This allows a history of messages (last 100 cycling 0-99) to be stored on the server if required.

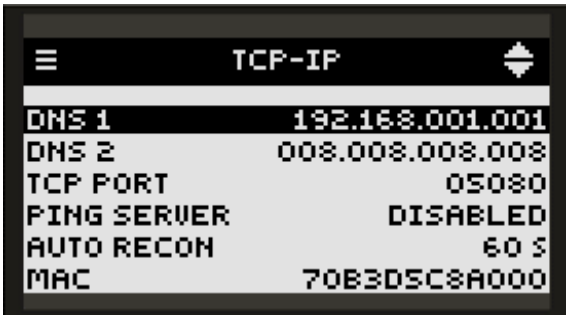
5: Only received messages are published without history. (**MO**).
Same as 4, but the **MS** topic is not published, and all received messages are published only to the **MO** topic. This saves storage space on the MQTT server and can simplify some implementations.

The LW topic remains to be periodically published in all cases.

PUB PERIOD
This is the period between the republishing of topics. This ranges from 30 seconds to 600 seconds (10 minutes) and can be incremented or decremented by 10 seconds at a time through the menu. For finer control over the republish period, refer to the ***MQTT_CONFIG** command section of the manual.

TCP-IP Menu





TCP-IP
Selects the TCP protocol for use on the TReX.

WEB:

This setting allows the TReX to be monitored and configured from a Chrome web browser either on a PC or mobile device.

SERVER:

This setting allows the TReX to be operated as a TCP server on the specified TCP port. SERVER would typically be used if a short term connection was required, such as to change a configuration item or send a message for transmitting. Only a single connection is allowed, however multiple users can conceivably connect in this mode for short durations in order to offload content to be transmitted. A long term or held connection will allow decoded messages to be viewed in real-time (preventing further connections).

CLIENT:

This setting allows the TReX to be operated as a TCP client on the specified TCP port and REMOTE IP. SERVER would typically be used if a remote device required a long duration or permanent connection. This would be desirable if monitoring decoded messages.

WEB+SERVER:

Concurrent WEB and SERVER functionality.

WEB+CLIENT:

Concurrent WEB and CLIENT functionality.

DISABLED:

Setting to DISABLED ensures the maximum possible power savings even when an Ethernet cable has been connected. When IP is DISABLED, current consumption will reduce by approximately 150mA and disable the TCP stack.

HOST
This is the name that can be associated to the TReX. This name can be used directly instead of the IP address to address the TReX. By default is "WTE-TReX"

LOCAL IP
IP Address for access to the TReX.

SERVER
IP Address for the TCP CLIENT to connect to. When performing a PING this is the resolved address that is used.

MASK
IP Mask

GATE
IP Gateway

DNS1
Primary Domain Name Server

DNS2
Secondary Domain Name Server.

TCP PORT
The port to use for TCP client TCP server connections. Default is 5080.

PING SERVER
Selecting this item results in a PING being sent to the SERVER address. Reply expected will be the responding IP address and status (OK/TIMEOUT/NOT RESOLVED).

This item is useful for testing connectivity. If the TReX cannot successfully PING the SERVER, it is likely that a firewall network filtering rule is preventing the connection.

***Note**: When changing IP configuration, new settings are not applied until leaving the MENU or the unit is restarted.*

AUTO RECON
The auto reconnect option provides a mechanism to reboot the TReX should a TCP CLIENT connection disappear for a specified period of time. Can be specified in steps of 60 seconds up to a max of 5 minutes. Provides RS232, visual and audible notification of the reboot.

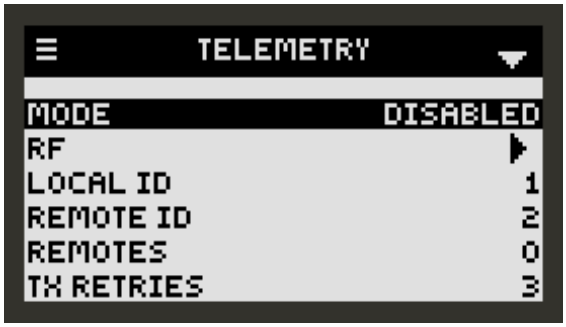
MAC
Non-editable MAC address.

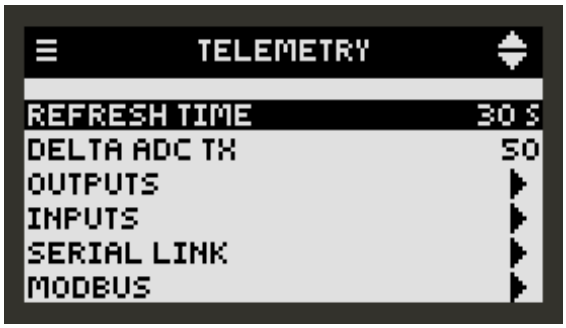
SECURITY
Configuration of TCP security settings.

SECURITY Sub-Menu

TLS
When ENABLED, the TReX will attempt to use Transport Layer Security over the TCP connection.

TELEMETRY Menu





MODE
DISABLED:
there are no autonomous transmissions.
SERIAL LINK:
Serial arriving on an enabled serial port is sent to a remote TReX unit.
IO MIRROR:
All local unit enabled inputs are mirrored to outputs of a remote device based on the IO MIRROR configuration. IO_MIRROR can only support 2 TReX units. SCADA monitoring and controlling is not possible in this MODE.
MASTER (Optional feature only):
The TReX unit can be connected via Modbus (TCP or RTU serial). This unit can then optionally report the status (and control) SLAVE TReX units.
SLAVE (Optional feature only):
The TReX can be installed in a remote location and wirelessly controlled by a MASTER. See **SCADA Configuration.**

LOCAL ID
It is possible to have many TReX units operating on the same frequency. This is the ID that the REMOTE TReX needs to use in its REMOTE ID field in order to communicate.

REMOTE ID
This is the ID of the remote device that all inputs will be sent to. When the MODE is configured to be MASTER this is the ID of the first SLAVE TReX. All SLAVEs must be consecutively numbered following this ID.

When the MODE SLAVE is used, the REMOTE_ID is configured to be the same as the LOCAL_ID (this is required by the MASTER to identify the source of the transmission).

REMOTES
This parameter is only used when the MODE is MASTER. This is the number of wireless SLAVE units that the MASTER will communicate with.

TX_RETRIES
This parameter is only used when MODE is configured to any non DISABLED state. This parameter allows for up to 9 transmission retries should a transmission not be acknowledged. When TX RETRIES is set to 0, there is only a single transmission, and no acknowledgments are used. When used in this manner, the REFRESH TIME should be set appropriately to ensure that if a transmission is not received, the TReX units in the system are eventually synchronised correctly.

INPUTS
This is a shortcut to the INPUT configuration menu.

OUTPUTS
This is a shortcut to the OUTPUT configuration menu. If the OUTPUT is DISABLED, then messages from a remote unit can NOT change the units outputs. This may be desired if the OUTPUT is already configured for another purpose such as LINK FAIL OUTPUT. Outputs to be used should be set to LATCHED.

REFRESH TIME
How long in seconds before sending all input information again. If any INPUT changes then there is an immediate transmission. The REFRESH TIME ensures that if a message is lost, the remote device will eventually resynchronise its OUTPUTS with the local device INPUTS.

DELTA ADC TX
Analog data is transmitted after each REFRESH TIME count elapses. This field allows an immediate transmission if an analog channel has changed by a certain amount since its last transmission. This is the raw ADC count that is a value up to 1023. Min value is 10 to ensure that very small changes do not result in continuous transmissions in an electrically noisy environment.

SERIAL LINK
Configuration of all SERIAL LINK Settings

MODBUS

Configuration of all MODBUS Settings

SERIAL LINK Menu

These settings allow the point to point serial transmission to be optimised. By default for a point to point serial link these items should not need changing.

TX TIMEOUT
This is the period of serial port inactivity in 10mS steps that the TReX will wait before transmitting. In this case, placing a small delay between characters will result in poor transmission efficiency.

TX CHAR
This configures a special character that can be used to mark the end of a serial message. This could be configured to be a carriage return for example (value to use is 13 for a carriage return). When any carriage return character is seen, then an immediate transmission would be forced. The TX TIMEOUT item takes priority. The value of this configuration item is the decimal value of the ASCII character. Please refer to a standard ASCII chart for decimal values for ASCII characters (1-127).

STORE FWD Menu

OPERATION
When store forward operation ENABLED the unit is used to listen to transmissions in the area, decode the messages and retransmit again to provide greater coverage than would normally be possible.

When DISABLED there is no store and forward function. The non zero value set is the delay in 100ms steps after each transmission. This delay allows time for any downstream forwarding equipment to clear the message. All messages received are immediately queued for transmission, and up to 5 messages may be retransmitted after the store forward delay.

DUPL REJECT
Setting to 0 disables the feature, otherwise this is the number of seconds to reject identical messages for up to 60 seconds. Duplicate rejection operates only on messages decoded for forwarding. This means that receiving of duplicate messages is not prevented (nor the transmission of same messages resulting from a protocol command), but when used as part of a simple store forward system re-queueing of messages can be controlled. Duplicate reject only tests the previous 10 messages in the historic transmit queue.

PLC Menu

!WARNING

UNINTENDED EQUIPMENT BEHAVIOUR

- Always ensure equipment is in a safe state prior to modifying PLC configuration, uploading or connecting to the TReX.
- Ensure risks have been considered, and mitigated by a suitably qualified person to ensure no harm to any person is possible should the PLC fail to operate, or critical input signal fail to be received.
- Programs should be carefully tested prior to being applied to any system.
- When the PLC is set to ENABLED, or controlled via input, the PLC program will automatically restart if power is cycled, or when leaving the menu. Ensure default program states always leave equipment in an initial safe state.

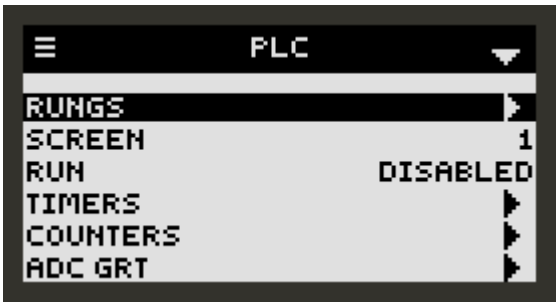
Failure to follow these instructions can result in death or serious injury

PLC configuration is performed through the **PLC** menu item from the main configuration menu.

The PLC must be stopped from running before any changes are allowed. When entering the menu, a confirm pop-up will be presented to request that the PLC is stopped before proceeding. When leaving the menu, if the PLC is in a state that would normally allow the PLC to run, the PLC will automatically begin running again.

The PLC can be configured through this menu or via commands. Commands can be issued via the serial ports, TCP connection or through direct editing of the PLC configuration file stored on the SD card. The PLC configuration file is **wte_plc.ini**, and can be edited with a standard text editor.

Note: *When the PLC program is edited through the menu, the file wte_plc.ini is regenerated. This means that any additional information in the PLC configuration file (such as comments) will be lost.*



SCREEN
The screen indicates which PLC ladder program "screen" is to be edited. Each screen on the TReX shows 6 rungs. This means that 42 screens can be edited to access all 250 rungs of the PLC program.

RUN
When DISABLED, the PLC is disabled and the PLC program is stopped from running. When ENABLED the PLC program runs normally and auto starts on TReX reset. When set to INPUT 1 to INPUT 8, the PLC will run only when that input is active (useful for a master PLC disable switch). PLC will stopped when entering the menu (after being prompted).

Note: When the PLC menu item is configured to DISABLED, the PLC active screen outside the menu is NOT visible.

LOGGING
When logging is ENABLED, Any TReX output changes are timestamped and logged to the TReX internal SD card. Please see **PLC Support** for logging details.

Ladder Program Quick-View

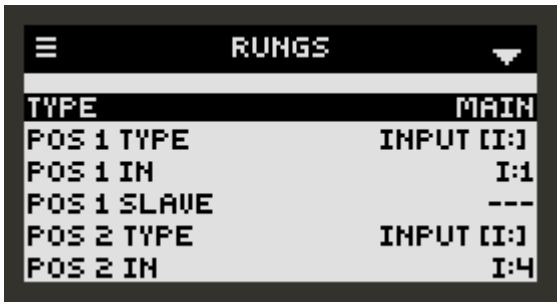
At any time from within the PLC menu items, the PLC program being edited can be viewed for correctness prior to saving.

Pressing the square ENTER button displays the current page being modified. Pressing ENTER a second time returns to the menu again, allowing further editing.

Note: The edited PLC program is not saved until leaving the menu system. Entering the "Quick-View" screen does not save the program.

RUNGS sub-menu

The rungs sub-menu is used to configure individual rungs of the ladder logic program. The top level of the sub-menu displays the configured type for each rung, either **MAIN**, **BRANCH**, or **UNUSED**. Selecting an individual branch allows for the configuration of both the individual inputs and the output of that rung if applicable.



Each **POS** entry corresponds to the input, output, timer or register bit to be used as an input, with **POS 1** referring to the number used by the first input on the rung.

Each **POS TYPE** entry is used to control the type of input used at the corresponding position in the rung. The possible types are:

- **INPUT [I:]**: Input will be active when the corresponding input of the TReX-460 is level high. Each of the following inputs are available for local and remotely accessed TReX units.
  - Inputs 1-8: refer to physical inputs.

  - Input 9: Voltage supply high/low, with hysteresis. Useful to report local and remote unit battery states.
  - Input 10: ADC1 high/low, with hysteresis.
  - Input 11: ADC2 high/low, with hysteresis.
  - Input 12: Link status, input indicates if the unit is actively receiving messages. Useful to act on remote units that are no longer communicating.
- **OUTPUT [Q]**: Input will be active when the corresponding output of the TReX-460 is closed.
- **COUNTER [CE]** (Counter Enabled): Input will be active if the corresponding counter is enabled.
- **COUNTER [CC]**(Counter Counting): Input will be active if the corresponding counter has a value greater than zero but less than the configured maximum value.
- **COUNTER [CD]** (Counter Done): Input will be active when the corresponding counter reaches it's configured maximum value.
- **TIMER [TE]** (Timer Enabled): Input will be active if the corresponding timer is enabled.
- **TIMER [TT]** (Timer Timing): Input will be active while the corresponding timer has a value greater than zero but less than the configured maximum value.
- **TIMER [TD]** (Timer Done): Input will be active when the corresponding timer reaches it's configured maximum value.
- **WORK BIT [B:]**: Input will be active if the corresponding register bit is currently set.
- **HOLD BIT [H:]**: Input will be active if the corresponding register bit is currently set. This bit is stored and will retain it's value on power reset.
- **MACRO [MD]** (Macro Done): Input will be active if the corresponding macro has been executed and not yet reset.
- **ALARM [AE]** (Alarm Enabled): Input will be active if the corresponding clock alarm timer is active.
- **COMPARATOR [G:]** (Greater Than Comparator): If the configured ADC value is greater than this comparator value, the input will be active.

Special Input Handling:
If any type is preceded by the '/' character e.g. **INPUT [/I:]** the type is logically inverted. Work bits may be used by other functions in some special cases. The PLC_MATCH command can be used to control work bits on serial input match, and WT protocol can be used so that bit 64 is controlled when a new message is received, that can be used to initiate a special program function (See **PLC Advanced Programming**).

The **TYPE** entry is used to configure the current rung as either **MAIN**, **BRANCH**, or **UNUSED**. Each **BRANCH** rung will automatically branch from the most recent **MAIN** rung and will not branch recursively if the above rung is also a **BRANCH**.

The **OUTPUT** entry is used to configure each individual rung output.

The **OUT TYPE** entry is used to configure what type of output is used. This can be configured as:

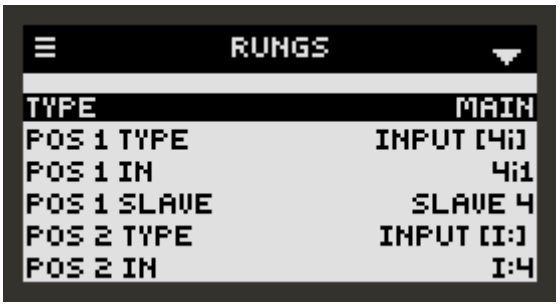
- **OUTPUT (Q:)**: Closes a specified digital output of the TReX-460 when the rung is

energised.

- **OUTPUT (SQ)**: Sets (latches) a specified digital output of the TReX-460 when the rung is energised.
- **OUTPUT (RQ)**: Resets (releases latch) of a specified digital output of the TReX-460 when the rung is energised.
- **TIMER (T:)**: Enables and starts a specified timer. If the timer type is TON or TOF, the timer will be automatically reset when the rung is de-energised.
- **TIMER (RT)**: Resets a specified timer. This resets the count and clears timer TD and TT flags.
- **COUNTER (C:)**: Enables and starts a specified counter. The counter will increment each time the rung energised.
- **COUNTER (RC)**: Resets a specified counter. This resets the count and clears the CD and CC flags.
- **WORK BIT (B:)**: Sets a specified work bit to the current output state of the rung.
- **WORK BIT (SB)**: Sets (latches) a specified work bit.
- **WORK BIT (RB)**: Resets (releases latch) of a specified work bit.
- **HOLD BIT (H:)**: Sets a specified non-volatile hold bit to the current output state of the rung. This bit retains it's value for several days after power has been removed.
- **HOLD BIT (SH)**: Sets (latches) a specified hold bit.
- **HOLD BIT (RH)**: Resets (releases latch) of a specified register bit.
- **MACRO (M:)**: Executes a macro, if found in the MACRO.TXT file stored on the SD card – used to transmit messages, or execute any TReX configuration command.
- **MACRO (RM)**: Clears the MACRO DONE (MD) flag that is set after a macro has been executed.
- **ALARM (RA)**: Normally the alarm enabled AE flag is set while a configured alarm is operating, for the duration of the alarm. The RA output resets the alarm should the alarm need disabling.

Slave Output Types:
Instead of OUTPUT types (Q:), (SQ) and (RQ), when addressing slave units the slave ID is displayed first. If the slave ID is 4, the outputs will viewed as (4**o**), (4**S**) or (4**R**)

The **POS SLAVE** entry is used to configure individual positions on the rung to use the IO of other TReX devices connected in a **SCADA** configuration. This is only applicable if the unit being configured is the **Master Unit**.



In the configuration above, for this rung:

- Position 1 is input 1 of the remote TReX slave 4.
- Position 2 is the local TReX physical input 4.
- Position 3 is the local TReX physical input 5.
- The output is the physical output 7 of remote slave 5.

The serial configuration for this rung is (assuming rung 1):
*PLC_RUNG=01:[4i1]-------[I:4]-------[-]---------(5o7)

Note: Remote devices use the character 'i' to indicate inputs, 'g' to indicate ADC comparators and 'o' to indicate outputs. The local unit uses the convention "I:" for inputs, "G:" for ADC comparators and "Q:" for outputs.

TIMERS Sub-Menu

The **TIMER** sub-menu is used to configure the maximum time or count a timer will increment to before setting it's corresponding **TD (Timer Done)** input flag. The configured value represents the time as a number of 100ms intervals. For example, a value of 0100 will result in a counter triggering after 100 increments or a timer triggering after 10 seconds. Each timer can be configured to be the type TON, TOF or RTON.

There are 32 independent timers available.

Timer Types

TON:
On Timer. TE (Time Enable) Flag is active when the rung for the timer rung output is "energised". Timer TT (Timer Timing) flag is active when counter is timing. When timer value is reached, the TD (Timer Done) flag is active, and the TT is inactive. The timer count is automatically reset at any time the rung is "de-energised".

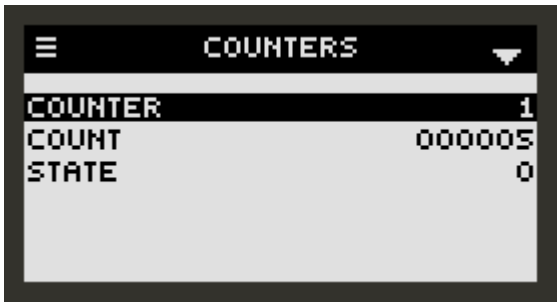
TOF:
Off Timer. Same as TON, but timer is not counting unless rung is "de-energised". Timer is auto reset when rung is energised.

RTON:
Retentive On Timer. Same as TON, but timer does not auto reset when the rung is de-energised. In order to manually reset the timer the RT output must be operated.

STATE:
The current value of the timer, and any set timer flags.

COUNTERS Sub-Menu

The **COUNTERS** sub-menu is used to configure the maximum count a counter will increment to before setting it's corresponding **CD (Counter Done)** input flag. The configured value represents the number to times that the rung needs to transition from the de-energised to energised states. For example, a value of 000005 will result in a counter CD flag being set after 5 transitions. The max count rate is 10Hz, or less depending on remote input radio data rates.



There are 16 independent counters available.

STATE:
The current value of the counter, and any set counter flags.

COMPARATOR Sub-Menu

The **COMPARATOR** sub-menu is used to configure the ADC associated with a comparator, and the ADC threshold that the ADC must exceed in order to report an active state.

COMPARATOR:
Analog Greater Than Comparator. 1-16 valid.

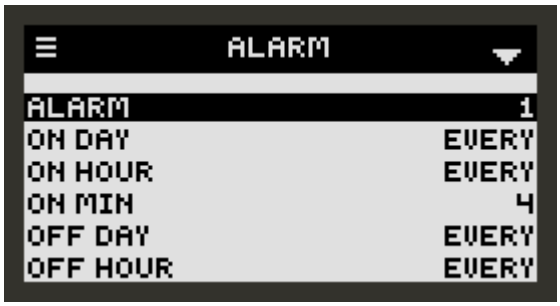
COUNT:
ADC comparison, from 0-1023.

INPUT:
The ADC to use for the comparison. This can be either ADC1 or ADC2.

There are 16 independent comparators available. Each comparator can be applied to the local MASTER TReX unit or any remote SLAVE TReX device.

ALARMS Sub-Menu

The ALARMS sub-menu allows configuring of up to 16 weekly, daily or hourly timers. These alarms operate from the set internal clock (SYSTEM->TIME). The time must already be set in order for these alarms to operate.



Once an ALARM has been selected, a day of the week, hour and minute must be specified for the alarm to turn on, and also similar parameters for when the alarm is to turn off.

If the DAY or HOUR is set to EVERY, then the alarm item is ignored, matching immediately. Using the configuration shown above, alarm 1 will turn on every hour at 4 past the hour, and will turn off 6 minutes later at 10 past the hour.

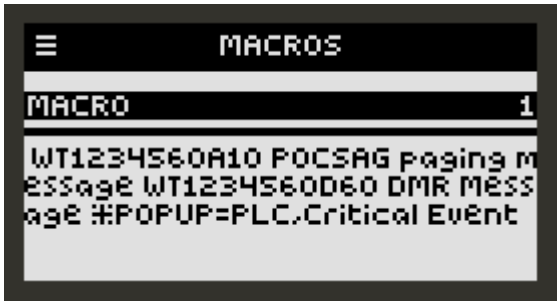
With the configuration shown below, alarm 1 will be enabled at the start of a working week on Monday, and turn off at the end of the working day on Friday. Any combination of any alarms can be used together as part of a PLC program to perform more complex timing tasks such as alarms that allow air conditioning to turn on during weekdays, but only between certain hours.


ALARM
ALARM 1
ON DAY MON
ON HOUR 8
ON MIN 0
OFF DAY FRI
OFF HOUR 5


ALARM
OFF MIN 30

MACROS Sub-Menu

The MACROS sub-menu is used to view configured macros. Editing of macros is not possible directly on the TReX.
See **PLC Support**.



There are 64 macros that can be viewed. Macros are set and edited in the file MACRO.TXT

MATCH Sub-Menu

The MATCH sub-menu is used to configure and view serial match strings. When these strings are identified as part of an incoming serial stream, the associated work bit can be set and used as part of a PLC program.

See **PLC Support**.

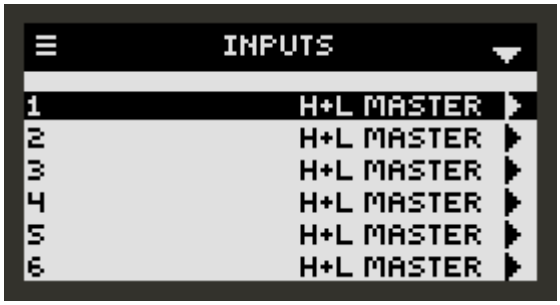
There are 4 serial match strings that can be configured.

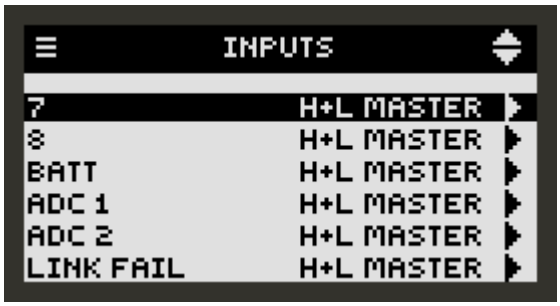
MATCH:
The serial input match string being edited (1-4)

EDIT TEXT:
Access to the text editor to allow the serial input string to be viewed and modified.

WORK BIT:
This is the associated work bit (B:1-B:64) that can be set when the input string is matched.

Inputs Menu





1-8
Configuration of messages that are transmitted when an input changes. Receiver only TReX units instead of transmitting can directly send WT protocol messages via serial ports or a TCP connection.

BATT
Treated as the 9th input. Messages transmitted when system voltage is high or low (high and low levels configurable).

ADC 1-2
Treated as inputs 10 and 11. Messages transmitted when ADC levels are above or below set thresholds. Thresholds are raw ADC counts.

LINK FAIL
Treated as input 12. The link fail count is configurable on any unit. Should any TReX fail to receive any message within this period, messages may be transmitted or this status used as a PLC program input.

ADC CAL
This manages calibration of analog inputs.

ADC CAL Sub-Menu

When the analog inputs are being read, scaling can be applied that allows the user to specify an INPUT from 0-1023 over a useful range from MIN to MAX. For example, if MIN is 200 and MAX is 400, then any analog INPUT below 200 will be SCALED to 0. Any INPUT above 400 will be SCALED to 1023. An INPUT of 300 will return a SCALED value of 512. These specified ADC values are raw ADC counts (value between 0 and 1023).

This is useful if a small voltage range is of interest, such as 1-5V instead of 0-10V. See following calibration procedure for full example.

1-2
Access to calibration items for ADC 1 and ADC 2.

MIN
This is the minimum used INPUT ADC value. If no scaling is to be applied set to 0.

MAX
This is the maximum used INPUT ADC value. If no scaling is to be applied set to 1023.

SCALED
This is a read only field that displays a value from 0-1023.

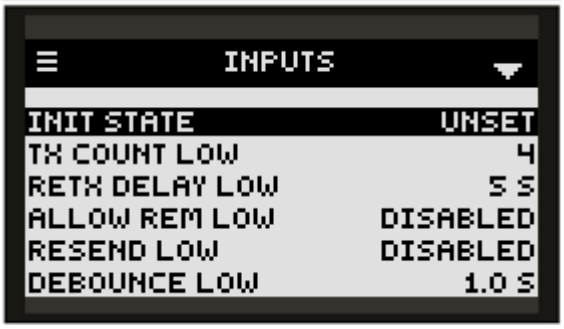
INPUT
This is a read only field that displays the raw analog input value from 0-1023. The INPUT is

not scaled.

Calibration procedure for voltage inputs:

1. Connect a voltage source (with an input resistance not more than 2 k ohm).
2. Set the voltage source to the minimum voltage that will be used.
3. Set ADC CAL->MIN to the value shown in the INPUT field.
4. Set the voltage source to the maximum voltage that will be used (up to 16V).
5. Set ADC CAL->MAX to the value shown in the INPUT field.
6. Check that when the minimum voltage is connected, the SCALED field displays close to 0.
7. Check that when the maximum voltage is connected, the SCALED field displays close to 1023.
8. Check that when a mid voltage between the maximum and minimum is connected, the SCALED field displays a mid value between 0 and 1023.
9. Exit MENU and settings will be saved.

Input Config Sub-Menu



These input configuration screens repeat for each of the 8 inputs plus the BATT and ADC inputs.

INIT STATE
Input messages are transmitted when the input changes from one state to another. On start-up the first transmitted message depends on this configuration. UNSET will ensure that there is never a transmission on start, whereas the HIGH or LOW states assume a certain start condition, so that an immediate transmission on start-up is possible.

UNSET

The input state is read on start-up. There will not be a transmission until the input changes (if configured to transmit on that HIGH or LOW level).

HIGH

The input is considered to be HIGH on start. If on start the input is read and found to be LOW, then there will be an immediate transmission (if configured to transmit).

LOW

The input is considered to be LOW on start. If on start the input is read and found to be HIGH, then there will be an immediate transmission (if configured to transmit).

TX COUNT LOW

If set to 0, then there will there will be NO transmissions when moving to the LOW state. If non-zero then this is the number of times the LOW message will be transmitted.

If there is a change of state again, then any remaining transmissions are cancelled.

When set to a non-zero TX COUNT, the input level is considered to be ENABLED, and displayed as ENABLED on the upper menu level.

ALLOW REM LOW

If ENABLED then should multiple retransmissions be configured, if the input state changes to HIGH (that would normally cancel the remaining transmissions), the remaining LOW transmissions are allowed to complete in full.

RESEND LOW

If not set to DISABLED, the interval specified is the time in seconds between repeating retransmissions. This will resend the configured LOW input level message indefinitely at this interval (Only if the input level is LOW).

RETX DELAY LOW

How long in seconds before sending the next message if set to more than 1.

DEBOUNCE LOW

How long in seconds that the input must be settled at a LOW level before transmitting

THRESH LOW

When configuring inputs 1-8, this field has no function.
On the BATT input this is the voltage that the TReX BATT input is considered to be low. A voltage below this may result in a BATT transmission if configured.

On the ADC 1 and ADC 2 inputs this is the ADC count that the TReX ADC input is considered to be low. An ADC count below this may result in an ADC input transmission if configured.

MSG LOW

The message that is transmitted when the input moves to the LOW level. Input messages must always use WT Protocol.

TX COUNT HI
If set to 0, then there will there will be NO transmissions when moving to the HIGH state. If non-zero then this is the number of times the HIGH message will be transmitted.

If there is a change of state again, then any remaining transmissions are cancelled.

When set to a non-zero TX COUNT, the input level is considered to be ENABLED, and displayed as ENABLED on the upper menu level.

ALLOW REM HI
If ENABLED then should multiple retransmissions be configured, if the input state changes to LOW (that would normally cancel the remaining transmissions), the remaining HIGH transmissions are allowed to complete in full.

RESEND HI
If not set to DISABLED, the interval specified is the time in seconds between repeating retransmissions. This will resend the configured HIGH input level message indefinitely at this interval (Only if the input level is HIGH).

RETX DELAY HI
How long in seconds before sending the next message if set to more than 1.

DEBOUNCE HI
How long in seconds that the input must be settled at a HIGH level before transmitting

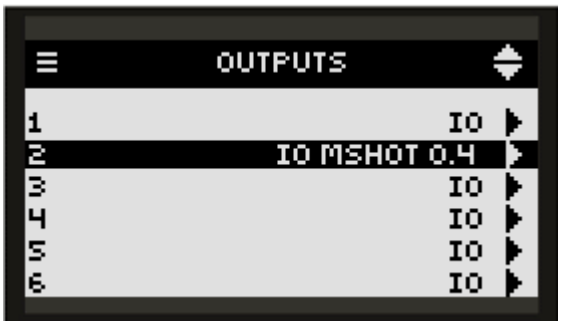
THRESH HI
When configuring inputs 1-8, this field has no function.
On the BATT input this is the voltage that the TReX BATT input is considered to be high. A voltage above this may result in a BATT transmission if configured.

On the ADC 1 and ADC 2 inputs this is the ADC count that the TReX ADC input is considered to be HIGH. An ADC count above this may result in an ADC input transmission if configured.

Note: The BATT input threshold settings are also used to set the battery icon on the main screens.

MSG HI
The message that is transmitted when the input moves to the HIGH level. Input messages must always use WT Protocol.

Outputs Menu

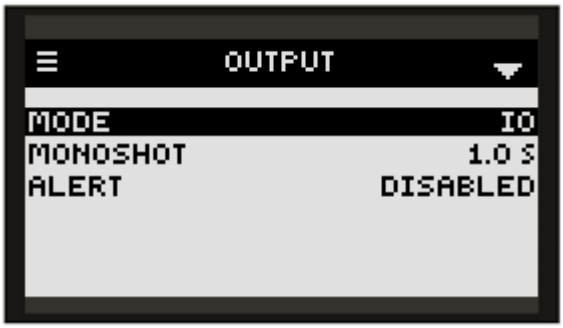


1-8
The output to configure. If the output has been configured for general output control through telemetry or messaging the output must be configured to IO or MSHOT. In order to set to IO or MSHOT the output MODE must be set to **IO** in the Output Config Sub-Menu.

Note: Care must be taken when assigning an output to more than one function (setting ALERTS->ALERT OUT to a used IO output) as the behaviour of the output can be difficult to predict or determine the trigger for the output change. In general, assignment of an output to more than one function is not recommended.

DAC CAL
Configures calibration of analog output 1 and 2. See DAC CAL Sub-Menu.

Output Config Sub-Menu



MODE
When set to IO the output can be controlled through TELEMETRY settings or through output control messages that may be received. Setting to IO will show the output to be configured to either IO or IO MSHOT depending on the MSHOT setting.

On start outputs are ALWAYS LOW. After the expiration of any MONOSHOT period for an output, the OUTPUT will return to the LOW state.

When RIC RANGE X, then the output is configured to close, either LATCHED or MSHOT when a message is received with a RIC within that RANGE. RIC RANGE N controls OUTPUT N.

MONOSHOT
If LATCHED or RIC RANGE the output will remain in the set state until another message is received to change the state. If set to a time, then after receiving a message to operate HIGH the output will return to a LOW state after this period of time has passed.

ALERT
If ENABLED, the output is able to generate an ALERT when operated. See **Alert Handling**.

DAC CAL Sub-Menu

Analog outputs can be configured to operate as constant voltage or constant current. This makes the outputs suitable for outputs such as 0-10V or 4-20mA.
The analog output is current limited internally at approx 35mA. DAC Output impedance is 5 ohms.

MODE set to VOLTAGE:
Ensure that the wiring SERIES impedance is as low as possible. There will be a voltage drop across any series resistance that will affect the output voltage. How much the output will vary will depend on the load of the connected equipment. This load resistance preferably should not be less than 2k ohms.

MODE set to CURRENT:
Ensure that the full loop impedance is less than 500 ohms and at least 100 ohms. Add a small series resistor if required since the internal series resistance is only 5 ohms.

When the analog outputs are being controlled, scaling can be applied that allows the user to specify an OUTPUT from 0-1023 over a useful range from MIN to MAX. For example, if MIN is 200 and MAX is 400, then setting the analog output to a SET value of 1023 will in fact set the OUTPUT to the MAX value of 400. SET configured to 0 will set the OUTPUT to the MIN value of 200. A SET value of 512 will set the OUTPUT to a value of 300. See following calibration procedure for full example.

MIN
This is the minimum used unscaled DAC count of interest. If no scaling is to be applied set to 0.

MAX
This is the maximum used unscaled DAC count of interest. If no scaling is to be applied set to 1023.

SET
This sets the output as a value between 0-1023 that is scaled and applied between the MIN and

MAX OUTPUT values. Regardless of the MIN and MAX settings, the full control range of 0-1023 can be used. This is a test parameter only, useful for calibration. This is the value that the user would send to the TReX in order to control the outputs.

OUTPUT
This is a read only field showing the current flowing and unscaled raw output. This value will sit between MIN and MAX.

MODE
Sets either constant VOLTAGE or CURRENT mode. When in VOLTAGE mode the output is fixed depending on the output set value. This mode is used for outputs such as 1-10V, 1-5V or any other voltage as configured. When in CURRENT mode the set value is the desired current that is to be maintained. This is used for outputs such as 4-20mA, 0-20mA or any other current up to 30mA as configured.

CAL mA
This how much to adjust the output current sense to read correctly. This field has no function when the MODE is set to VOLTAGE. This must be set by connecting an ammeter through a small series resistor such as 100 ohms. This setting would then be adjusted until the reading is the same as the reading from the ammeter.

Calibration Procedure for Voltage Output

1. Connect load (a resistance not less than 2 k ohm).
2. Set DAC output to 0 using the DAC->OUT parameter.
3. Alter DAC->MIN until the low limit output can be obtained.
4. Set DAC output to 1023 (maximum) using DAC->OUT
5. Alter DAC->MAX until the high limit output has been set. The output voltage does not vary with power supply, but the maximum output IS based on the TReX input supply voltage. Typically with a supply voltage of 12V the DAC max output is 10.0V.
6. Exit MENU and settings will be saved.

Calibration Procedure for 4-20mA Current Output

1. Connect load with ammeter in series through a 100R resistor.
2. Set DAC->MIN to 117 and DAC->MAX to 583
3. Set DAC output to 0
4. Adjust DAC->MIN until output current is approximately 4mA.
5. Set DAC output to 1023
6. Adjust DAC->MAX until output current is approximately 20mA.
7. Exit MENU and settings will be saved.

Alerts Menu

See **Alert Handling** for more information.

MSG
When ENABLED, an alert will be raised when any message is received. If the MSG FILT menu option is ENABLED, locally stored MSG.TXT file is searched and the alert is operated ONLY if a keyword in the MSG.TXT file is found in an incoming message. See **MESSAGE FILTER**.

BUSY
When ENABLED, an alert will be raised when receive channel is BUSY (when the signal strength on the channel exceeds the RX BUSY LEVEL).

LINK FAIL
When ENABLED, an alert will be raised when the RX LINK FAIL time is exceeded between received messages.
Typically the LINK FAIL output would be used in conjunction with a known periodic message from another transmitter.

TEMP
When ENABLED, an alert will be raised when the TReX has reached the max temperature. The max temperature is set in MENU->SYSTEM->OVERTEMP. This is the TReX board

operating temperature and NOT the ambient temperature.

MAINS FAIL
When ENABLED, an alert will be raised when a MAINS FAIL event has been detected.

Alert is raised when "MAINS FAIL" is seen in the payload of an input message. Alert is cleared when "MAINS RESTORED" is seen in another input message. A typical application for this is to connect a plug pack to provide a voltage source to an input. The input HIGH and LOW messages would be configured with "WT0000000A10 MAINS_FAIL" and "WT0000000A10 MAINS_RESTORED".

RF ERROR
When ENABLED, an alert will be raised when an RF ERROR has been detected.

Alert is raised when there an antenna mismatch or low power condition at the beginning of a transmission.

BATT
When ENABLED, an alert will be raised when low BATT voltage has been detected.

Alert is raised when the system voltage is below the minimum BATT input voltage threshold.

ALERT REPEAT
When DISABLED and SYSTEM->SOUND is ENABLED an alert will result in a single audible indication. This is the seconds between repeated alert beeps that will repeat until the alert has been acknowledged either by pressing the ENTER button, cycling power or auto-clearing as described in **Alert Handling**.

ALERT OUT
When set to an output from 1-8, this is the output that can be operated when ANY alert is raised.

SOUND
Enables sound for alerts and key presses.

Serial Command Configuration

Most items that can be changed via the MENU can also be changed through serial commands. There are some additional commands that make the TReX more usable when being managed via a serial connection. These are listed immediately below.

These commands must begin with the character '*' and are processed with a carriage return character. Any characters before the '*' may result in the command not being processed.

Main Commands

*REBOOT

Forces the unit to immediately restart.

Usage:

**REBOOT<CR>*

*CONFIG

Displays current configuration.

Usage:

**CONFIG<CR>*

*SAVE

Saves all configuration settings (all configuration changes are restored on start-up).

Usage:

**SAVE <CR>*

*LIST

Displays all available commands. This command also lists many specific field names that need to be used with listed commands.

Usage:

**LIST<CR>*

*DEFAULTS

Forces to reset temporary to factory default settings. The user must issue the **SAVE<CR>* command in order to write these default settings to internal memory.

Usage:

**DEFAULTS<CR>*

*RSSI

Returns the receiver signal strength in -dBm. (returns between 0 and -130).

Usage:

**RSSI<CR>*

*USERPASS

Sets the web and TCP user and password. User must be at least 3 letters and password must be at least 4 letters. These credentials are requested for each new web and TCP connection.

Typical usage:

**USERPASS=admin:TReX<CR>*

When prompted for a login when using a TCP connection (not through web browser), login with the full user and password together.

e.g. in response to "login:"

enter

"admin:TReX"

The TReX will immediately report if successfully logged in.

To completely disable all web and TCP connection user and passwords, enter

USERPASS=none:none**<CR>*

**SAVE<CR>*

*By default the user and password is set to "**none:none**"*

*IO

Returns all input and output states.

Typical usage:

**IO<CR>*

Typical output:

IO=I:01000000--- O:00000000 ADC:257,252 DAC:0,0

In this typical output, there are 11 inputs shown. First 8 are the digital inputs. The 9th input is 1 or 0 based on battery high/low thresholds set. Inputs 10 and 11 are ADCs, again displayed as 1 or 0 based on set thresholds. The '-' is shown when the input level is unknown, such as when an input is between the high and low configured thresholds. Output states for all 8 outputs follow, then ADC inputs 1 and 2 and finally the current DAC settings.

*TEMP

Returns temperature of first the digital board, then the RF temperature sensor. This is NOT the ambient temperature. Temperatures in excess of 100 degrees C are completely normal under typical transmitting operation.

Usage:

**TEMP<CR>*

Typical output:

TEMP=DIG:55.0C RF:60.1C

*PWR

Returns current forward power ADC count and system current both at the time of reading and recorded during the last transmission.

Usage:

**PWR<CR>*

Typical output:

**PWR=500,34,160,0.28,1.23*

The first parameter is the forward power ADC count at the time of reading. The second value is the forward power recorded during the last message transmission. Parameter 3 is the RF output drive value used to achieve the ADC count. Parameter 4 is the system current. Parameter 5 is the system current recorded during the last message transmission.

*VER

Sends the TReX sign on message back to the user. This is useful to determine the model and serial number of the unit.

Usage:

**VER<CR>*

*RTC_DATE

Sets the TReX clock date. Format is DD/MM/YY,W

Where:

DD is day of the month (1-31)

MM is the month (1-12)

YY is the year (0-99)

W is optional day of the week, MON-SUN (1-7)

Typical Usage:

**RTC_DATE=7/12/22,3<CR>*

*RTC_TIME

Sets the TReX clock time. Format is HH:MM:SS

Where:

HH is the hour (0-23)

MM is the minute (0-59)

SS is the second (0-59)

Typical Usage:

**RTC_TIME=12:34:30<CR>*

*ENCRYPT

Returns an encrypted message, having applied the RF_KEY encryption options. This command is used to generate an encrypted message that can be provided to a paging service provider. Max input message length is 200 characters.

Usage:

**ENCRYPT=XXXX<CR>*

where:

XXXX is any message to encrypt.

Typical Usage:

**ENCRYPT=Test Message<CR>*

Typical Output:

[031C9316]<CR><LF>

m3@W?Z8ZZG0``W9XL=0[4P0

Note: line 1 is a unique incrementing hexadecimal ticket number, line 2 is the actual encrypted message that can be provided to a paging service provider.

*BYPASS

This a command that is useful for test and special serial control cases. This command specifies a RIC code and beep level that allows processing as if arriving from the receiver. In order for the message (in the case below "Test Message") to arrive as a message, a RIC range must be configured in the TReX to suit.

**BYPASS=[NNNNNNN:L]MMMMMMMM<CR>*

where:

[is the character '['

NNNNNNN are 7 digits specifying the RIC code to be used for the message
: is the character ':'
L is beep level for the message to be processed from 0-3.
] is the character ']'
MMMMMM is the payload of the message to be processed.

Typical Usage 1:

**BYPASS=[1234567:1]Test Message<CR>*

"Test Message" will be added to the RX message screens, logged etc, as if received across the air.

Typical Usage 2:

**BYPASS=[1234567:1][[01]12345-8]<CR>*

"[[01]12345-8]" will be added to the RX message screens, logged etc., as if received across the air. In this case, the message will also be processed as a **WTE Output Protocol** message and immediately operate the TReX outputs.

*LAB

Set the unit in transmit mode, it can be configured to transmit carrier only or modulated. This feature together with the *RSSI command are useful when antenna alignment is necessary.

*LAB syntax:

**LAB=x,y<CR>*

Where:

x is used to enable (1) or disable (0) the carrier; Setting to 2 enables random modulation for the configured transmit modulation.

y is the time in seconds which the TReX will be transmitting for.

Typical usage:

**LAB=1,10<CR>*

Note: *LAB=1<CR> can be used, as it will enable carrier for 60 seconds

*POPUP

This a command that is useful for test and special cases. This command specifies content will be displayed as a popup on the screen. This is most useful for the displaying of PLC events in conjunction with PLC Macros.

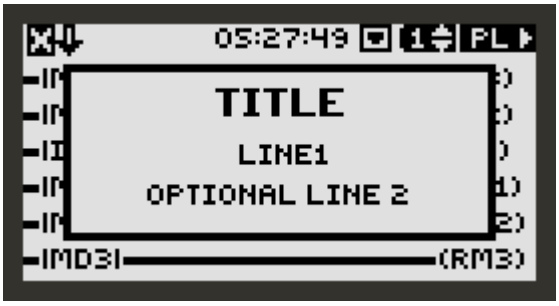
**POPUP=TITLE, LINE1,LINE2<CR>*

where:

TITLE is a popup title to display. Max 15 characters.

LINE1 is the content to display on the first content line. Max 20 characters.

LINE2 is optional, the content to display on the second content line. Max 20 characters.



Transmit Commands

*TX_FREQ

Specifies the transmit frequency in Hz. For the TReX-460 the minimum is 421000000 and maximum is 480000000.

Typical usage:

**TX_FREQ=460000000<CR>*

*TX_PROTO

Specifies the protocol to apply for serial input. Accepts WTE, RAW and AUX.

Typical usage:

**TX_PROTO=WTE<CR>*

Note: See protocol section for more details on protocols and configuration.

*TX_BAUD

Specifies the baud rate of the transmitter when using a protocol that does not permit a baud rate to be specified.

Accepts: 512_25, 512_12, 512_6, 1200_25, 1200_12, 1200_6, 1600_25, 2400_25, 2400_12, 2400_6, 4800_25, 4800_12, 4800-4L_6, 9600_25, 9600-4L_25, 9600-4L_12, 16K-4L_25, 16K-4L_12, 32K-4L_25

Typical usage:

**TX_BAUD=512_25<CR>*

Note: This product has been certified for use in multiple markets. The modulation 32K-4L_25 is compliant under FCC only – it is the responsibility of the user to ensure that this modulation is used in the application territories only.

*TX_PWR

Specifies the output power of the transmitter. Also allows the high power load matching method to be specified.

Syntax:

**TX_PWR=A,B<CR>*

Where:

- A is 250MW, 500MW, 1W, 2W, 4W
- B (optional) is 0 if current sense is primarily used for power setting at 4W (default) or 1 if ADC power sense is primarily used. Default method is more tolerant to load

mismatching, but less capable of detecting and reporting mismatch errors. When the RF fault output is being used for antenna mismatch detection, this option is ignored and the ADC sense method is applied.

Typical usage:

**TX_PWR=4W,0<CR>*

Note: It is the responsibility of the user to ensure that a power level is selected that is compliant with the frequency and region of use.

*TX_MODE

Specifies the transport method of the transmitter (how the information is transmitted over the air).

- POCSAG_A must be used in order to transmit alphanumeric messages.
- POCSAG_N must be used in order to transmit numeric messages.
- POCSAG_T should be used in order to transmit tone only messages ("TONE" displayed on screen for message payload, but not actually transmitted or received).
- WTE_EN must be used in order to transmit 8 bit characters (POCSAG_A transmits 7 bit characters only).

Accepts POCSAG_A, POCSAG_N, POCSAG_T and WTE_EN.

Typical usage:

**TX_MODE=POCSAG_A<CR>*

*TX_LEVEL

Specifies the default level of messages transmitted. This is sometimes referred to as "Beep Level". This is a value 0-9, however, when POCSAG is the transport method, only 0-3 will be used.

Typical usage:

**TX_LEVEL=3<CR>*

*TX_CAP

Specifies the default code used to identify transmissions (same as the RIC code). A list of up to 9 codes can be specified.

The TX_CAP code would be used when a protocol supplied code is to be overridden, and sent to a single or multiple other recipients instead.

TX_CAP syntax:

**TX_CAP=X:nnnnnnn<CR>*

Where:

X, is the input range index from 1 to 9

nnnnnnn, This code can be any number between 8 and 2000000.

Typical usage:

**TX_CAP=1:1324560<CR>*

*TX_DMR

Specifies a list of DMR group IDs that messages will be sent to. All entries in this list require the colour code, radio type and transmit frequency to be specified in the DMR_DB command. The TX_DMR code would be used when a protocol supplied code is to be overridden, and sent to a single or multiple other recipients instead. This DMR recipient list is only for use with group IDs. Should a single radio need to be addressed, a group should be created with only a single user.

TX_DMR syntax:

**TX_DMR=X:nnnnnnn<CR>*

Where:

X, is the input range index from 1 to 9

nnnnnnn, This code can be any number between 8 and 2000000.

Typical usage:

**TX_DMR=1:1324560<CR>*

*TX_PERIODIC

Allows a periodic message to be transmitted. This could be used as a "heartbeat" to confirm that the system is continuing to operate as expected. WT protocol must be used for the periodic message.

**TX_PERIODIC=TT,MMMM<CR>*

where:

TT is the time in seconds between transmissions (0-255. 0 disables the feature).

MMMM is the periodic message to transmit (up to 50 characters).

Typical usage:

**TX_PERIODIC=10,WT1234560A10 Test_Message<CR>*

*TX_PREAMBLE

Sets the preamble length in multiples of 32 bits.

Short preambles allows the messages to be transmitted quickly.

Long preambles are typically used in conjunction with a matching receiver to save battery power when the receivers is in deep sleep mode.

The POCSAG standard uses a setting of 18 (576 bits – configured in steps of 32). This very long preamble means that paging receivers need only to wake briefly once per second (at 512 baud) in order to check for an incoming message. If the receiver is always powered and receiving, then much shorter preambles can be used, and in some cases halve the channel activity. When the TReX is used as transmitter and receiver at both ends of the link, a setting of 2 (64 bits) will work equally well.

Typical usage:

*TX_PREAMBLE=18<*CR*>

*TX_LEAD

Sets the transmit lead-in and lead-out time in multiples of 10ms.

Some receivers require time to settle when a transmitter is keyed up. The command allows the lead-in and lead-out times to be set.

**TX_LEAD=II,OO<CR>*

where:

II is the lead-in time. This is the duration after the carrier is applied BEFORE data is transmitted. Default is 0, max is 50 (500ms).

OO is the lead-out time. This is the duration AFTER data is transmitted that the carrier is applied before keying down the transmitter. Default is 0, max is 50 (500ms).

Typical usage:

TX_*LEAD=5,5<*CR*>

*TX_LOG

Enables logging of transmitted messages to the file TX-LOG.TXT. If set to 0, disables logging, 1 enables logging, and 2 deletes the log file.

Typical usage:

**TX_LOG=0<CR>*

*TX_REPEAT

Sets the number of repeated transmissions from all serial protocols. A delay can be configured between each transmission. Configuration if this item DOES NOT affect messaging from inputs, the periodic timer or any store and forward function. If the RIC_DB or DMR_DB has been configured, the repeated transmission will result in ALL entries in the databases being used for retransmitted messages.

**TX_REPEAT=A,BB<CR>*

where:

A is the number of repeated transmissions. Max 5. Default 0.

BB is the delay in seconds between repeated transmissions. Max 60, min 1.

Typical usage:

*TX_REPEAT=3,10<*CR*>

*RF_KEY

Sets RF link encryption key details, including the 32 or 64 character AES keys and encryption options. This command must be used in order to set the used key, and is not available through the menu. Once the key is set, resetting to factory defaults will NOT clear the key.

**RF_KEY=A,B,C,DDDD<CR>*

where:

A is 1 when encryption is enabled for RF links.

B is 0 for AES 128-bit encryption, or 1 for AES 256-bit encryption.

C is 1 when rejection is enabled for repeated or older messages.

CCCC is the shared 128 or 256 bit key. This is a random hex sequence that must be 32 or 64 hexadecimal characters in length. All TReX devices in a system must share this key.

Typical usage:

*RF_KEY=1,1,1,452948404D635166546A576E5A7234753777217A25432A462D4A614E64526755 <CR>

*RF_KEY?

Typical response:

*RF_KEY=1,1,1,-4529****

Note: only the first 4 characters of the key are displayed.

Receive Commands

*RX_ENABLE

Allows the receiver to be disabled to save power if required. Set to 0 to set to SIMPLEX. Use 1 for DUPLEX operation (may be set to different frequency than the transmitter), 2 for RX DISABLED operation. Set to 3 for TX DISABLED operation.

Typical usage:

**RX_ENABLE=0<CR>*

*RX_FREQ

Specifies the receive frequency in Hz (range limited to the variant of product).

Typical usage:

**RX_FREQ=160000000<CR>*

*RX_BAUD

Specifies the baud rate of the receiver.

Accepts: 512_25, 512_12, 512_6, 1200_25, 1200_12, 1200_6, 1600_25, 2400_25, 2400_12, 2400_6, 4800_25, 4800_12, 4800-4L_6, 9600_25, 9600-4L_25, 9600-4L_12, 16K-4L_25, 16K-4L_12, 32K-4L_25

Typical usage:

**RX_BAUD=512_25<CR>*

*RX_PROTO

Specifies the protocol to apply for serial output, accepts WTE, RAW and AUX. See protocol section for more detail on protocols and configuration.

Typical usage:

**RX_PROTO=WTE<CR>*

*RX_MODE

Specifies the transport method of the receiver (how the information is received over the air).

- POCSAG_A must be used in order to receive alphanumeric messages.
- POCSAG_N must be used in order to receive numeric messages.
- WTE_EN must be used in order to receive 8 bit characters (POCSAG_A transmits 7 bit characters only).

Accepts POCSAG_A, POCSAG_N, WTE_EN and FLEX.

Typical usage:

**RX_MODE=POCSAG_A<CR>*

*RX_RANGE

Specifies up to 8 CAP RX ranges for decoding. Messages received with CAP codes not within the RX_RANGE will be discarded by the receiver.

CAP codes should not fall within multiple ranges. If an output has been configured to operate on a range match, a second output configured for another range with the same CAP code will not operate.

*RX_RANGE=N:LLLLLLL,HHHHHHH (where N is the range between 1 and 8, LLLLLLL is the lowest cap code to match, HHHHHHH is the highest).

Typical usage:

**RX_RANGE=1:8,200<CR>*

*RX_BUSY

Enables the BUSY alert and channel busy level for the configured channel.

*RX_BUSY=A,BB,CC

Where:

A Enables the BUSY alert (0-1)

BB is the signal level from 0 to -130 (in dBm).

CC is the max duration in seconds that the channel may be “busy” before transmitting regardless of channel activity. Max is 100 seconds.

In this example the channel will be considered “busy” if signal strength is above -80dBm.

Typical usage:

**RX_BUSY=1,-80,5<CR>*

Note: If the TReX continually reports BUSY, issue the command **RSSI<CR>* to view the current noise floor and adjust the busy level appropriately.

*RX_LINK

Enables the LINK FAIL alert and timeout period.

*RX_LINK=A,BB

Where:

A Enables the LINK FAIL alert (0-1)

BB is the period in seconds in which a message should be received within.

Typical usage:

**RX_LINK=1,120<CR>*

*RX_LOG

Enables logging of received messages to the file RX-LOG.TXT. If set to 0, disables logging, 1 enables logging, and 2 deletes the log file.

Typical usage:

**RX_LOG=0<CR>*

Store Forward Commands

Store forward operation is when the unit is used to listen to transmissions in the area, decode the messages and retransmit again to provide greater coverage than would normally be possible.

> **Note:** In order to forward messages the decoded message CAP codes must fall within the configured CAP ranges.

*STORE_FWD

Configures the store forward operation, this command uses 2 parameters as follows:

**STORE_FWD=XX,YY<CR>*

Where:
XX is the **Store Forward Operation**
YY is the **Duplicate Reject Operation**

Store Forward Operation:
Setting to 0 disables the feature. The non zero value set is the delay in 100ms steps after each transmission. This delay allows time for any downstream forwarding equipment to clear the message. Max store forward delay is 24 seconds. All messages are immediately queued for transmission, and up to 5 messages may be retransmitted after the store forward delay.

Duplicate Reject Operation:
Setting to 0 disables the feature, otherwise this is the number of seconds to reject identical messages for up to 240 seconds. Duplicate rejection operates only on messages decoded for forwarding. This means that receiving of duplicate messages is not prevented (nor the transmission of same messages resulting from a protocol command), but when used as part of a simple store forward system re-queueing of messages can be controlled. Duplicate reject only tests the previous 5 messages in the historic transmit queue.

For example, to configure to use a 2 second clearing delay after each transmission and 10 second message duplicate reject:

**STORE_FWD=20,10<CR>*

Protocol Commands

*SENT_RESP

Configures the response sent out the serial port at the completion of each transmitted message. Considering the transmitted message: WT1234560A10 Test\r

Set the serial output to the default WT[xxx] as defined by WT Protocol.

**SENT_RESP=<CR>*

typical response:

WT[090,017]

Set the serial output to "Page Sent"

**SENT_RESP=PAGE SENT<CR>*

typical response:

Page Sent

Set the serial output to payload of transmitted message

**SENT_RESP=*<CR>*

typical response:

Test

Set the serial output to the full sent message

SENT_RESP=<CR>*

typical response:

WT1234560A10 Test

If the command WT1234560A11 TEST is sent to the TReX, the serial output will echo the full WT protocol command including the message payload.

*MQTT_CONFIG

Configures parameters used by the MQTT protocol and some general IP configuration items.

**MQTT_CONFIG=USER,PASS,MQTT_CLLIENT,A,B,C,D,E<CR>*

Where:

USER is the TCP user password that can be used over a secure connection (or without security).

PASS is the TCP user password if used.

MQTT_CLIENT is a unique ID used by an MQTT server (set to the TReX serial number by default).

A is the MQTT quality of service (either 0, 1 or 2).

B is set to 1 if TLS security is enabled.

C is set to 0 if all TReX MQTT topics are published periodically, set to 1 if topics are only published when they change.

D is set to 1 if all published topics are to have the "retain" flag set.

E is the time (in seconds, ranged 30 - 600) between republishing of topics.

*PROTO_OPTS

This command is used for customer-specific protocol implementations. Please contact info@wte.co.nz for more details. It is not recommended to use this command unless instructed to do so by WTE Ltd.

Input Commands

The input commands allow messages to be configured for transmission when changing state. Debouncing (how long an input is settled before acting on the new level) can be configured with the number of times to transmit the input message. Periodic retransmissions of all messages for latched input states are possible at independent intervals.

Note: Even if an input is configured to transmit a certain number of messages, should the input level change before all messages are transmitted, then the remaining transmissions will be cancelled. Should this behaviour not be required, modify the "Allow remaining input transmissions" option.

Please refer to **Input Output Hardware Connection** section on this manual for examples of how to connect the input and output pins on the TReX.

Also refer to **Input Handling** for more information and applications such as controlling outputs from input messages.

*IN_INIT

Specifies the expected initial logic level for each input on start. Input messages are transmitted when the input changes from one state to another. On start-up the first transmitted message depends on this configuration. Setting an input to a value of 2 will ensure that there is never a transmission on start, whereas setting to 0 (low) will result in an immediate transmission on start if the input is 1 (high). Setting to 1 will result in an immediate transmission on start of the input is 0 (low).

*IN_INIT=I:S<*CR*>

Where:

I = The input to configure (1-11 valid). Input 9 is the VIN input, 10 is ADC 1 and 11 is ADC 2.

: = the colon character ':'

S = The expected start level required for no start transmission (0,1 or 2)

Typical usage:

**IN_INIT=1:2<CR>*

*IN_CONFIG_L

Specifies all input Low configuration parameters. Inputs are triggered by connecting the input to ground for a time exceeding the specified debounce period. The input message is configured using the ***IN_MSG_L** command. Usage is as follows:

*IN_CONFIG_L=I:N,D,R,A,L<*CR*>

Where:

I = The input to configure (1-11 valid). Input 9 is the VIN input, 10 is ADC 1 and 11 is

ADC 2.

: = the colon character ':'

N = number of transmissions (0 = no transmissions, 9 is max tx count)

, = the comma character ','

D = debounce in 100 ms steps (from 0-255)

R = time in seconds between retransmissions.

A = Allow remaining input transmission on state change (1 = Allow). If 0 then all remaining transmissions will be cancelled on any debounced state change.

L = Latched resend interval. This is a period from 0 – 255 (0 is disabled). Should the input be latched (for an L input is when the input is low, for a H input, is when the input is high). At this repeating interval, if non-zero, a there will be another single transmission.

Example. Configure input 1 to send 2 messages after input is debounced by 300 milliseconds and repeated with 5 seconds between transmissions. Any remaining messages to transmit are cancelled if the state changes again to high before all transmissions are complete. The messages are not retransmitted periodically.

Typical usage:

**IN_CONFIG_L=1:2,3,5,0,0<CR>*

*IN_CONFIG_H

Specifies all input High configuration parameters. Inputs are triggered by moving the input to a high state or released from GND for a time exceeding the specified debounce period. The input message is configured using the ***IN_MSG_H** command. Usage is as follows:

*IN_CONFIG_H=I:N,D,R,A,L<*CR*>

Where:

I = The input to configure (1-11 valid). Input 9 is the VIN input, 10 is ADC 1 and 11 is ADC 2.

: = the colon character ':'

N = number of transmissions (0 = no transmissions, 9 is max tx count)

, = the comma character ','

D = debounce in 100 ms steps (from 0-255)

R = time in seconds between retransmissions.

A = Allow remaining input transmission on state change (1 = Allow). If 0 then all remaining transmissions will be cancelled on any debounced state change.

L = Latched resend interval. This is a period from 0 – 255 (0 is disabled). Should the input be latched (for an L input is when the input is low, for a H input, is when the input is high). At this repeating interval, if non-zero, a there will be another single transmission.

Example. Configure input 1 to send 2 messages after input is debounced by 300 milliseconds

and repeated with 5 seconds between transmissions. Any remaining messages to transmit are cancelled if the state changes again to low before all transmissions are complete. The messages are not retransmitted periodically.

Typical usage:

**IN_CONFIG_H=1:2,3,5,0,0<CR>*

*IN_MSG_L

Specifies the low level message that will be transmitted if configured. Input messages must always use WT Protocol.

Typical usage: .

**IN_MSG_L=1:WT1234560A10 IN_1_LOW<CR>*

*IN_MSG_H

Specifies the high level message that will be transmitted if configured. Input messages must always use WT Protocol.

Typical usage:

**IN_MSG_H=1:WT1234560A10 IN_1_HIGH<CR>*

*IN_ANALOG

Specifies the high and low ADC count thresholds for an analog input to be considered a digital HIGH or digital LOW. When these thresholds are exceeded, then programmed messages for HIGH and LOW levels can be transmitted. All ADC counts are the SCALED ADC counts.

*IN_ANALOG=1H,1L,2H,2L,3H,3L<*CR*>

Where:

1H = Input voltage high (x10)

1L = Input voltage low (x10)

2H = ADC1 voltage high ADC count

2L = ADC1 voltage low ADC count

3H = ADC2 voltage high ADC count

3L = ADC2 voltage low ADC count

Typical usage:

**IN_ANALOG=138,114,200,100,500,400<CR>*

Output Commands

The output commands allow the GPIO pins to be configured as outputs or inputs. Following configuration of the pins as outputs, they are controlled using the **WTE Output Control Protocol**.

> **Note:** Please refer to **Input Output Hardware Connection** section on this manual for examples of how to connect the input and output pins on the TReX board.

*OUT_CONFIG

Specifies all output configuration items, usage as follows:

*OUT_CONFIG=O:E,T <*CR*>

Where:

O = The output to configure (1-8 valid)

: = the character ':'

E = IO enabled mode (0 is DISABLED, 1 is ENABLED, 2 assigns output to close on a RIC RANGE match). When DISABLED, the output can still be used by the alert output.

T = time for output to close for in 100ms steps. E.g. 100 is 10 seconds. Max value is 32000. Setting to 0 disables the timer and output is latched indefinitely.

Typical usage:

**OUT_CONFIG_L=1:1,10<CR>*

*OUT_OPTS

Specifies the format used for the WTE Output Control Protocol, specifically the type of brackets used e.g. an output command could either be "[[01]1]" or "((01)1)". Usage as follows:

*OUT_OPTS=X<*CR*>

Where:

X = Format to use, 0 uses '[' and ']' characters, 1 uses '(' and ')' characters.

*UNIT_ID

Specifies the output unit ID. The unit ID is also used to identify DMR transmissions. If set to 0, DMR transmissions use the unit serial number as the DMR ID, if the unit ID is set, the DMR ID will assume this value.

*UNIT_ID=XX<CR>

where:

> XX are any characters (up to 12 either numeric or alphanumeric) that are used to uniquely address each TReX when used in conjunction with the **WTE Output Control Protocol**. By default this ID is "01", allowing numeric paging to be used to transmit messages.

Typical usage:

> **UNIT_ID=Unit-A<CR>*

Mismatch Commands

Commands relating to the configuration of the MISMATCH feature. This feature is best operated from within the MENU (see MISMATCH Sub-Menu for further details).

When an antenna is missing, damaged or mismatched, the following may be observed; The current may increase/decrease and the RF power detected may increase/decrease through reflection. Should any of these be detected, the mismatch output can be configured to operate.

*MISMATCH_CAL

After sending this command the transmitter will calibrate on the next transmission.

When calibration is complete the transmitter will return "CAL DONE" and calibration threshold figures to the terminal receive window.

Typical usage:
**MISMATCH_CAL=1<CR>*

Through the MENU this command may be invoked with the MISMATCH CAL item, setting to ENABLED.

*MISMATCH_DATA

Sets parameters that control the antenna mismatch detection feature. These parameters are not intended to be manually set. Use MISMATCH_CAL=1 to auto-set the following parameters.

*MISMATCH_DATA=**YY,ZZ**,BB,CC,DD,EE<*CR*>

where:

YY = allowed DAC variation (DAC count).

ZZ = allowed current variation (mA).

The following parameters should not be manually changed unless with factory assistance.

BB = the min forward power permitted (ADC count).

CC = the max forward power permitted (ADC count).

DD = the min permitted TX current (mA).

EE = the max permitted TX current (mA).

Typical usage:

**MISMATCH_DATA=7,70<CR>(sets DAC variation to 7, current variation to 70mA)*

DMR Commands

Commands relating to DMR Transmissions.

*DMR_CAL

Factory Use only.

*DMR_DB

Sets parameters that are associated with transmissions from the DMR database (see TX_DMR). The DMR database is only for use with group IDs. Should a single radio need to be addressed, a group should be created with only a single user.

*DMR_DB=A,B,C,D<*CR*>

where:

A = DMR Radio Type (0-2)

B = DMR transmission Colour Code (1-16)

C = DMR Slot (not used for Tier 1)

D = DMR transmit frequency.

Typical usage:

**DMR_DB=0,6,0,458600000<CR>*

System Commands

*TREX_LANG

Specifies the language used by the unit

*TREX_LANG=X<*CR*>

where:

0 = English

Typical usage:

**TREX_LANG=0<CR>*

*TREX_BACKLIGHT

Specifies the time in seconds which the display LED backlight will be lit for after a key is pressed. Setting to 0 disables. Setting to 30 enables permanently. This command is also used to set the LCD contrast. The default LCD contrast value is 32.

Typical usage:

**TREX_BACKLIGHT=10,32<CR>*

*TREX_SOUND

Controls sounds made when a key is pressed or when a message is received that results in an ALERT being raised.

Typical usage:

**TREX_SOUND=1<CR>*

*TREX_RS232

Sets the serial baud rate of the RS232 port. The second parameter should be set to 1 if EVEN parity is required.

Typical usage:

**TREX_RS232=9600,0<CR>*

*TREX_RS422

Sets the serial baud rate of the RS422 port.

Typical usage:

**TREX_RS422=4800<CR>*

*TREX_ALERT

Configures alerting configuration and some alerting options.

*TREX_ALERT=A,BB,C,D,E,F,G<*CR*>

Where:

A Enables the MSG alert (0-1)

BB Sets the time before an ALERT beep is repeated (0-32000). Setting to 0 results no repeat.

C Sets the alert output to use (0-8). Setting to 0 disables the output function.

D Enables the BATT alert (0-1)

E Enables the MAINS FAIL alert (0-1)

F Enables the over-temperature alert (0-1)

G Enables the RF Fault (antenna mismatch) alert (0-1)

See **OUT_CONFIG** and **Alert Handling**.

Typical usage:

**TREX_ALERT=0,60,0,0,0,0,0<CR>*

*TREX_OVERTEMP

Configures the over-temperature set-point. This is the TReX board operating temperature and NOT the ambient temperature.

See **Alert Handling**.

*TREX_OVERTEMP=T

Where:

T is the RF temperature sensor set point.

Typical usage:

**TREX_OVERTEMP =95<CR>*

*TREX_FILTERS

Sets the message filters that are in use when a message is received.

*TREX_FILTERS =I,E,A<CR>

where:

I is set to 1 if the INCL.TXT filter is to be used.

E is set to 1 if the EXCL.TXT filter is to be used.

A is set to 1 if the MSG.TXT filter is to be used.

See **FILTERS** for details of use.

Typical usage:

**TREX_FILTERS =0,0,0<CR>*

*TREX_TELEMETRY

Sets all parameters necessary to enable either the point to point serial link or back to back mirror mode of operation.

*TREX_TELEMETRY=M,R,A,B,C,D<*CR*>

where:

M is telemetry mode of operation

0 = DISABLED,

1 = SERIAL_LINK

2 = IO_MIRROR

3 = SLAVE

4 = MASTER

R is the number of remote TReX units when the telemetry mode is MASTER (valid 0-9)

A is the local unit ID (from 1-255).

B is the remote unit ID (from 1-255).

C is how long in seconds before sending all input information again.

D is the number of transmission retries. (from 0-9). When set to 0, the TReX does not transmit or process acknowledgements.

Typical usage:

**TREX_TELEMETRY=0,0,1,2,10,3<CR>*

Note: Telemetry parameters should be set taking the data transmission rate into account. High data rates, such as 16K baud will send and process acknowledgements in around 200ms,

whereas 512 baud transmissions will send and process acknowledgements in around 4 seconds. See Telemetry specifications for full data transmit rates for telemetry modes.

*TREX_SCREEN

Sets the default main screen and the page for that main screen. On start-up the first screen viewed is this screen. After a period of keypress inactivity, this is the return screen. This is shown here only for completeness. Typically this would only be set through the MENU system, and has no relevance when the TReX is being serially controlled.

*TREX_SCREEN=X,Y<*CR*>

where:

X = main screen

Y = page for that main screen.

Typical usage:

**TREX_SCREEN=0,0<CR>*

*TREX_PIN

Sets the Personal Identification Number, which can be used to unlock the unit. The PIN prevents accidental mis-configuration or changes by unauthorised users.

*TREX_PIN=nnnn

where:

nnnn = 4 digit PIN number.

Typical usage:

**TREX_PIN=0000<CR>*

*TREX_AN_CAL

Sets parameters used to calibrate the analog outputs and inputs. See DAC and ADC CAL Sub-Menus for more information.

*TREX_DAC_CAL=AA,BB,CC,DD<*CR*>

where:

AA = DAC1 minimum count. Default 0.

BB = DAC1 maximum count. Default 1023.

CC = DAC2 minimum count. Default 0.

DD = DAC2 maximum count. Default 1023.

EE = ADC1 minimum count. Default 0.

FF = ADC1 maximum count. Default 1023.

GG = ADC2 minimum count. Default 0.

HH = ADC2 maximum count. Default 1023.

Typical usage:

**TREX_AN_CAL=0,1023,0,1023,0,1023,0,1023,*

*LIMITS

Sets parameters used to set max and minimum limits used to protect the TReX from installation faults. This command is for factory use only. Linked to the MIN PWR, MAX PWR and MAX I items found in MENU->SYSTEM->FACTORY.

*LIMITS=AA,BB,CC

where:

AA = minimum output power sense setting. If, during a transmission this output power is not achieved, a low output fault condition will be raised. Default value 10.

BB = maximum output power sense setting. During a transmission, the output power is not permitted to exceed this level. If it is reached, a fault condition will be raised. Default value 1000.

CC = Current limit in mA. This is the maximum current permitted during transmission. This limit ensures that the TReX and connected power supply is protected during an installation fault condition. Default value 1500.

CC = Current limit in mA. This is the maximum current permitted during transmission. This limit ensures that the TReX and connected power supply is protected during an installation fault condition. Default value 1500.

*TIME_SRC

Sets the method by which the TReX maintains internal time.

*TIME_SOURCE=X

where:

X is the method of maintaining internal time

0 = NONE

1 = FLEX

2 = SEQ TEST

3 = RTC

Typical usage:

**TIME_SOURCE=0<CR>*

PLC Commands

PLC_CONFIG

Displays PLC current configuration.

Typical Usage:

**PLC_CONFIG<CR>*

PLC_RUNG

Configures individual rungs of the PLC program.

Note: *Although programming the PLC via serial commands is possible, the user may find it easier to either use the menu, or connect to the TReX via USB cable and directly edit the PLC rungs using any text editor. The PLC config file is wte_plc.ini.*

***PLC_RUNG**=RR:XXX<*CR*>

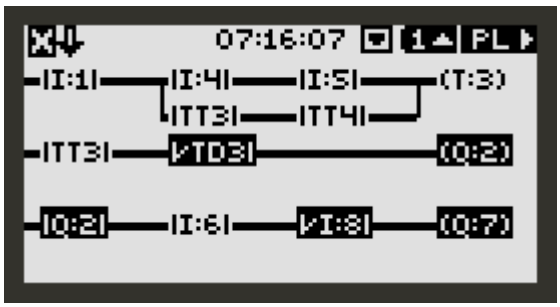
Where:

- **RR** is a 1-3 digit rung number being configured (01 to 250 valid). "NN" may also be specified (literal "NN"). This specifies a rung number one higher than the last.
- **XXX** is the ladder logic for the rung.

Typical Usage:

```
PLC Configuration:
*PLC_RUNG=01:[I:1]-------[I:4]-------[I:5]-------(T:3)
*PLC_RUNG=02:[-]     +----[TT3]-------[TT4]---+
*PLC_RUNG=03:[TT3]-------[/TD3]------[-]---------(Q:2)
*PLC_RUNG=04:
*PLC_RUNG=05:[Q:2]-------[I:6]-------[/I:8]------(Q:7)
*PLC_RUNG=06:
```

The above configuration will result in the following ladder logic equivalent program.



The same configuration can be simplified when entering in commands, but the output from the TReX is automatically aligned for ease of reading as ladder logic.

The same commands may be optionally simplified for ease of entry:

```
*PLC_RUNG=01:[I:1][I:4][I:5](T:3)
*PLC_RUNG=02:[-][TT3][TT4]
*PLC_RUNG=03:[TT3][/TD3][-](Q:2)
*PLC_RUNG=04:
*PLC_RUNG=05:[Q:2][I:6][/I:8](Q:7)
*PLC_RUNG=06:
```

By using the rung of "NN", a program may be written or edited without needing to specify an absolute rung number. This can make programs significantly easier to write when new sections need to be added or removed. The same above program may be entered as:

```
*PLC_RUNG=01:[I:1]-------[I:4]-------[I:5]-------(T:3)
*PLC_RUNG=NN:[-]     +----[TT3]-------[TT4]---+
*PLC_RUNG=NN:[TT3]-------[/TD3]------[-]---------(Q:2)
*PLC_RUNG=NN:
*PLC_RUNG=NN:[Q:2]-------[I:6]-------[/I:8]------(Q:7)
*PLC_RUNG=NN:
```

Note: When the TReX generates a PLC config, absolute rung numbering is always used. This means that although "NN" may be specified as a command input, the "NN" will not be returned.

PLC_OPTS

Displays PLC configuration options.

***PLC_OPTS**=A,B<*CR*>

Where:

- **A** is the PLC enabled state. Set to 1 if PLC scanning is enabled. In the enabled state, the PLC will automatically start running on power up. Set to 0 if PLC scanning is disabled. If PLC scanning is disabled, the PLC active screen will not longer be visible, and program execution will cease. Values 2-9 are for inputs 1-8. When set to these values, the PLC will run only when this input is enabled. This may be convenient in order to use a master PLC run control switch.
- **B** is the LOGGING output change enabled state. When set to 1, any physical output change will be saved to internal SD card. **See PLC Support.**

Typical Usage:

**PLC_OPTS=1,0<CR>*

PLC_TMR

Configures individual timers that are available to the PLC program.

*__PLC_TMR__=T:A,B<*CR*>

Where:

- **T** is the timer number being configured (1-32 valid).
- **A** is the timer type. This can be TON, TOF or RTON.

  B is the timer value. The TD flag is active when this value is exceeded. This value is in deci-seconds. A max value of 999999 is possible allowing for timers up to 99999 seconds.

Typical Usage:

**PLC_TMR=1:TON,40<CR>*

PLC_CNTR

Configures individual counters that are available to the PLC program.

*__PLC_CNTR__=C:A,B<*CR*>

Where:

- **C** is the counter number being configured (1-16 valid).
- **A** is the counter type. For future use. CTU (up counter) is the default type.
- **B** is the counter value. This is the value, that when exceeded the CD flag is active. A max value of 999999 is possible.

Typical Usage:

**PLC_CNTR=1:CTU,400<CR>*

PLC_CMP

Configures individual comparators that are available to the PLC program.

*__PLC_CMP__=C:A,B<*CR*>

Where:

- **C** is the comparator being configured (1-16 valid).
- **A** is the ADC used for the comparison. If 1, uses ADC1, if 2 uses ADC2.
- **B** is the comparator threshold. Can be set from 0-1023.

Typical Usage:

**PLC_CMP=1:1,400<CR>*

PLC_ALARM

Configures individual system clock alarms that are available to the PLC program.

*__PLC_ALARM__=T:A,BB:CC,a,bb:cc<*CR*>
Where:

- **T** is the alarm number being configured (1-16 valid).
- **A** is the day of the week the alarm is turned ON (1-7, else 0 for EVERY day).
- **BB** is the hour. (-1 if not used, indicating EVERY hour, else 0-23)
- **CC** is the minute.
- **a** is the day of the week the alarm is turned OFF (1-7, else 0 for EVERY day)
- **b** is the off hour. (-1 if not used, indicating EVERY hour, else 0-59)
- **c** is the off minute.

Note: For days of the week Monday is 1 and Sunday is 7.

Typical Usage:

**PLC_ALARM=1:2,22:58,3,22:58 (turn on alarm 1 TUE 22:58, turn off WED 22:58)*

PLC_MATCH

Configures serial input match strings, and allows a PLC program work bit to be set when each input serial string is matched.

*__PLC_MATCH__=M:W,SSSSSSSSSS<*CR*>
Where:

- **M** is the match string (1-4 valid)
- **W** is the work bit to set on a match (1-64)
- **SSS**... is the serial to be matched (up to 20 characters)

Examples:

To match on the serial input "AT23" then set work bit 4 (B:4) on a match:

**PLC_MATCH=1:4,AT23<CR>*

To match on the serial inputs "AT\r" then set work bit 4 (B:4) on a match, and also set work bit 5 (B:5) on match of "B\r\n":

**PLC_MATCH=1:4,AT$0D<CR>*

**PLC_MATCH=2:5,AT$0D$0A<CR>*

Note: The $ character when using this command is reserved for specifying any non-printable character. When the character '$' is used, 2 hexadecimal characters must follow (ASCII code). To specify '$' itself as a match, the sequence $24 must be used.

When work bits are set using a serial match, it is up to the programmer to clear the bit after the match has been processed.

Typical usage would be:

```
*PLC_RUNG=15:[B:4]-------[-]---------[-]---------(SQ8)
*PLC_RUNG=16:                                   +-(RB4)
```

In this example, work bit 4 is set when a serial match is detected. Output Q:8 is set immediately when work bit 4 is set. In order to detect another serial match, the work bit 4 is immediately cleared when used.

TCP-IP Commands

*IP_ENABLE

Enable/disable the Ethernet subsystem of the radio. Also allows configuration of the TCP Client Auto reconnect feature.

**IP_ENABLE=A,B<CR>*

where:

A = the IP enable mode.

1 to enable WEB only.

2 to enable WEB plus TCP SERVER

3 to enable WEB plus TCP CLIENT

4 to enable TCP SERVER only.

5 to enable TCP CLIENT only.

B = The TCP Auto reconnect time. Set to 0 to DISABLE, else this is the time in seconds before rebooting. Provides RS232, visual and audible notification of reboot.

Typical usage:

**IP_ENABLE=1,0<CR>*

*IP_HOST

Configures the name used by the DNS server to allocate name to IP translation on the network.

Typical usage:

**IP_HOST=WTE-TReX<CR>*

*IP_ADD

Specifies the default TReX IP address and the server address.

**IP_ADD=LLL,SSS<CR>*

where:

LLL = the local IP (the default IP is 192.168.1.21)

SSS = the server IP or address.

Typical usage without setting a server:

**IP_ADD=192.168.1.21<CR>*

Typical usage including a server name or IP:

**IP_ADD=192.168.1.21,m24.cloudmqtt.com<CR>*

*IP_PORT

Specifies TCP Port used by the TCP server and client. Port for web configuration is fixed at 80.

Typical usage:

**IP_PORT=5080<CR>*

*IP_MASK

Specifies default network mask number.

Typical usage:

**IP_MASK=255.255.255.0<CR>*

*IP_GATE

Specifies the address used for the gateway.

Typical usage:

**IP_GATE=192.168.1.1<CR>*

*IP_DNS

Specifies the IP number used to connect to the DNS server, up to 2 DNS servers can be set.

*IP_DNS=aaa.bbb.ccc.ddd,eee.fff.ggg.hhh

where:

aaa.bbb.ccc.ddd = first DNS server IP,

eee.fff.ggg.hhh = second DNS server IP

Typical usage:

**IP_DNS=192.168.1.1,0.0.0.0<CR>*

Note: The IPs are separated by the use a “,” (COMMA)

*IP_MAC

Returns the MAC (Media Access Code) number of the unit, this is a readable field only.

Typical usage:

**IP_MAC?<CR>*

Typical output:

**IP_MAC=60AD45676000<CR>*

*PING

Sends a PING to the SERVER address. Reply expected will be the responding IP address and status (OK/TIMEOUT/NOT RESOLVED).

This item is useful for testing connectivity. If the TReX cannot successfully PING the SERVER, it is likely that a firewall network filtering rule is preventing the connection.

Usage:

**PING<CR>*

Protocols

Serial input into and out of the TReX can be formatted differently by selecting an appropriate protocol handler.

WT Protocol

The **WT Protocol** is the default protocol used by WTE products. It allows for a variety of over the air transport methods (such as POCSAG and DMR paging) to be used and a variety of baud rates. The WT Protocol also supports the use of macros to embed variable information in messages such as system voltage, time etc. – see **Variable Content Macros**.

Transmitting Messages
Message format:

WTNNNNNNNABC<SPACE>MMMMM<CR>

Where:

WT are the 2 characters WT
NNNNNNN are 7 ASCII digits from 0000000-9999999
A is the Transport method:

A = POCSAG Alpha

N = POCSAG Numeric

T = POCSAG Tone Only

D = DMR Text Message (directed to a group)

d = DMR Text Message (directed to an individual)

W=WTE proprietary 8 bit format.

- 2L modulations: tx is POCSAG based with forward bit correction.
- 4L modulations: tx is raw 4 level FSK with no bit correction.

B is the Level 1-9. Note that POCSAG only supports levels 1-4 which is the same as the "Beep Level". When the Transport method is 'D' this is the DMR "colour code"

C is the data rate (specified in channel width ranges):

25 kHz Channel Space Settings

0 = 512 Baud 2 Level FSK
1 = 1200 Baud 2 Level FSK
2 = 1600 Baud 2 Level FSK
3 = 2400 Baud 2 Level FSK

4 = 3200 Baud 4 Level GFSK
5 = 4800 Baud 2 Level GFSK
6 = 9600 Baud 2 Level GFSK
7 = 9600 Baud 4 Level GFSK
8 = 16000 Baud 4 Level GFSK
9 = 32000 Baud 4 Level GFSK

12.5 kHz Channel Space Settings

A = 512 Baud 2 Level FSK
B = 1200 2 Level FSK
C = 2400 2 Level FSK
D = 4800 2 Level GFSK
E = 9600 2 Level GFSK
F = 9600 4 Level GFSK
G = 16000 4 Level GFSK

6.25 kHz Channel Space Settings

a = 512 Baud 2 Level FSK
b = 1200 2 Level GFSK
c = 2400 2 Level GFSK
d = 4800 4 Level GFSK

NOTE: Although the protocol supports the following modulation types and channel spacings, the supplied WTE product may only support a subset of these modulation rates (determined by regional restrictions).

<SPACE> is a single space character.

MMM... is the payload, up to 240 characters.

<CR> is the carriage return character

Example:
To send a 512 baud alpha message to 1234567 level 1 with payload of "TEST"
WT1234567A10<SPACE>TEST<CR>

Responses

After processing/transmitting responds with:
WT[TTT,NNN]<CR>

where:

TTT is the “ticket ID” that was assigned to the transmission. Rotates from 999 to 0.

NNN is the number of characters from W until, but not including <CR> , the test message above results in the following response

WT[123,017]<CR>

If a user specified response is required this response can be changed. To change the sent response to “Page Sent” a leading ‘*’ character must be used in the PROTOCOL->SENT RESP config item. e.g. “*Page Sent”.

If the entire WT Protocol message needs to be sent out the serial port after each transmission:

Change the sent response to “**” using the menu item PROTOCOL->SENT RESP or the command **SEND_RESP=**<CR>. This means that triggering an input with the programmed content of “WT1234560A10 test message” will result in “WT1234560A10 test message\r\n” being sent out the configured serial/TCP ports. If the message is not to be transmitted, change WT1234560A10 to WT1234560**S**10.

Received Messages

All messages received come out via the serial port as configured in by the *RX_PROTO setting:

If *RX_PROTO=WTE then the output will look like:

WT1234567A10<SPACE>TEST<CR>

The exact same format allows units to be connected together, or protocols to be converted from one type to another.

Serial Only Output

There is sometimes a need to only send WT protocol messages out a serial port and not transmit on a particular event. For example, if an input changes state, it might be desirable to send a message out the serial port to control another piece of equipment, or it might be useful to use the periodic message to send a health check message out the serial port once every 5 seconds. Receiver only TReX units use this method to output messages.

From v3.45 firmware a new type of message has been assigned for this purpose. This is ‘WTS’

Example:

To send the message “INPUT 1 LOW” out the serial port when input 1 moves low program the input 1 low message with:

*WTS**INPUT 1 LOW**<CR>*

To send “WT1234560A10 test” out the serial port:

*WTS**WT1234560A10 INPUT 1 LOW**<CR>*

The WTS serial output message type also supports sending of any non-printable character. When the ‘$’ is seen, the following 2 characters are treated as hex.

To send 3 non-printable characters <SOH><STX><ETX> out the serial port:

WTS**$**01**$**02**$**03<CR>

$W1 and $W2 are also accepted, :

- $W1 – first comma separated field in last processed WT protocol payload.
- $W1 – second comma separated field in last processed WT protocol payload.

For the sequence:

1. Message of **WT0000000A10 FIRST,SECOND** is processed
2. Message of WTStest$0Doutput$W1and$W2<CR> is received

the serial output will be:

test<CR>outputFIRSTandSECOND

4 Level Modulations

All WTE 4L modulations, regardless of the used channel spacing, transmit data using the WTE_EN transport method. 4L modulations also do not include forward error correction information as all 2L modulation supported do. This gives much faster possible transmission speeds.

To transmit a 16000 baud, 12.5kHz channel message:

WT1234560**W**1G test message<CR>

Ensure the receiving TReX has the RF->MODE configured to WTE_EN

Support for Multiple Messages

The WT protocol allows for the same message to be sent to a variety of different radio types. This allows for an efficient way to send to several different RIC codes or technology types. Many message transmissions can be supported, until the max message length for the message

is exceeded.

Example:
To send the message “TEST” to RIC codes 1234560 and 1222222 as a 512 baud POCSAG message.

WT1234560A10*WT1222222A10*<SPACE>TEST<CR>

2 messages will be transmitted, batched in a single transmission.

Note: The format is the standard WT Protocol format, but repeated without a space in-between headers.

Example:
To send the message “TEST” to RIC code 1234560 as a 512 baud POCSAG message and also a DMR message to group 1001, colour code 6 for a Hytera radio.

WT1234560A10*WT0001001D60*<SPACE>TEST<CR>

2 messages will be transmitted, as 2 transmissions. First message is in a POCSAG format, second transmission is in a DMR format.

Example:
To send the message “TEST” to RIC codes 1234560 and 1222222 as a 512 baud POCSAG message and also RIC codes 0201234 and 0005647 as a 1200 baud POCSAG message.

WT1234560A10*WT1222222A10*WT0201234A11*WT0005647A11*<SPACE>TEST<CR>

4 messages will be transmitted, batched in 2 transmissions, one for 512 baud messages and another transmission for the 1200 baud messages.

DMR Message Format

The WT Protocol can be used for sending DMR tier 1 messages. The protocol allows for an ID (group or individual), colour code, radio type and message to be specified.

Different DMR Radio manufacturers frequently have differing DMR implementations that often allows only same brand to same brand communication.
The WT protocol uses the commonly used "baud" field to set the DMR radio type. Sending a DMR message to an incorrect radio type may result in the radio not receiving messages, or the message being corrupted. Ensure that the group ID used is common to all same brand radios.

Basic Format:
WT1234567D6**x** TEST\r

Where all fields are previously defined, but '**x**' is now a DMR "Type".
Type '0' – This is a short message type, often used by Hytera.
Type '1' – This is a short message type, often used by Kirisun.
Type '2' – This is a compressed UDP type, often used by Hytera and Motorola.

Motorola Radio Usage:
No messages are transmitted using any Motorola format. Motorola radios must be configured as follows:

- Compressed UDP Data Header: **DMR Standard**
- Text Message Type: **DMR Standard**

Example:
To send a DMR message to group ID 1001, colour code 6 with payload of "TEST MESSAGE" and to a type '0' radio (Hytera)

*WT0001001D6**0**<SPACE>TEST MESSAGE<CR>*

Example:
To send a DMR message to individual ID 104, colour code 6 with payload of "TEST MESSAGE" and to a type '0' radio (Hytera)

*WT00001041d6**0**<SPACE>TEST MESSAGE<CR>*

TReX DMR ID

Messages transmitted will have the TReX serial number as the source. If the TReX unit ID is configured to a numeric value greater than 1, then this becomes the transmitted source ID.

Variable Content Macros

WT Protocol can use several macro tags to display variable content. This may be useful as part of a periodic message for example to report battery voltage or IO conditions. Any number of macros can be used in any location of the message until the max message length has been reached.

Macro Tag	Description	Example Output
**01	Auto Incremented Ticket ID (3 digits rotating)	123
**02	Time/Date	23:34 01/02
**03	Digital IO	I:11110000--- O:1111000000
**04	Analog IO	ADC:1023,1003 DAC:1023,1003
**05	System Voltage	12.1
**06	Temperature (Digital, RF degrees Celsius)	23.4, 44.5
**09	MQTT Topic	XX/YY/ where XX is the MQTT user and YY is the Unit ID

Example:
To transmit the system voltage when input 1 goes low, program the input 1 low message with:

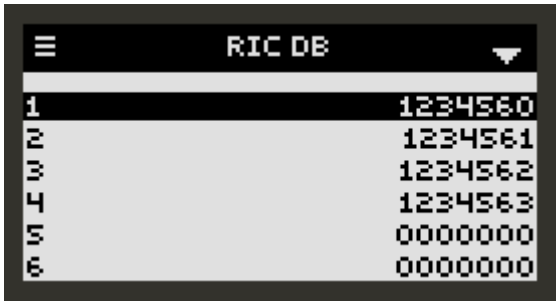
*WT1234567A10<SPACE>INPUT 1 **05V<CR>*

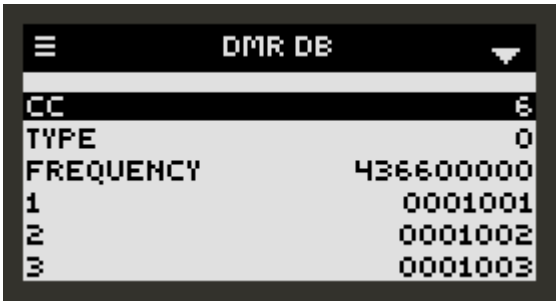
The message that will be transmitted and then received will look approximately like:

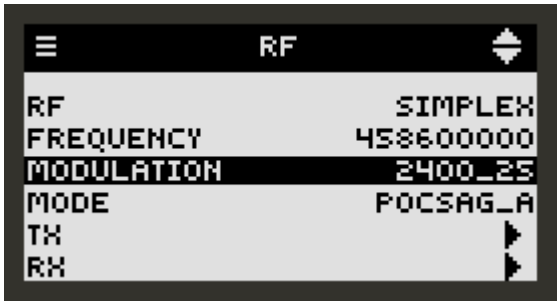
INPUT 1 12.1V

Using the RIC and DMR Database

The TReX is capable of sending messages to multiple different cap codes or DMR codes using a configurable database. This database is able to store up to 9 cap codes and 9 DMR codes that can be configured through the RF->TX menu. The DMR database menu is also used to configure the transmission frequency, colour code and type.







To make the WT protocol use the database for either POCSAG or DMR, the following format must be used:

*WT**0000008**XXX<SPACE><MESSAGE><CR>*

Using the digits **0000008** in place of a cap code or DMR code will make the protocol refer to the database and transmit the given message to all recipients in either the RIC and/or DMR database. It is important to note that only entries up to the first zero entry will be transmitted. Any subsequent non-zero entries will be ignored. If there are no entries in the RIC DB, the DMR DB will still be used if entries are present.

For example, to send a message to all recipients in the RIC and DMR database:

*WT0000008**A10**<SPACE>TEST MESSAGE<CR>*

The message "TEST MESSAGE" will be sent to each recipient in the RIC and DMR database. Although "**A10**" is specified, since the RIC database is being used, only MODULATION and MODE is used that has been specified in the RF screen. If "**D60**" is specified instead of "**A10**" behaviour will be the same.

When directed to send a DMR message, the transmission frequency, colour code and type will be as configured in the DMR DB menu.

Note: DMR transmissions of any type, regardless of whether a DMR DB entry (forced by using the 0000008 cap code), will always use the frequency specified by the DMR DB menu.

If there are no entries in either the RIC or DMR DB, then WT**0000008**XXX messages will be directed to ID **0000008**.

Modbus

The TReX optionally supports both RTU and TCP modbus protocol options. These are well established and defined protocols used primarily in SCADA control and monitoring applications. For more information on how to configure the TReX device for SCADA applications, refer to the **SCADA Support** section.

These Modbus protocols can be used over any of the RS232, RS422, RS485 and Ethernet interfaces.

Baud-rates, IP configuration and Modbus specific configuration items are through:

MENU->PROTOCOL->MODBUS. This is an optional feature.

Note that the Modbus TCP protocol by default uses port 502. This is not a firm requirement, and this can be changed to another port. The TReX defaults to port 5080.

Modbus RTU

The Modbus RTU protocol, as well as the TCP extension, are well documented in the specifications which are available at http://www.modbus.org, a website established by the Modbus Organization for supporting and organizing the Modbus protocol. Only the use of the protocol is documented here.

The first byte of the Modbus RTU protocol is a single byte Modbus Slave ID. The TReX uses the Slave ID as the Unit ID when the Modbus TCP protocol is used. These ID codes allow multiple units to be addressed, or in the case of Modbus TCP, multiple units to be used on the same IP address.

Modbus TCP

The Modbus/TCP extension includes 6 additional bytes to the original Modbus RTU protocol, which allows for transport over the TCP/IP layers.
Only a single TCP connection is permitted at any one time.

The TReX sends these 6 bytes PLUS the entire RTU protocol payload (except the last two CRC bytes). The first byte of the RTU protocol is the unit ID (usually described as part of the Modbus MBAP header)

Function Codes

Listed are the supported Modbus function codes. All function codes not specified will return a Modbus standard error response.

The TReX supports 1 MASTER plus up to 10 SLAVES wirelessly connected.

Note: in the following mapping, provision has been allowed for multiple SLAVE units. The first single register (and in the case of discrete I/O, 8 registers) are for the MASTER unit, and

following registers are for the installed SLAVE units in the system.

Function Code	Description	Valid Address Range	Registers
01 – Read Coils	Code to read the 8 TReX digital outputs (MASTER TReX plus up to 10 wireless SLAVE TReX units)	0x0000 - 0x0057	1 to 88
02- Read Digital Inputs	Code to read the up to 88 TReX digital inputs (MASTER TReX plus up to 10 wireless SLAVE TReX units)	0x0000 - 0x0057	10001 to 10088
03- Read Holding Registers	Read DAC1 registers Read DAC2 registers	0x0000 – 0x000A 0x0100 - 0x010A	40001 to 40011 40257 to 40267
04 – Read Input Registers	Code to read the ADC1 Code to read the ADC 2 Code to read Temperature Reserved Code to read BattV Read Link Status Count	0x0000 – 0x000A 0x0100 – 0x010A 0x0200 – 0x020A 0x0300 – 0x030A 0x0400 – 0x040A 0x0500 – 0x050A	30001 to 30011 30257 to 30267 30513 to 30523 30769 to 30779 31025 to 31035 31281 to 31291
05 – Write Single Coil	Code to write to the 8 TReX outputs(MASTER TReX plus up to 10 wireless SLAVE TReX units)	0x0000 - 0x0057	1 to 88
06 – Write Single Register	Code to write DAC1 Code to write DAC2 Special Command Code	0x0000 – 0x000A 0x0100 – 0x010A 0x0200 – 0x020A	40001 to 40011 40257 to 40267 40513 to 40523
15 – Write Multiple Coils	Code to write to up to 8 outputs at once (MASTER TReX plus up to 10 wireless SLAVE TReX units)	0x0000 - 0x0057	1 to 88
16- Write Multiple Registers	Message TX Buffer (see below)	0x0300 – 0x03FA	40769 to 40892

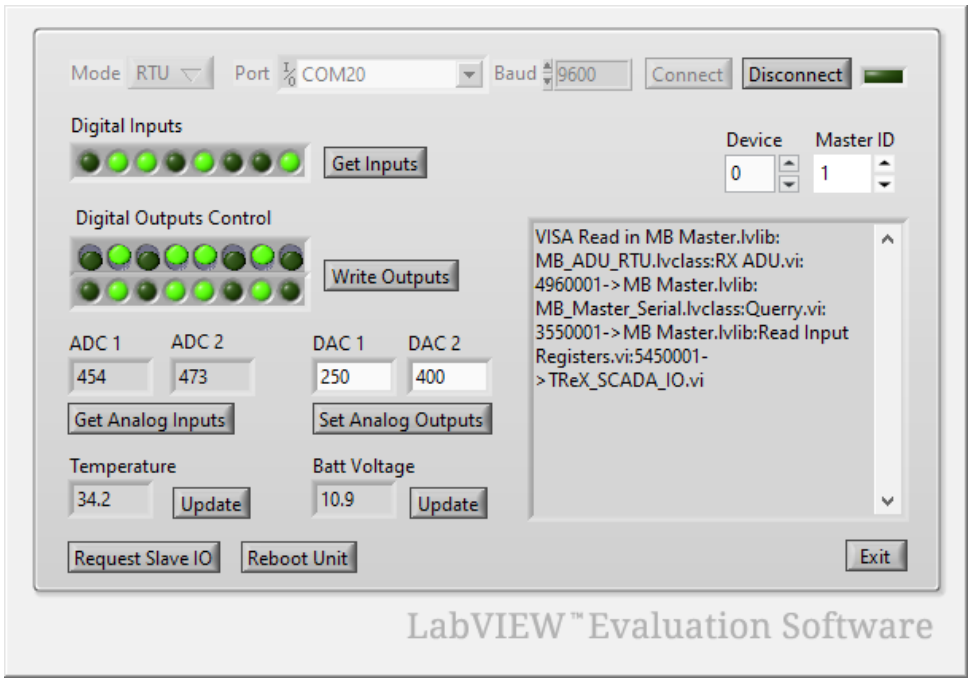
Modbus Mapping Table

Base Address	Num Registers	Description	R/W	Bits
1	88	Digital Out (discrete)	R/W	1
10001	88	Digital In (discrete)	R	1
30001	11	ADC 1 (raw count 0-1023)	R	16
30257	11	ADC 2(raw count 0-1023)	R	16

30513	11	Temperature 1(signed short x 10)	R	16
30769	11	Status(signed short x 10)	R	16
31025	11	Battery(signed short x 10)	R	16
40001	11	DAC 1 (value from 0-1023)	R/W	16
40257	11	DAC 2 (value from 0-1023)	R/W	16
40513	11	Special Function Commands 1 – Reboot Unit 2 – Request Slave I/O to be returned to Master.	W	2

Software Integration

An example integration of the TReX into the control software LabVIEW is provided by WTE on request. This integration consists of the virtual interface (VI) file TReX-SCADA.vi.



This VI provides basic control over the different inputs and outputs of the connected master TReX device as well as the slave devices communicating wirelessly with the master device. The master device can be connected either through an RTU serial connection or through a TCP/IP connection by selecting the corresponding options from the mode selection menu. Connecting via RTU requires the selection of a serial port and baud rate, while connecting via TCP requires the entry of the target device's IP address and configured TCP port.

The IO of slave devices connected wirelessly to the master device can be accessed by selecting the desired device index using the "Device" input. Device 0 corresponds to the master device while 1-10 correspond to up to 10 slave devices.

RAW Protocol

The Raw protocol uses all default settings to determine the data rate, transport method, cap code etc. This protocol is the protocol used when using a point to point serial link.

Default transmission settings are configured with the commands:
*TX_BAUD
*TX_CAP
*TX_LEVEL

In addition, the following commands are used with RAW protocol:

*RAW_TIMEOUT

Specifies the time of inactivity in 25ms steps before sending all stored data (max 255), example for a timeout of 100mS:

Typical usage:

**RAW_TIMEOUT=4<CR>*

*RAW_END

Specifies a character that results in immediate transmission, or displayed after reception (0 if unused). Decimal value of ASCII character.

Typical usage:.

**RAW_END=13<CR>*

This means transmit immediately after the carriage return character is seen. Also after decoding each message, the carriage return character is also displayed.

*RAW_CONFIG

Specifies all RAW protocol parameters.

Parameter 1 specifies the time of inactivity in 25ms steps before sending all stored data (max 255).

Parameter 2 specifies a character that results in immediate transmission (0 if unused). Decimal value of ASCII character,

Typical usage:

**RAW_CONFIG=4,13<CR>*

MQTT

MQTT is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol.

When this protocol is selected a MQTT password, user, port, server and client ID can be configured for use.

The TCP-IP mode should either be TCP CLIENT or WEB+CLIENT in order to operate as a MQTT TCP client. The TReX does not support operation as an MQTT server – an external MQTT broker must always be used.

The TReX uses a system that allows an indefinite number of IoT devices to be connected and monitored using any MQTT phone application or software. The TReX also allows outputs to be controlled and paging messages to be transmitted and sent as MQTT messages.

TReX units can be used as intermediate repeaters for connected sensors allowing for extremely long range monitoring and control for IoT devices. Range is limited by the power that the TReX is allowed to transmit at for the channel of use and how TReX repeaters have been deployed.

While operating an MQTT IoT network, the network continues to operate normally for paging messages, allowing notifications to be delivered to any paging receiver or TReX operating within the MQTT IoT network.

Configuration

To configure MQTT operation on the TReX, refer to the **MQTT Sub-Menu** section.

Connecting to an MQTT Broker

When the TReX starts the IP configuration will be displayed. Once the TReX has connected to the MQTT broker service the icon should be displayed on the screen.

If the authentication fails while connecting the MQTT broker, then the icon will blink on the screen.

The MQTT broker service will provide tools showing connected devices and will allow testing from another MQTT device such as phone application. If the connection to the TReX fails, first prove that you are able to connect successfully to the MQTT broker from another device.

Subscribed Topic

The TReX subscribes only to a single MQTT topic. This is TREX/MI. Whenever a MQTT message is received by the TReX there is a short duration screen popup showing part of the value published to TREX/MI.

To transmit a message the value of used for TREX/MI should be in WT Protocol format. To control outputs, both analog and digital the value should be in the WT Output Control format. To send commands and configuration to remote devices, use the WT Output Control format.

Full descriptions of both these formats can be found in the **WT Protocol** section.

Examples:

Topic	Value	Description
TREX/MI	WT1234560A10 Test Message	A 512 baud paging message is transmitted with payload “Test Message”.
TREX/MI	[[01]12-]	If the TReX unit is is set to “01” outputs 1 and 2 are set high.

There are many topics published from the TReX, in fact an unlimited number is possible that can be configured to be any topic required by the user.

Published Topics

By default published topic format is TREX/01/XXX where XXX is the input or output.

e.g. TREX/01/Di1 where 01 is the unit id. This can be anything like “Unit_1”. The entire topic length must not exceed 32 characters.

When any input is changed or output is changed, after transmitting, the associated topic will be published. These topics are NOT configurable (other than the unit ID part.). When any message is received by the TReX, the message payload that is sent out the serial port will be also published.

Under specific configurations, all TReX topics are periodically republished to the broker. Sending a value of “**” to TREX/MI at any time will result in all topics being immediately transmitted again.

Output topics listed here are ONLY for displaying the current state of that output. To change an output, the TREX/MI topic must be used.

There is a last will and testament topic that is always published on loss of connection with default QoS settings. Upon connection to the broker, the TReX will publish the message “Online” to this topic. Upon disconnection, the broker will automatically publish “Offline” to this topic.

Published Topics (for a unit ID of “01”)

TOPIC	Description	Values (Message Body)
TREX/01/Di1	Digital Input 1	0 or 1
TREX/01/Di2	Digital Input 2	0 or 1
TREX/01/Di3	Digital Input 3	0 or 1
TREX/01/Di4	Digital Input 4	0 or 1
TREX/01/Di5	Digital Input 5	0 or 1
TREX/01/Di6	Digital Input 6	0 or 1
TREX/01/Di7	Digital Input 7	0 or 1
TREX/01/Di8	Digital Input 8	0 or 1
TREX/01/Di9	Batt Input	0 or 1
TREX/01/Di10	ADC1 Input	0 or 1
TREX/01/Di11	ADC2 Input	0 or 1
TREX/01/Do1	Digital Output 1	0 or 1
TREX/01/Do2	Digital Output 2	0 or 1
TREX/01/Do3	Digital Output 3	0 or 1
TREX/01/Do4	Digital Output 4	0 or 1
TREX/01/Do5	Digital Output 5	0 or 1

TREX/01/Do6	Digital Output 6	0 or 1
TREX/01/Do7	Digital Output 7	0 or 1
TREX/01/Do8	Digital Output 8	0 or 1
TREX/01/Ai1	Analog Input 1	0-1023 (scaled per calibration)
TREX/01/Ai2	Analog Input 2	0-1023 (scaled per calibration)
TREX/01/Ao1	Analog Output 1	0-1023 (scaled per calibration)
TREX/01/Ao2	Analog Output 2	0-1023 (scaled per calibration)
TREX/01/V	Supply V	0.0 to 15.8
TREX/01/A	Supply A	0.12 to 1.75
TREX/01/T1	Digital Temperature	23.4
TREX/01/T2	RF Temperature	44.5
TREX/01/MO	Message Out	Any WT format text directed out serial port e.g WT1234560 INPUT2 LOW published as “INPUT2 LOW”.
TREX/01/MO/# Where: # is 0 to 99	Message Out (Rotating Sequence)	Same as Message Out.
TREX/01/MS	Current Message Sequence Number	The current sequence number for the Rotating Sequence Message Out topics, 0-99.
TREX/01/LW	Last Will and Testament – published on loss of connection	Either “Online” if TReX device is connected to broker or “Offline” otherwise.

Rotating Message Out

When using the Rotating Message Out scheme, individual serial output messages are sent over a series of topics prefixed with TREX/01/MO/. These topics are numbered from 0 to 99 and wrap around when the maximum number is reached. This mode, when used with retained messages enabled, provides an alternative method for preventing MQTT messages from being missed by a client. This also allows a new client to view the last 100 messages sent by the TReX before the initial connection by the client to the broker.

Full System Operation

Using any MQTT application, any of these topics can be subscribed to and display digital inputs and outputs including incoming messages as they arrive.

Remote Device Support

Any number of devices or topics are supported by the TReX. In order to publish a change of input of a remote TReX device the following is required:

Inside the payload of any transmitted message to the TReX that is connected to the MQTT broker an MQ: tag.

To publish the topic "TEST/TOPIC2" with a value of "23" inside the message starting with IN_1 High

Complete Message Payload:
IN_1_High MQ:TEST/TOPIC2 23

The TReX supports macros that can be used to simplify topic publishing. See the TReX for full details of variable content macro usage.
Using the ****09** Macro in a message will expand to "TREX/XX/" where XX is the unit id (e.g. "02" or "UNIT_B" etc).

If an input on TReX unit id "02" is programmed with the following:
WT1234560A10 INPUT_1_HIGH MQ:****09**Di1 1
Will result in the transmitted payload of:
INPUT_1_HIGH MQ:TREX/02/Di1 1

The TReX connected to the MQTT broker will decode the message:
INPUT_1_HIGH MQ:TREX/02/Di1 1
and will publish the topic "TREX/02/Di1" with the value "1"

Using this method any number of remote devices can be used that will uniquely publish an unlimited number of MQTT topics that can be displayed on any MQTT device (smartphone etc.).

PLC Support

An optional feature of the TReX-460 is a telemetry-optimised PLC. This allows automated control of outputs and transmissions based on configurable inputs, received messages, counters, comparators and timers. This PLC utility uses a ladder logic interface similar to other commercially available PLC devices.

!WARNING

PLC OPERATION AUTO-STARTS

When the PLC has been enabled, then on system restart or loss of power, the PLC reverts to initial program state. This means that all counters, and work bits reset to default states. Hold bits will retain values, but if power has been off for more 3 days, system clocks and hold bits may reset to default values.
Ensure that default output states have been fully understood, and that on power loss PLC program returns equipment to a safe initial state.
DO NOT use hold bits to directly operate any device if the device is not safe to be energised immediately on PLC restart.

Failure to follow these instructions can result in death or serious injury

!WARNING

USE OF EMERGENCY/CRITICAL CONTROLS

Critical system controls, such as emergency stops must not be wired through the PLC as a sole means of safely stopping equipment. Any critical system that must disable the system must operate separately from the PLC!

Failure to follow these instructions can result in death or serious injury

Program execution is from the first rung to the last. All output flags are set immediately after evaluating each rung, that may in turn be used to influence later rungs.

!CAUTION

Changes to used radio data rates result in how quickly inputs are read and outputs can be set. Please view PLC latency specifications to ensure the TReX is configured and used appropriately for the intended application.

This section provides a technical overview of the feature, instruction on it's use and multiple

examples to act as starting points when designing a PLC program for the TReX-460.

Key Terminology

Inputs:
These are sometimes referred to as relays or relay inputs in historical PLC devices. The TReX PLC supports:

- Physical digital and analog inputs on the local TReX and many remote TReX units.
- Physical digital outputs on the local TReX and remote TReX units.
- Work bits or temporary control outputs used for downstream program flow.
- Hold bits or temporary control outputs used for downstream program flow. Hold bits retain their values when power is removed.
- Timers and counter operating flags.
- Weekly, daily or hourly alarm enabled flags.
- Macro completion flags used to sequence serial or wirelessly transmitted messages.
- Serial match strings, allowing work bits to be set and controlled on serial input.
- Greater than comparators, allowing logical operations to be performed on ADC inputs.

Outputs:
These are sometimes referred to as relay coils on some PLC devices. The TReX PLC supports:

- Physical digital outputs on the local TReX and up to 9 remote TReX units.
- Up to 32 timers. Timers can be TON, TOF or RTON types.
- Up to 16 counters. Counters are of the CTU up counting type.
- Up to 64 bits/temporary “Work Bits” used for downstream program flow.
- Up to 16 “Hold Bits” for retaining critical program flow states on power removal.
- Up to 64 user-defined macros. This is a powerful feature that allows transmission or command based reconfiguration of any aspect of TReX operation.
- Up to 16 Daily or hourly alarms.
- Support for “SET” and “RESET” control extensions to allow latched control of digital outputs, work bits and hold bits.

Rung:
Line of ladder logic that includes up to 3 inputs and one optional output. When all used inputs for a rung are “active” the rung is considered to be “energised”, allowing the output associated with the rung to become “active”. The TReX supports up to 250 rungs of ladder logic program.

Macro:
A user-defined command that can be triggered selectively as a PLC output. This can range from configuration commands such as ***TX_FREQ** (used to set frequency) to message transmissions such as **WT1234560A1B TEST**.

PLC Logging

When PLC LOGGING has been ENABLED through command or the menu, there is a timestamped log entry added for each physical output change on the local or remote TReX unit(s).

There is a small delay in writing log entries, that will slightly affect the PLC program scan rate. A delay of up to 10ms can be expected per write, therefore logging would typically only be used when looking for key events during system commissioning or logging of infrequent critical events. Storage capacity on the internal SD card will typically allow for more than 100,000 entries.

Log files are saved to the file PLC-**AABB**.LOG where:

AA is the current year.

BB is the current month.

New log files are automatically created as the month changes.

File content is:

2022-02-03 TUE 18:36:24,R:3,(Q:5) 1

Date and time are logged, together with the rung of the PLC program that resulted in the change, and the output that did change. Finally the new output state is displayed (1 or 0).

PLC Macros

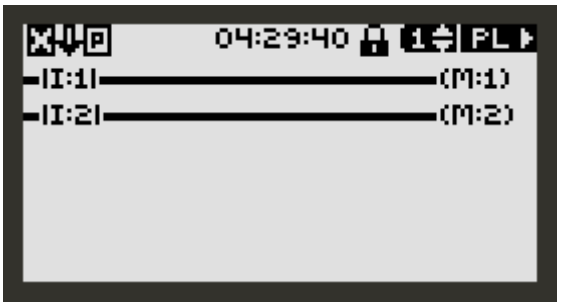
Up to 64 macros are supported as PLC outputs. Each macro allows for up to 8 commands to be processed (depending on length, max 300 characters). This is a powerful unique feature that allows complete radio reconfiguration under ladder logic program control. The macro file is MACRO.TXT, stored on the USB accessible internal SD card.

Consider a MACRO.TXT text file with the following content:

```
<M:1>
*TX_FREQ=458550000
WT1234560A10 Test Message 1
WT0001001D60 DMR Test Message
</M:1>

<M:2>
WTSTest Serial Output$0D$0A
*POPUP=PLC,PLC Critical Event
</M:2>
```

Consider a PLC program configured as below:



If input 1 is active, macro 1 (M:1) will be executed.
Macro 1 will:

1. Change the frequency to 45855000MHz
2. Transmit a POCSAG message on this frequency with payload “Test Message 1”
3. Transmit a DMR message with the payload “DMR Test Message”

If input 2 is active, macro 2 (M:2) will be executed.
Macro 2 will:

1. Send out the serial port “Test Serial Output\r\n” (See **WT Protocol)**
2. Display a popup on the screen as shown below.

Macro sequencing

Each time a macro is executed, a "macro done" flag is set. This allows a sequence of commands to be executed. Note that this is a very simplified example, and the use of timers may improve sequencing flow. See **WT Protocol** for usage of the WTS serial messages.

Consider the MACRO.TXT file content:

<M:1>WTS123</M:1>
<M:2>WTS456</M:2>
<M:3>WTS789</M:3>

In the above configuration:

1. When input 1 is activated, macro 1 will execute. 3 characters will be sent out the serial port ("123").
2. Macro 2 will execute, after macro 1 is done. 3 characters will be sent out the serial port ("456").
3. Macro 3 will execute, after macro 2 is done. 3 characters will be sent out the serial port ("789").
4. All macro flags are reset after macro 3 is done allowing activating of input 1 again to repeat the sequence.

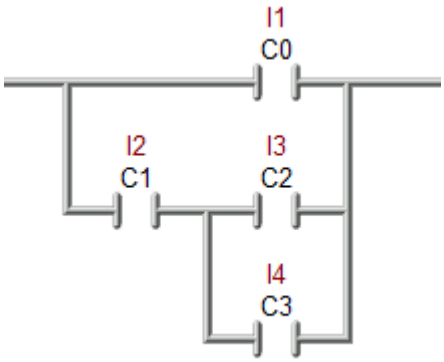
Note: macro flags do not need to be cleared to executed macros again. Macros are normally executed each time the rung is energised.

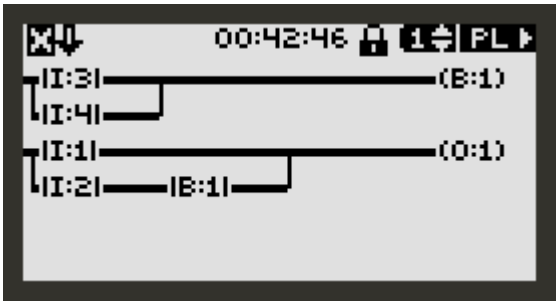
PLC Equivalent Structures

While the TReX-460 does not directly support several common structures found in PLC programming software, equivalent functionality can be achieved using the following configurations:

Nested Branches

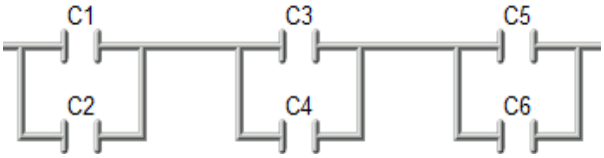
The TReX does not directly support nested branching, however, equivalent functionality can be achieved by evaluating nested branches beforehand and storing their result using an internal register bit. In this example, the nested branch evaluating **Input 3 OR Input 4** is replaced with a preceding rung which evaluates the statement and stores the result in **Register Bit 1**.

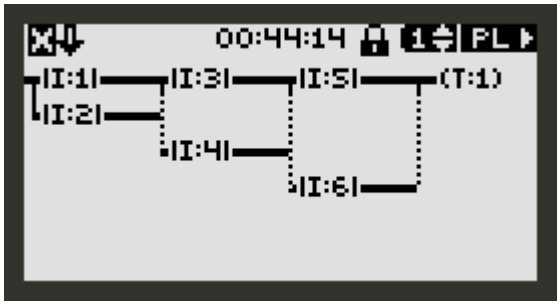




Multi-Branch Rungs

The TReX-460 does not directly support the implementation of multiple separate branches on a single rung. If multiple branches from a single main rung are required, these branches must be placed on separate rungs like so:

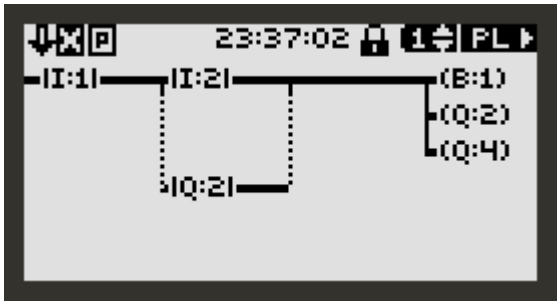




PLC Parallel Outputs

Any number of parallel outputs are supported. If the inputs for any adjacent rung are identical, then the outputs will treated as parallel. The important processing difference for parallel outputs is that the inputs are read from left to right, the rung energised state evaluated, then all outputs set in parallel in a single operation.

Consider the configuration below:




```
PLC Configuration:<0D><0A>
*PLC_RUNG=01:[I:1]-------[I:2]-------[-]---------(B:1)
*PLC_RUNG=02:                                    +-(Q:2)
*PLC_RUNG=03:                                    +-(Q:4)
*PLC_RUNG=04:[-]     +----[Q:2]---+    [-]
*PLC_RUNG=05:
*PLC_RUNG=06:
```

Note, when entering commands, the above configuration may be simplified to:

```
*PLC_RUNG=01:[I:1][I:2][-](B:1)
*PLC_RUNG=02:(Q:2)
*PLC_RUNG=03:(Q:4)
*PLC_RUNG=04:[-][Q:2][-]
```

Operation of this program will be:

- Rung energised state is read from left to right.
- Input I:1, Input I:2 and output Q:2 all evaluated. Note that Q:2 in this example is a parallel output.
- Once the rung state is evaluated, all outputs are applied. Even after the output Q:2 has changed (note, is also an input), the following Q:4 is not affected by this change. All outputs are applied simultaneously, without any application affecting the rung energised state.

PLC Examples

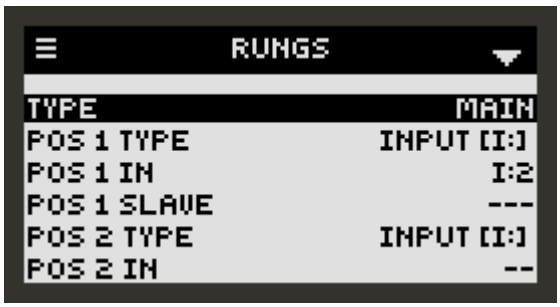
Ladder logic programs and methods of implementation are completely up to the programmer, and many approaches are possible to solve the same problem. Following are provided as simple examples, and not intended to provide the best solution for any application.

These examples and PLC documentation provided here does not intend to replace any prior training in ladder logic programming. If unfamiliar with PLC ladder logic, please refer to online ladder logic examples and course material that is readily available.

One Input to One Output

In this example, the input 2 directly controls the output 3

PLC->RUNGS Menu configuration:

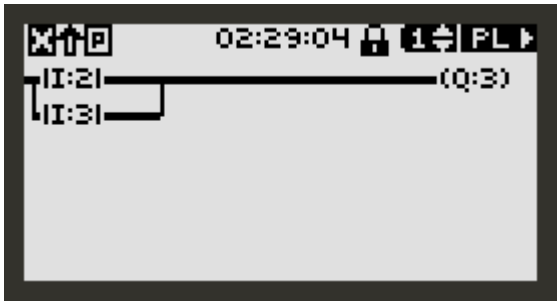


PLC RUNG configuration:

```
*PLC_RUNG=01:[I:2]-------[-]---------[-]---------(Q:3)
*PLC_RUNG=02:
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

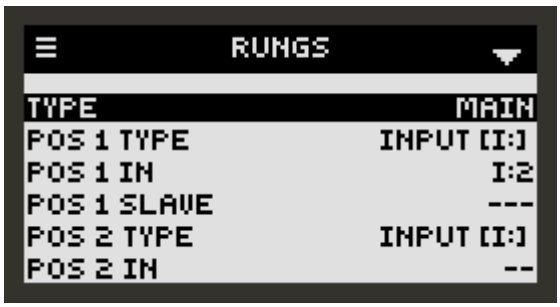
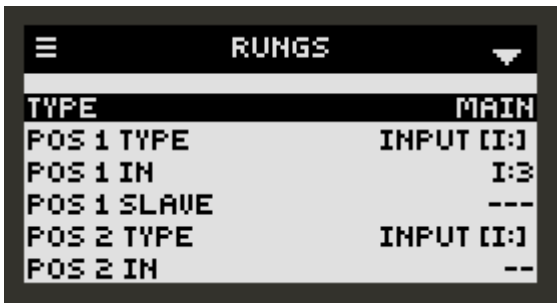
Two Input to One Output

In this example, the input 2 and input 3 directly controls the output 3, here demonstrated in two different ways.

Using Main type rungs only	Using Branches
	

Using MAIN Rungs

PLC->RUNGS Menu configuration:

RUNG 1	RUNG 2
	
	
	

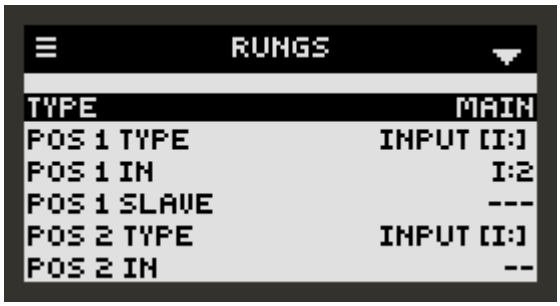
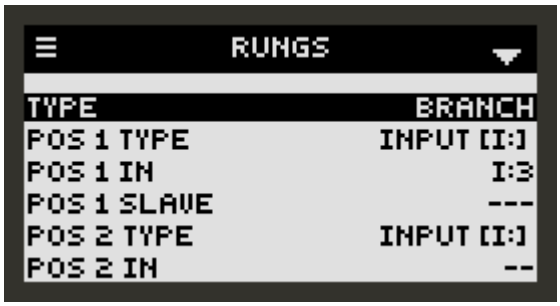
PLC RUNG configuration:

```
*PLC_RUNG=01:[I:2]-------[-]---------[-]---------(Q:3)
```

```
*PLC_RUNG=02:[I:3]-------[-]---------[-]---------(Q:3)
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

Using MAIN and BRANCH Rungs

PLC->RUNGS Menu configuration:

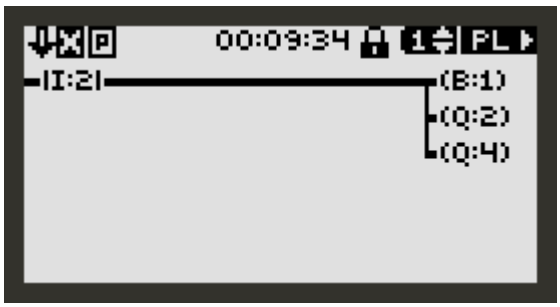
RUNG 1	RUNG 2
	
	

PLC RUNG configuration:

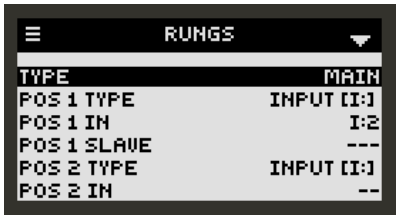
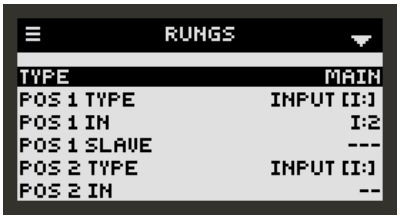
```
*PLC_RUNG=01:[I:2]-------[-]---------[-]---------(Q:3)
*PLC_RUNG=02:[I:3]---+   [-]          [-]
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

One Input to many Outputs

In this example, the input 2 controls the output 3 and output 4 and output 5



PLC->RUNGS Menu configuration:

RUNG 1	RUNG 2	RUNG 3
		
		
		

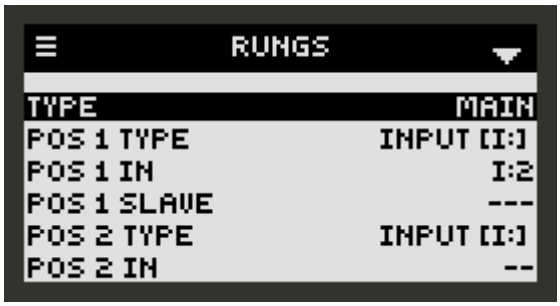
PLC RUNG configuration:

```
*PLC_RUNG=01:[I:2]-------[-]---------[-]---------(B:1)
*PLC_RUNG=02:                                     +-(Q:2)
*PLC_RUNG=03:                                     +-(Q:4)
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

One Input to one slave output

In this example, the input 2 controls the output 3 on a remote unit 6 (slave) TReX-460

PLC->RUNGS Menu configuration:



PLC RUNG configuration:

```
*PLC_RUNG=01:[I:2]-------[-]---------[-]---------(6o3)
*PLC_RUNG=02:
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

One Slave Input to master output

In this example, the slave 3 input 2 controls the master unit output 7

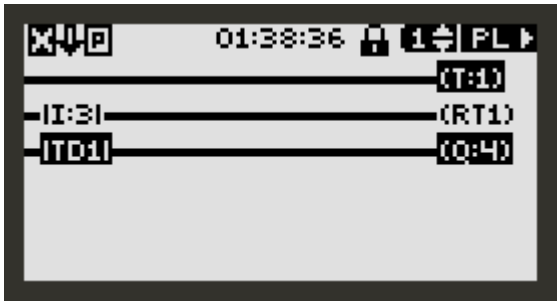
PLC->RUNGS Menu configuration:

PLC RUNG configuration:

```
*PLC_RUNG=01:[3i2]-------[-]---------[-]---------(Q:7)
*PLC_RUNG=02:
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

Output controlled by a Timer

In this example, the input 3 will reset the timer 1 and after 20 seconds the output 4 will be energised.



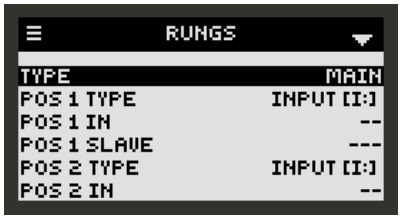
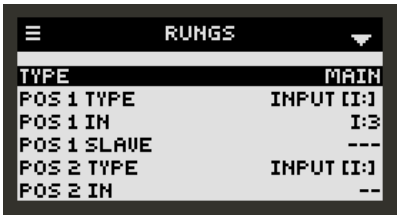
First the Timer 1 needs to be configured for 20 seconds.

PLC->TIMERS Menu:

The configuration sequence, in this case, will be:

- Energised (enabled) the Timer 1
- Input 3 to reset Timer 1
- Timer 1 Done to control the output 4The following images shows the PLC RUNGS configurations:

PLC->RUNGS Menu configuration:

RUNG 1	RUNG 2	RUNG 3
		
		
		

PLC RUNG configuration:

```
*PLC_RUNG=01:[-]---------[-]---------[-]---------(T:1)
*PLC_RUNG=02:[I:3]-------[-]---------[-]---------(RT1)
*PLC_RUNG=03:[TD1]-------[-]---------[-]---------(Q:4)
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

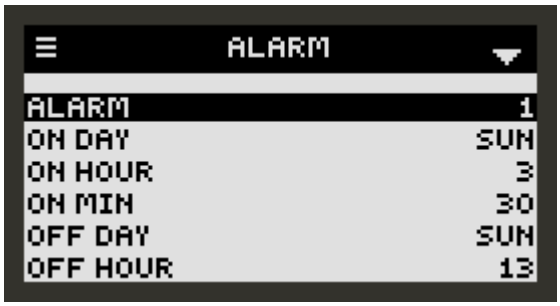
PLC TIMER configuration:

```
*PLC_TMR=1:TON,200
```

Output controlled by an Alarm

In this example, the output 4 will be energised every Sunday from 3:30AM to 1:00PM

Setting the Alarm via the **PLC->ALARMS** Menu:



PLC->RUNGS Menu configuration:

PLC Rung configuration:

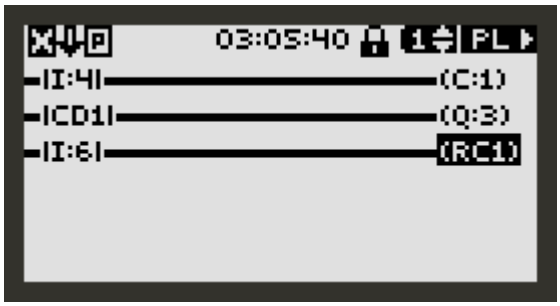
```
*PLC_RUNG=01:[AE1]-------[-]---------[-]---------(Q:4)
*PLC_RUNG=02:
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

PLC ALARM configuration:

```
*PLC_ALARM=1:7,03:30,7,13:00
```

Output Controlled by a Counter

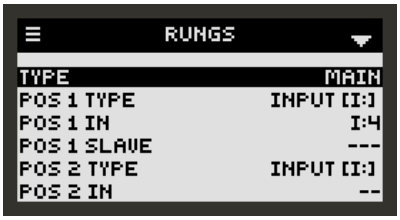
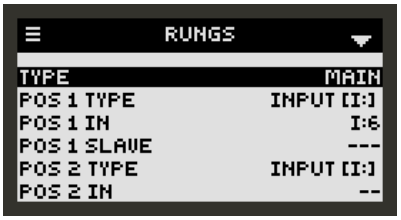
In this example, the output 3 will be energised only after the input 4 toggles 10 times, and the input 6 resets the counter.

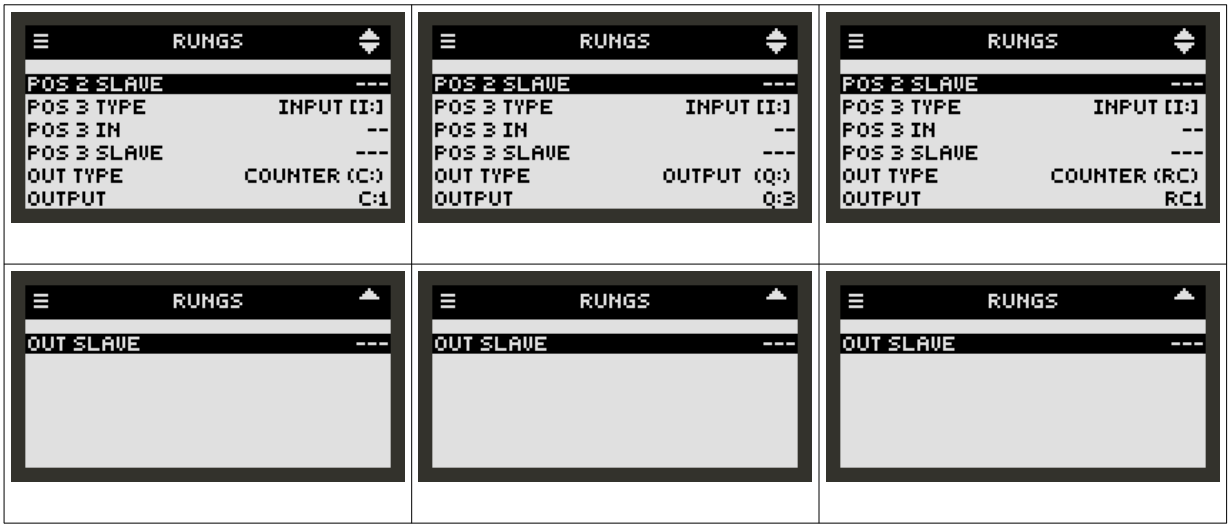


First the COUNTER 1 needs to be configured.

PLC->COUNTERS Menu:

PLC->RUNGS Menu configuration:

RUNG 1	RUNG 2	RUNG 3
		



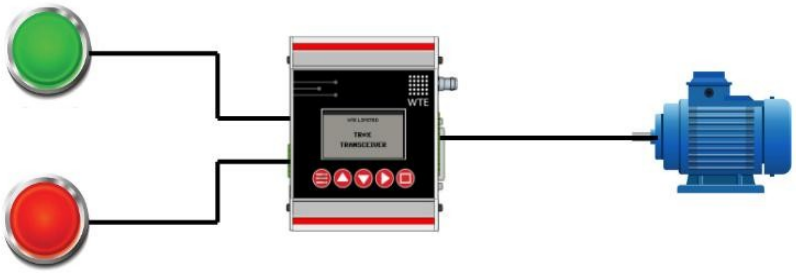
PLC RUNG configuration:

```
*PLC_RUNG=01:[I:4]-------[-]---------[-]---------(C:1)
*PLC_RUNG=02:[CD1]-------[-]---------[-]---------(Q:3)
*PLC_RUNG=03:[I:6]-------[-]---------[-]---------(RC1)
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

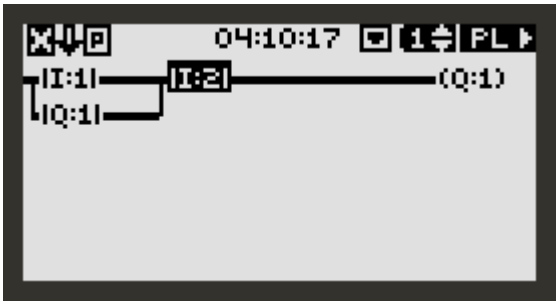
PLC Counter configuration:

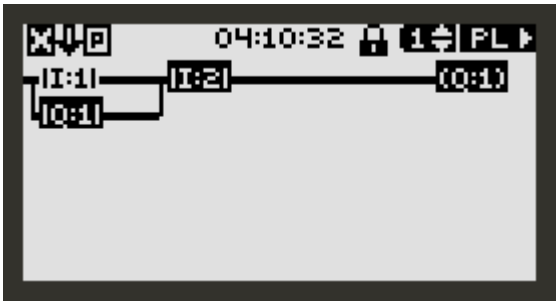
```
*PLC_CNTR=1:CTU,10
```

Latched Motor Starter



A TReX-460 is set up with a **normally open start button** connected to **Digital Input 1** and a **normally closed stop button** connected to **Digital Input 2**. **Digital Output 1** of the TReX is configured to control a pump motor (through external relay or contactor). The intended behaviour is that the motor will start when the start button is pressed and will only stop when the stop button is pressed, disconnected or damaged. This can be achieved with the following configuration:

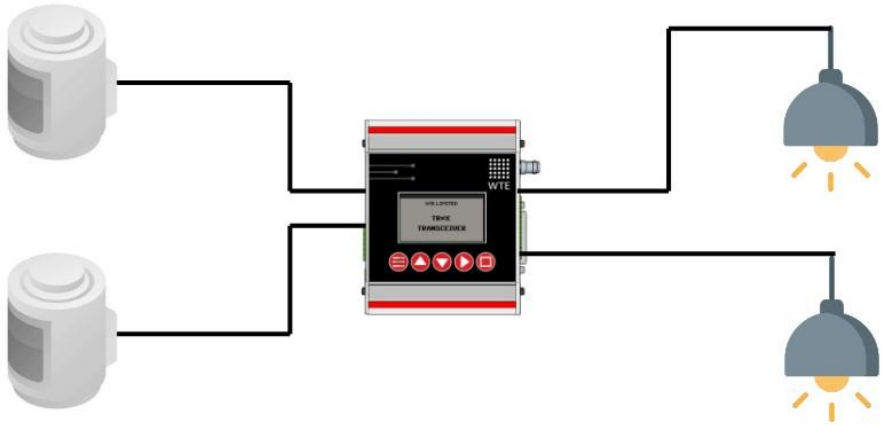




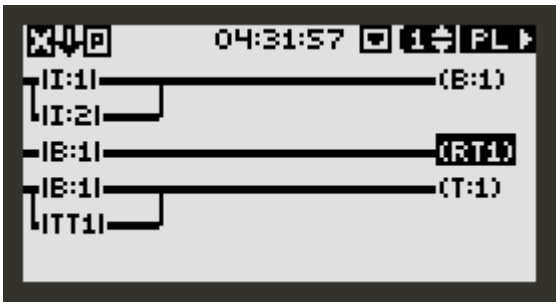
After pressing the start button, **Output 1** is held closed until **Input 2** is opened by pressing the stop button.

```
PLC Configuration:
*PLC_RUNG=01:[I:1]-------[I:2]-------[-]---------(Q:1)
*PLC_RUNG=02:[Q:1]---+   [-]          [-]
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

Motion-Activated Lights



A TReX-460 is set up with two motion sensors connected to **Input 1** and **Input 2** that provide a **normally open** input signal until movement is detected and two lights connected to the TReX via inputs on **Output 1** and **Output 2**. The motion sensors are set up at opposite ends of a large room. The intended behaviour is to have the lights turn on and stay on for **10 minutes** every time motion is detected. After **10 minutes** of no detected motion, the lights should automatically turn off. The configuration for this behaviour is shown below:



Screen 1 displays the input handling, timer reset and timer latching mechanisms. The input handling (rungs 1 and 2) sets **Work Bit 1** if either motion sensor is currently detecting movement. The timer reset mechanism restarts the timer if motion has been detected and **Timer 1** is already running. The timer latching mechanism is necessary as the timer will not remain active unless the rung is also active. Therefore, the latching mechanism will keep the timer active for the duration of it's set time using the **Timer Timing 1** input. Screen 2 displays the output control mechanism, which keeps **Output 1** and **Output 2** turned on while either the timer is active or motion is currently being detected.

This PLC program requires configuration of **Timer 1** to a value of 6000, or 10 minutes. The maximum time that the lights will stay turned on is configurable through this menu entry.

```
PLC Configuration:
*PLC_RUNG=01:[I:1]-------[-]---------[-]---------(B:1)
*PLC_RUNG=02:[I:2]---+   [-]         [-]
*PLC_RUNG=03:[B:1]-------[-]---------[-]---------(RT1)
*PLC_RUNG=04:[B:1]-------[-]---------[-]---------(T:1)
*PLC_RUNG=05:[TT1]---+   [-]         [-]
*PLC_RUNG=06:
*PLC_RUNG=07:[TE1]-------[-]---------[-]---------(Q:1)
*PLC_RUNG=08:                                   +-(Q:2)
*PLC_RUNG=09:
*PLC_RUNG=10:
*PLC_RUNG=11:
*PLC_RUNG=12:
```

Wireless Motion Activated Light

In this example, a motion sensor being used to activate a timed light. The light needs to stay on while the motion sensor is being triggered, and turn off after 30 seconds inactivity time.

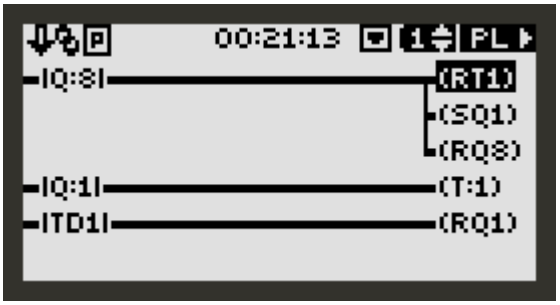
In this configuration:

Q:8: is being latched on, by a message received from the wireless sensor. The TReX receives a standard **WT Output Protocol** message from the sensor instructing it to close **Digital Output 8**. By configuring the wireless motion sensor to transmit this message (**[[01]8-]**), the PLC program can be started without the need for a physical connection.

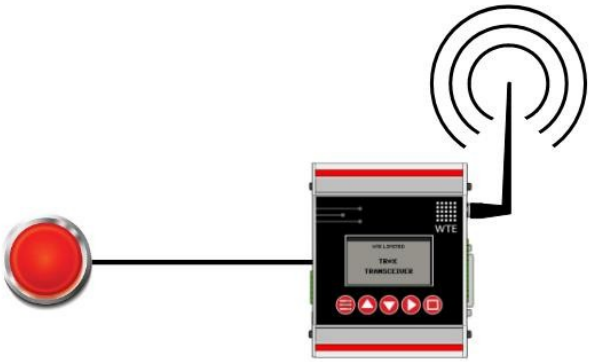
Q:1 is the output controlling the light.

T:1 is the timer, that is reset each time a message is received from the wireless sensor.

```
PLC Configuration:
//With every new incoming message, reset the "light on" timer
*PLC_RUNG=01:[Q:8]-------[-]---------[-]---------(RT1)
//Immediately turn on the light
*PLC_RUNG=02:                                   +-(SQ1)
//Clear the output set each time a message is received.
*PLC_RUNG=03:                                   +-(RQ8)
//Keep the timer running as long as the light is turned on.
*PLC_RUNG=04:[Q:1]-------[-]---------[-]---------(T:1)
//As soon as the timer expires through inactivity, turn off the light
*PLC_RUNG=05:[TD1]-------[-]---------[-]---------(RQ1)
*PLC_RUNG=06:
```



Delayed Action Transmitter



A TReX-460 is set up with a single **normally closed** button connected to **Input 1**. The intended behaviour is to have the TReX transmit a message when the button is held open for **30 seconds**.

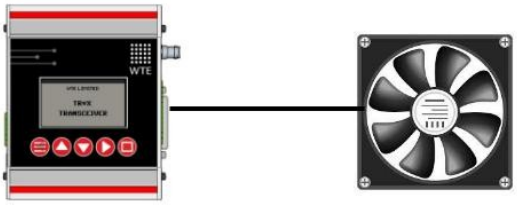

```
PLC Configuration:
*PLC_RUNG=01:[/I:1]------[-]---------[-]---------(T:1)
*PLC_RUNG=02:[TD1]-------[-]---------[-]---------(M:1)
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

For this PLC program to function, a **macro** must be configured. This is done by adding the following line to **MACRO.TXT** in the TReX-460s internal filesystem:

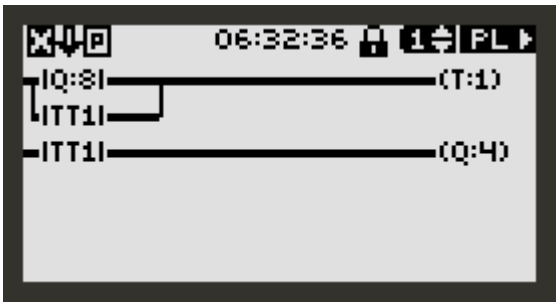
```
<M:1>WT1234560A1B DELAYED MESSAGE</M:1>
```

Rung 1 ensures that the timer only starts and runs while the button on **Input 1** is held open. If the button is released before the **Timer 1** completes, **Timer 1** will be reset. **Rung 2** manually triggers **Macro 1** once **Timer 1** has completed. Once **Macro 1** has been triggered, the message is transmitted.

Alert-Based Cooling System

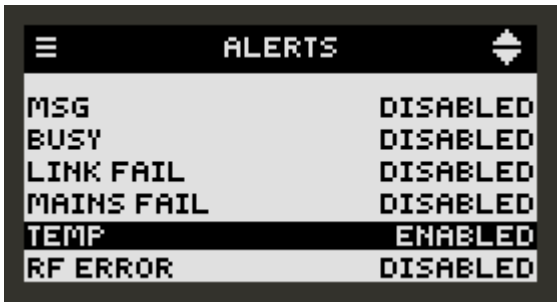


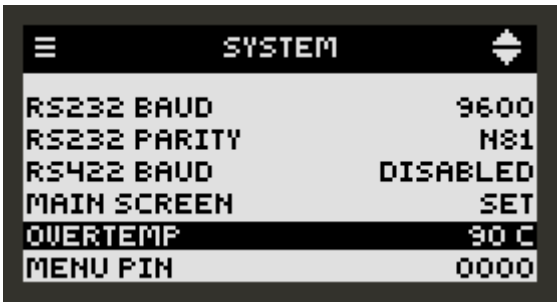
In this example, a TReX-460 is set up in a hot environment with a cooling fan controlled from **Digital Output 4**. The intended behaviour is that the TReX will turn on the cooling fan for 10 minutes whenever it's onboard temperature sensor passes 90°C.




```
PLC Configuration:
*PLC_RUNG=01:[Q:8]-------[-]---------[-]---------(T:1)
*PLC_RUNG=02:[TT1]---+   [-]         [-]
*PLC_RUNG=03:[TT1]-------[-]---------[-]---------(Q:4)
*PLC_RUNG=04:
*PLC_RUNG=05:
*PLC_RUNG=06:
```

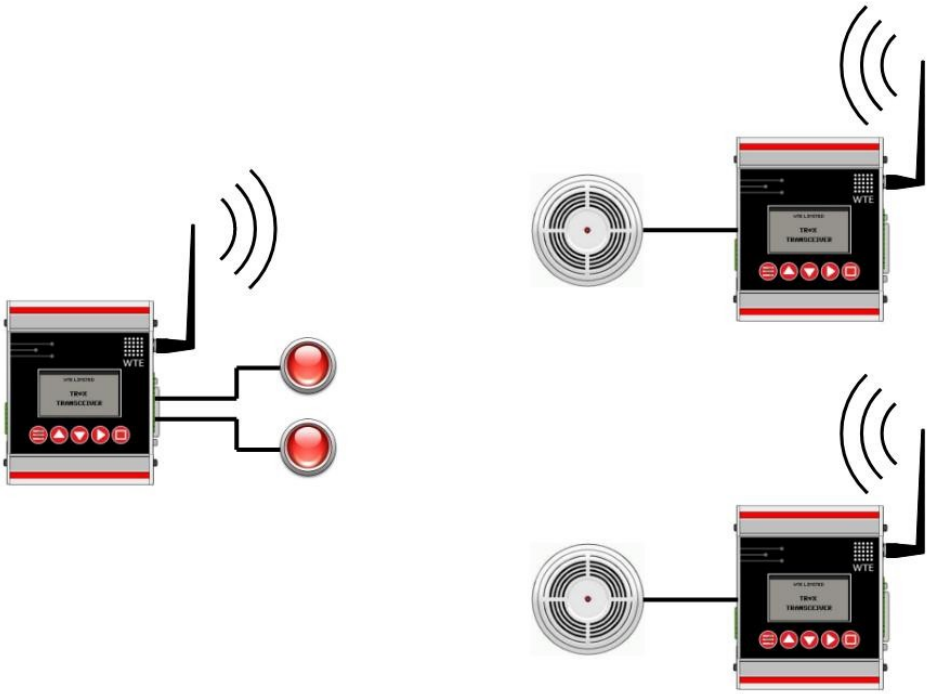
This PLC program requires the configuration of the **Temperature Alert**, the **Alert Output** and the **Overtemp**. The first two configuration items can be found in the **ALERTS** sub-menu of the main configuration menu and the third can be found in the **SYSTEM** submenu of the main configuration menu.





This PLC program takes advantage of the **Alert Output** functionality of the TReX-460 to provide an intelligent response to alert events. This is achieved by using the configured alert output (**Output 8**) as an input to the PLC program.

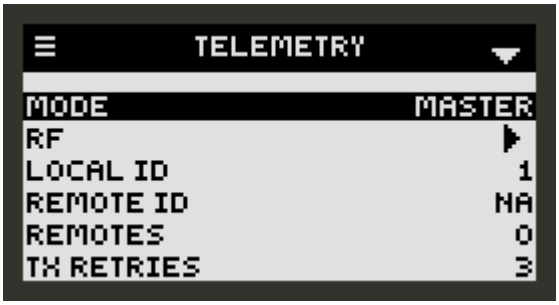
Simple Multi Unit Alarm System



In this example, one TReX-460 is configured as a **SCADA Master Device** and two TReX-460s are configured as **SCADA Slave Devices**. The **Master Device** has two LED indicators connected to **Output 1** and **Output 2**, while both slave devices have smoke sensors connected to **Input 6**. The intended behaviour for this configuration is when a **Slave Device** detects smoke, the corresponding indicator light connected to the **Master Device** should be switched on.

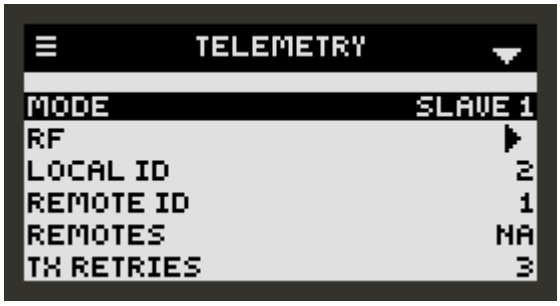
A PLC configuration is not required on remote units.

Master Unit Configuration (ID:01)

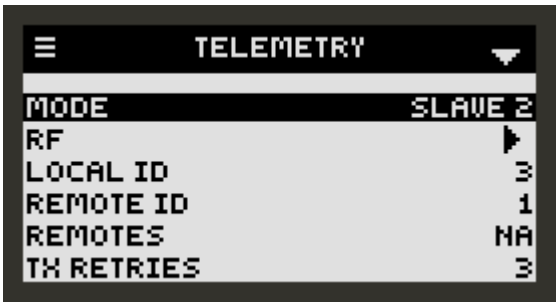



```
PLC Configuration:
*PLC_RUNG=01:[1i6]-------[-]---------[-]---------(Q:1)
*PLC_RUNG=02:[2i6]-------[-]---------[-]---------(Q:2)
*PLC_RUNG=03:
*PLC_RUNG=04:
*PLC_RUNG=05:
```

Slave Unit 1 Configuration (ID:02)



Slave Unit 2 Configuration (ID:03)



PLC Advanced Programming

Complex programming is possible, using serial inputs to control formatted serial output and reconfiguration of the TReX during program operation. This flexibility allows integration with third party devices or to extend the TReX feature set.

In the following example, the TReX is being used to accept a serial command, and format outgoing serial messages for connection to an AT command set serial modem. The basic operational intent is to notify the user should the modem become disconnected and follow a simple sequence, reformatting a message that can then be accepted by the modem for transmission.

Note: This example is supplied purely as an indication of a valid useful application, and although it has been tested there is no claim that it is complete, or fit for any general use.

The PLC program uses:

- WT protocol to parse key information used in message and to initiate transmission.
- Serial inputs, to match content received from an AT command set modem.
- Macros (defined in MACRO.TXT) to manage outgoing serial content, and to provide user feedback.
- Timers to control state transitions and notify on error conditions.

PLC Program:

```
PLC Configuration:<0D><0A>
*PLC_RUNG=01:[-]---------[-]---------[-]---------(T:1)  // Enable Modem present poll timer (10 seconds)
*PLC_RUNG=02:[TD1]-------[-]---------[-]---------(M:1)  // Every 10 seconds send, AT+CMGF=1$0D macro 1
*PLC_RUNG=03:                                   +-(RT1)  // Start poll timer again.
*PLC_RUNG=04:
*PLC_RUNG=05:[-]---------[-]---------[-]---------(T:2)  // Enable Modem no response timer (20 seconds)
*PLC_RUNG=06:[TD2]-------[-]---------[-]---------(M:7)  // If timer expires, display "Not Connected"
*PLC_RUNG=07:                                   +-(RB1)  // Clear flag indicating that the modem is not connected.
*PLC_RUNG=08:                                   +-(SB4)  // Flag that cleanup for next is required.
*PLC_RUNG=09:
*PLC_RUNG=10:[B:21]------[-]---------[-]---------(RT2)  // If the serial content AT+CMGF seen, this is a response to the Modem present Poll
*PLC_RUNG=11:                                   +-(RB21) // Allow another AT+CMGF to be detected.
*PLC_RUNG=12:                                   +-(SB1)  // Set flag indicating modem is connected.
*PLC_RUNG=13:
*PLC_RUNG=14:[B:1]-------[-]---------[-]---------(M:6)  // Any time that the modem becomes connected display "Connected"
*PLC_RUNG=15:[B:64]------[B:1]-------[-]---------(SB2)  // Set flag that WT seen, and ready to send message to modem.
*PLC_RUNG=16:
*PLC_RUNG=17:[B:64]------[TT3]-------[-]---------(M:10) // If another WT message attempted to be queued for transmission while busy, indicate BUSY
*PLC_RUNG=18:                                   +-(RB2)
*PLC_RUNG=19:
*PLC_RUNG=20:[B:64]------[-]---------[-]---------(RB64) // Allow another WT protocol message detection.
*PLC_RUNG=21:[B:2]-------[-]---------[-]---------(M:2)  // Send AT+CMGS=$W2 to modem.  $W2 is the phone number from the WT protocol message
*PLC_RUNG=22:
*PLC_RUNG=23:[B:2]-------[-]---------[-]---------(M:3)  // Send $W3$1A which include the SMS message content from the WT message.
*PLC_RUNG=24:                                   +-(SB3)  // Set Ready to send SMS message flag
*PLC_RUNG=25:[B:3]-------[-]---------[-]---------(M:9)  // Display POPUP "QUEUED"
*PLC_RUNG=26:
*PLC_RUNG=27:[B:3]-------[-]---------[-]---------(T:3)  // Start timer, waiting for success response
*PLC_RUNG=28:[TD3]-------[-]---------[-]---------(M:4)  // Send FAILED POPUP.
*PLC_RUNG=29:                                   +-(SB4)  // Flag that cleanup for next is required.
*PLC_RUNG=30:
*PLC_RUNG=31:[B:22]------[-]---------[-]---------(M:5)  // If send OK message seen (+CMGS 209), send "SUCCESS" POPUP
*PLC_RUNG=32:                                   +-(SB4)  // Flag that cleanup for next is required.
*PLC_RUNG=33:
*PLC_RUNG=34:[B:4]-------[-]---------[-]---------(RB4)  // If "cleanup required" flagged, clean up all variables ready for next detection.
*PLC_RUNG=35:                                   +-(RB3)  // Allow another attempt to send
*PLC_RUNG=36:                                   +-(RB22) // Allow another send OK message detection.
*PLC_RUNG=37:                                   +-(RB2)  // Clear the WT protocol seen flag
```

Timers:
*PLC_TMR=1:TON,100 //10 seconds – How often the modem is polled
*PLC_TMR=2:TON,300 // 30 seconds – Disconnect timeout
*PLC_TMR=3:TON,100 // 10 seconds, How waiting for response from modem

Serial Match:
*PLC_MATCH=2:21,AT+CMGF=1 // Returned from modem when polled
*PLC_MATCH=3:22,+CMGS 209 // Returned from modem on successful send.

PLC Macro File Content:
<M:1>WTSAT+CMGF=1$0D</>
<M:2>WTSAT+CMGS=$W1$0D</>
<M:3>WTS$W2$1A</>
<M:4>*POPUP=SMS,FAILED TO SEND
WTSFAILED$0D</>
<M:5>*POPUP=SMS,SEND SUCCESS</>
<M:6>*POPUP=SMS,Modem Connected</>
<M:7>*POPUP=SMS,Modem Disconnected</>
<M:9>*POPUP=SMS,QUEUED</>
<M:10>*POPUP=SMS,BUSY</>

Initiating a Transmission

When the TReX receives WT0000000A10 64226073333,Message Body<CR> the TReX will automatically store "**64226073333"** as argument 1 (accessible using the macro extension $W1). Also stored will be "**Message Body**" as argument 2 (accessible using $W2). When each WT protocol message is received with a RIC of 0000000, these arguments will be updated and a PLC work bit (B:64) will be set. This allows the PLC program to be notified of a new incoming message for transmission.

The macro file is MACRO.TXT that must be stored on the TReX internal storage.
*POPUP is used in many macros and is very useful for PLC program debugging. In the same way the *POPUP command is used, any other TReX command can be executed.
The WTS command is also used in many macros. This is the preferred method to output serial data.

Macro 2 uses: <M:2>WTSAT+CMGS=**$W1**$0D</>.
Serial output from the TReX will be:
AT+CMGS=**64226073333**<CR>

Macro 3 uses: <M:3>WTS**$W2**$1A</>
Serial output from the TReX will be:
Message Body<\x1a>
Macro 4 has multiple commands that are executed. First a popup is displayed, then serial

output of “FAILED<CR>”.

PLC Configuration Tool

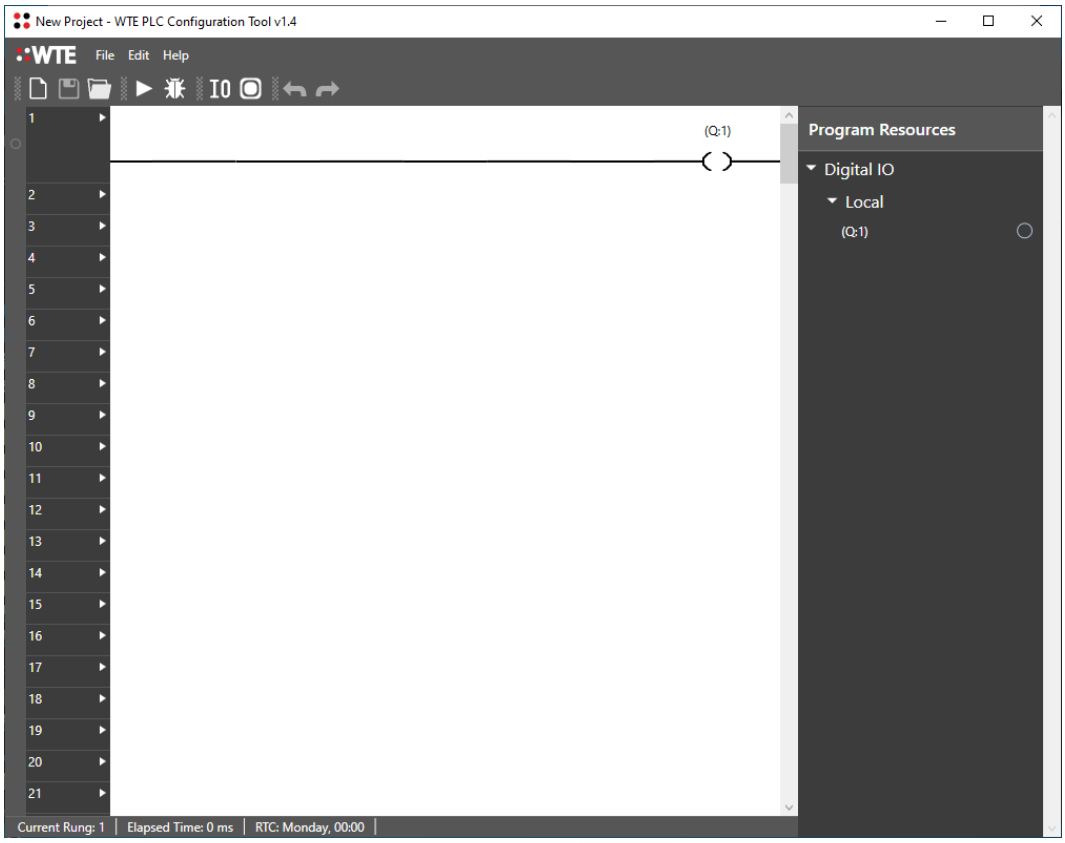
The WTE PLC Configuration Tool is a desktop application designed to enable fast development of TReX PLC programs. This tool is available free of charge. The WTE PLC Configuration tool gives the ability to not only construct TReX PLC programs, but to also run and debug these programs in a simulated TReX environment. The WTE PLC Configuration tool also provides tools for annotation and documentation of programs, allowing for clear and straightforward communication in a collaborative development environment.

Getting Started

To install the WTE PLC Configuration Tool, download the installer .zip from https://wte.co.nz/tools. To start the installation process, run "Install PLC Configuration Tool.exe" from the downloaded .zip file. Follow the steps provided by the installer to install both the configuration tool as well as any pre-requisite software.

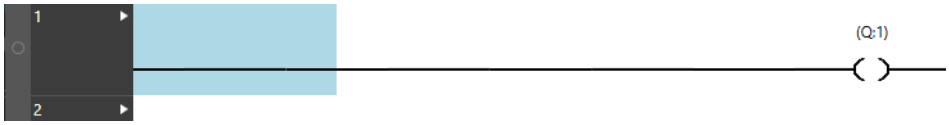
Creating a Project

With the program now installed, opening the program will create a default empty project, with a single main rung enabled.

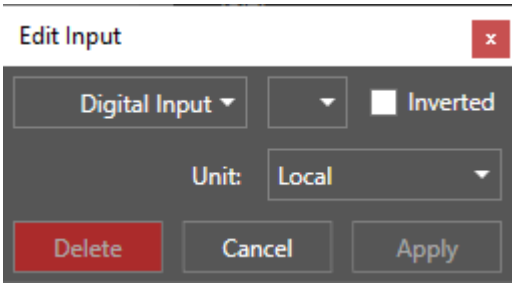


Adding/Modifying Rung Inputs

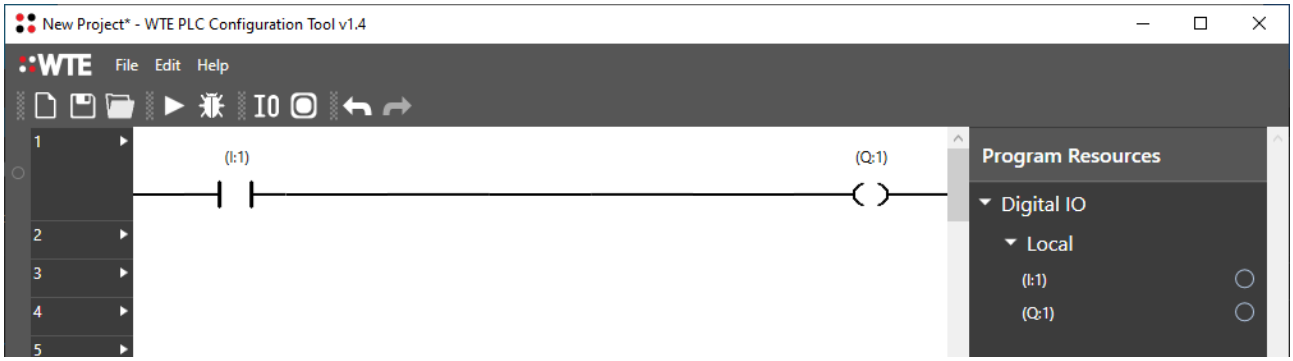
To add an input to this rung, hold the cursor over any area of the rung. The input that is currently selected will be highlighted in blue.



Clicking a given highlighted area will open a dialog window wherein the given input can be configured.

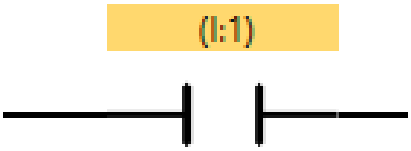


Selecting "1" from the drop-down menu will assign Digital Input 1 to this rung input. Digital Input 1 will also appear on the application sidebar on the right-hand side of the screen.

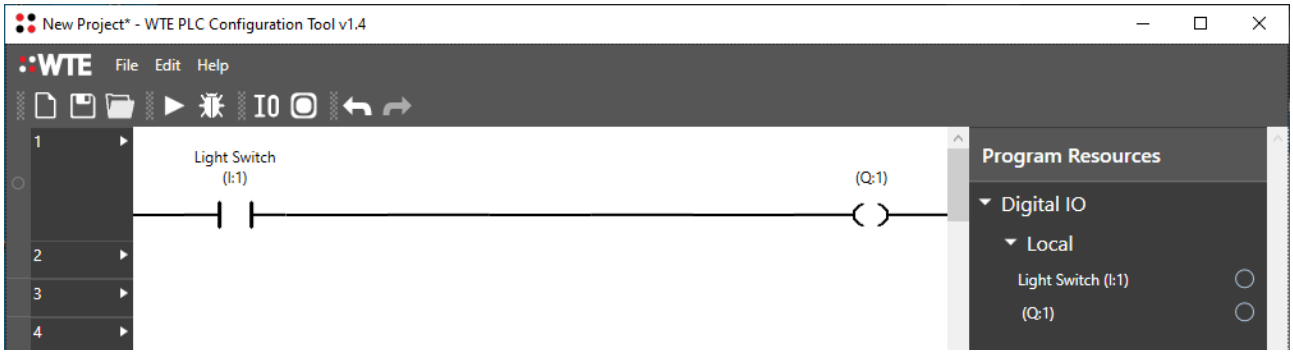


Adding/Editing Annotations

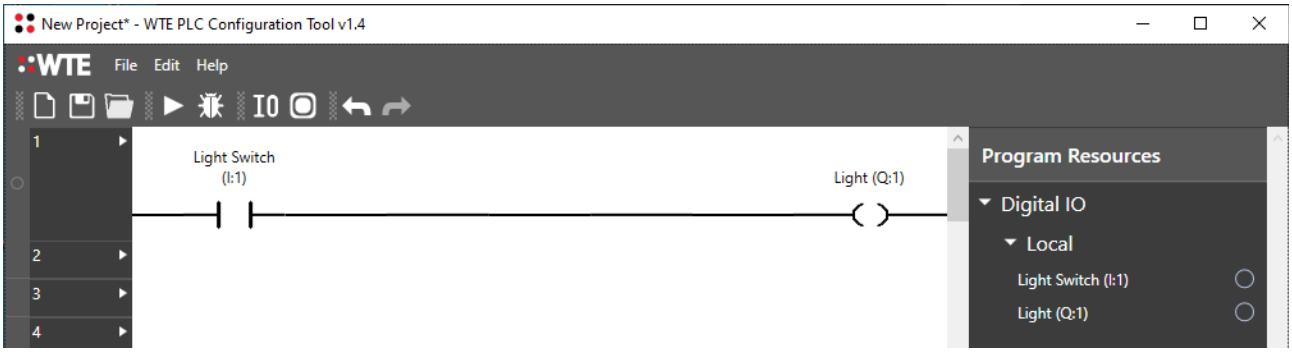
For most (I:1) will not be descriptive enough to clearly indicate an input's purpose in a program. To remedy this, the annotation (I:1) can be selected and a nickname to the input can be given. In this case, the input is named "Light Switch".



This new name for the input is displayed on the application sidebar as well as above the input itself.



The same process can be used to apply an annotation to the digital output. In this case, it will be named "Light".

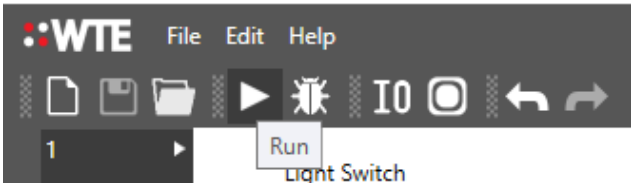


Saving Projects

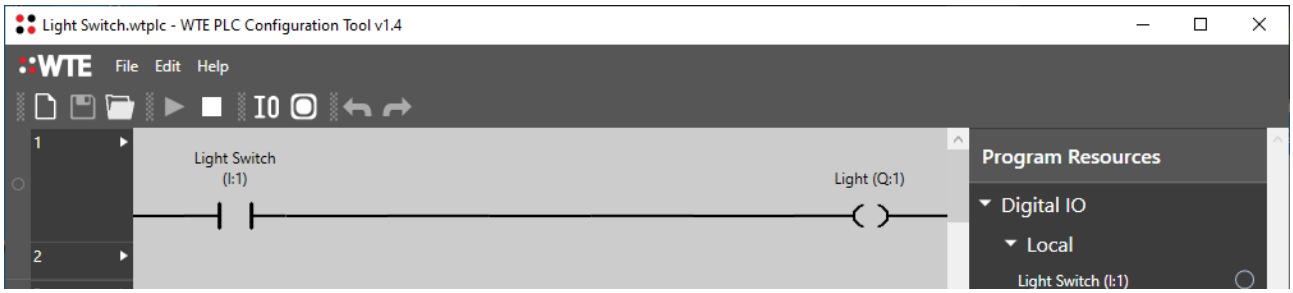
This PLC Program now has a basic level of functionality. To save this program, select either the "Save" button in the toolbar at the top of the program, or select File->Save Project. This will allow the project to be saved as a WTE PLC file (.wtplc).

Running Simulated Programs

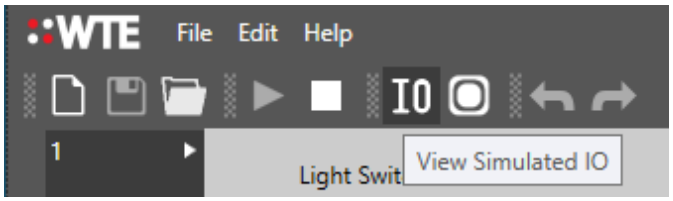
This PLC program can be tested in a simulated TReX environment. To start a simulation run, select the "Run" icon in the application toolbar.



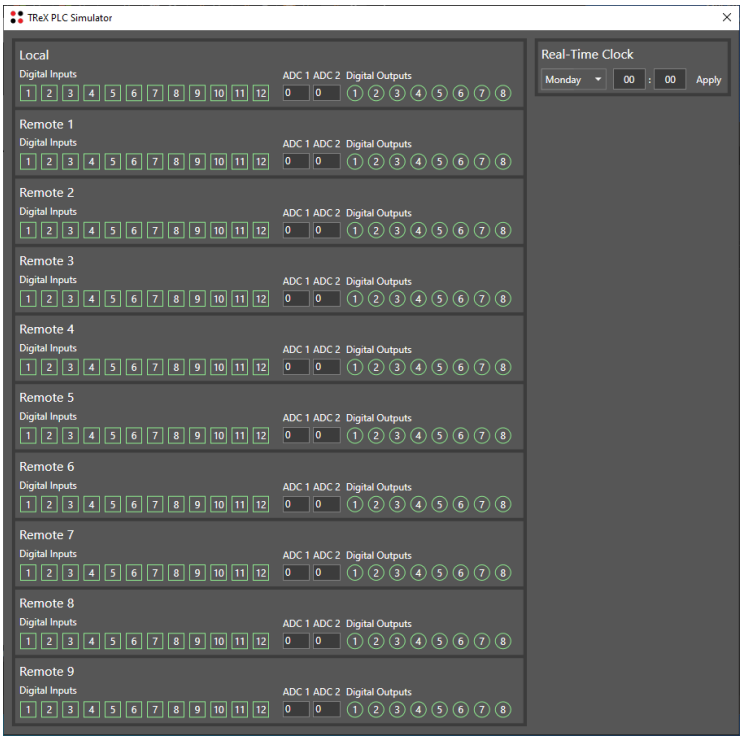
Running PLC programs are indicated by a darker background behind the PLC rungs display. Note that the PLC program cannot be editing while it is running or being debugged.



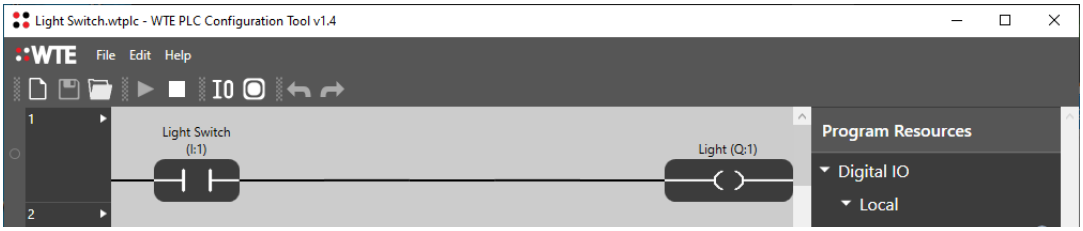
This particular program requires the use of physical digital IO to function. An interface for simulated IO can be opened by selecing the “View Simulated IO” button from the application toolbar.



This will open the PLC Simulator screen, which provides simulated IO for one local unit and nine remote units. This example currently only makes use of the “Local” unit.



Selecting Digital Input 1 of the "Local" device will enable that input in the PLC Program. This will result in the corresponding rung input to become energized as well as the rung output. An energized rung input or output is denoted by a dark rectangle surrounding a white input/output symbol.



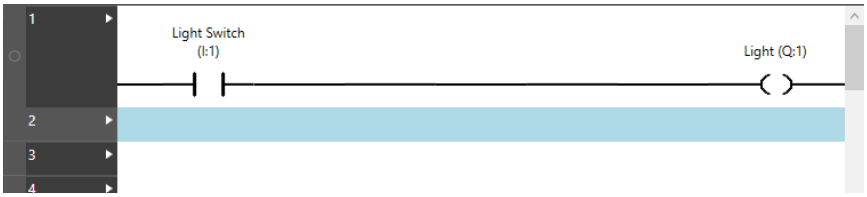
Returning to the simulated IO window, Digital Output 1 is now enabled. Toggling of Digital Input 1 results in toggling of Digital Output 1.

Adding Rung Branches

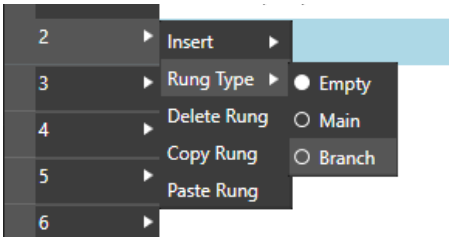
The next step in this example is to add a branching path to the first rung of the program. First, to continue editing the program, select the "Stop" icon from the application toolbar. Note that

this icon is only visible while the program is running.

With the PLC program no longer running, select the second rung by hovering the mouse over the button to the left of rung 2. When hovering over the button, the entire rung will be highlighted in blue.

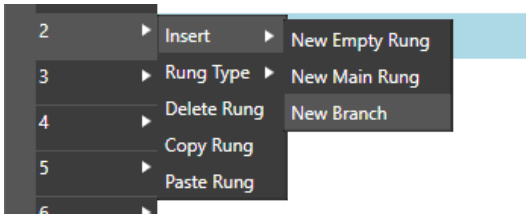


Select this button, then select Rung Type->Branch.



This will convert the empty rung into a new branch, with a default input at position 1.

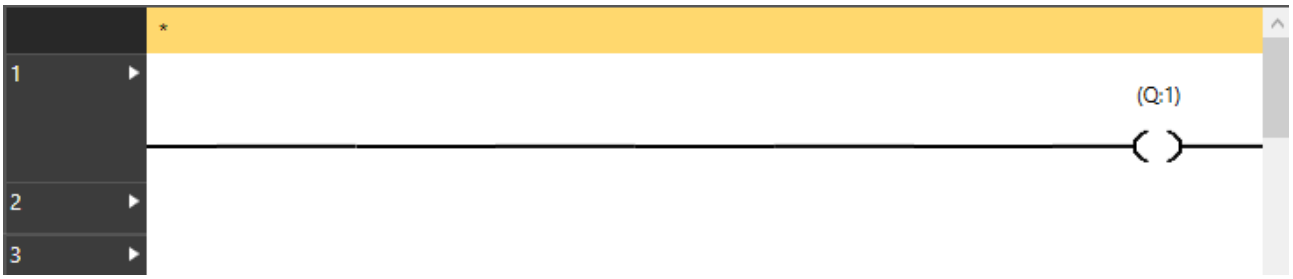
To insert a new branch rather than overwrite an existing rung, select Insert->New Branch.



This will insert a new branch below the selected rung, shifting lower rungs down by one place. Note that if a rung is used at the bottom of the program, inserting a rung in this manner will cause the information on this rung to be lost. The PLC Configuration Tool will warn the user if this is about to occur.

Rung Comments

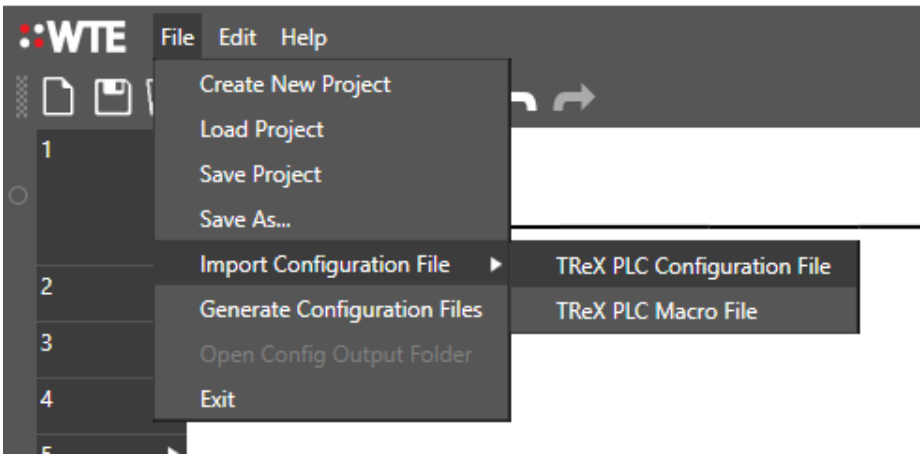
Main rungs support the addition of comments, allowing for detailed descriptions of program sections. To add a comment to a main rung, select the rung control menu, then Insert->Main Rung Comment. This will create an empty rung comment above the selected rung.



Selecting this comment allows the user to edit the text contained within. The comment supports multiple lines of text for detailed descriptions. To remove a rung comment, simply delete all text contained within. The empty comment will disappear when either the “Enter” or “Escape” key are pressed, or the cursor is clicked elsewhere within the window.

Importing TReX Configuration Files

Existing TReX PLC configuration files and macro files can be imported into the PLC Configuration Tool for easy editing and simulation. To import a TReX PLC configuration file, select File->Import Configuration File->TReX PLC Configuration File.



This will open a dialog window through which the PLC configuration file (typically named WTE_PLC.INI) can be selected. Upon selection, the PLC program will be displayed on the

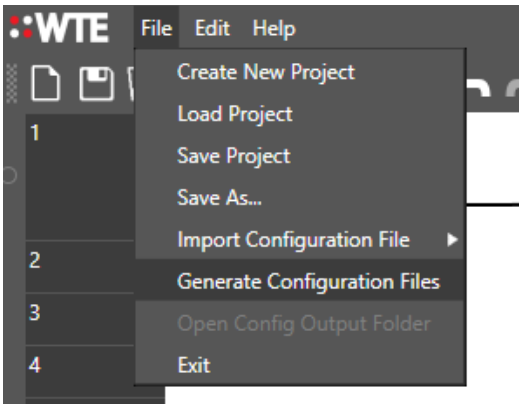
main window.

Note that importing a configuration file does **NOT** create a new project, instead overwriting the current PLC program. Ensure that the current project has been saved before attempting to import an existing PLC program.

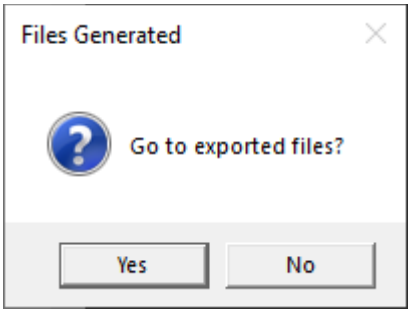
To import a TReX PLC macro file (typically named MACRO.TXT), instead select File-> Import Configuration File->TReX PLC Macro File. A similar dialog window will appear to select the macro file. Note that macros are only displayed in the sidebar if they are currently used in the PLC program.

Exporting PLC Configuration Files

Once a program has been created and tested thouroughly through the provided simulation tools, configuration files containing the program and any associated macros can be generated by selecting File->Generate Configuration Files.

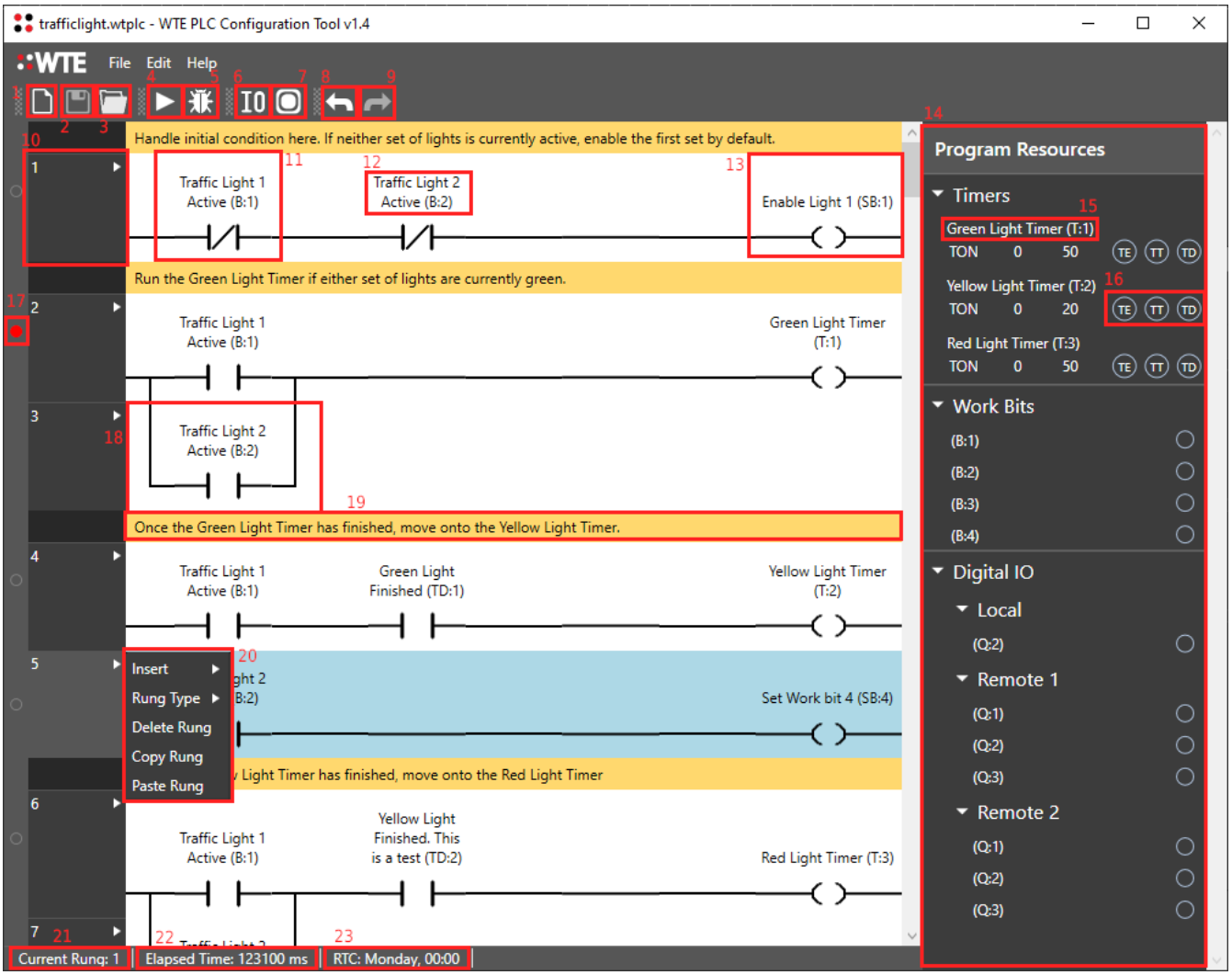


This will generate both a WTE_PLC.INI file and a MACRO.txt file in a pre-defined location within the program directory. A popup will appear asking whether to open the output folder. Selecting “Yes” will open the folder in using the system file browser.



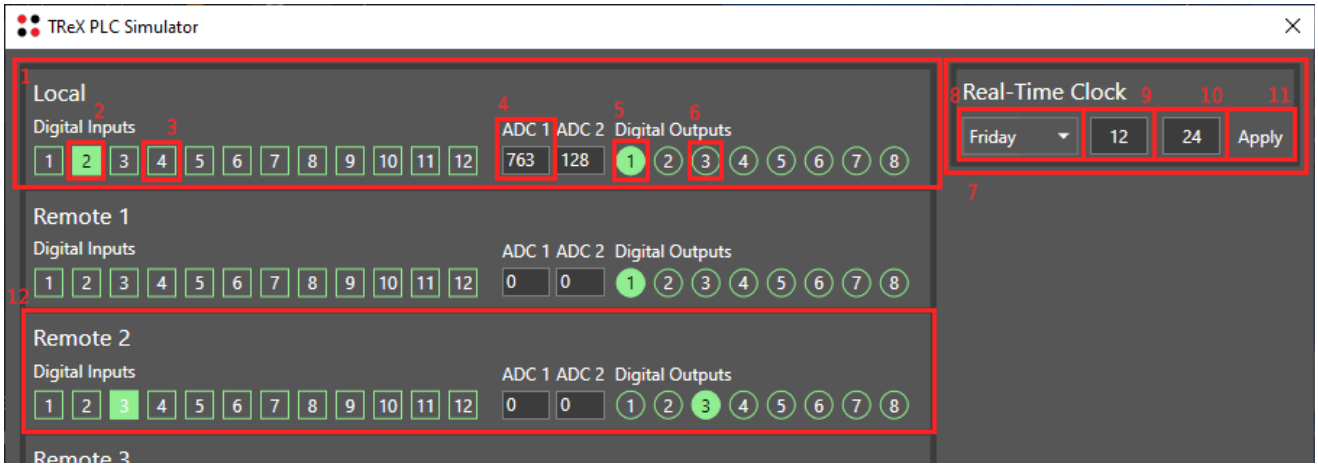
These files can be loaded onto a WTE TReX PLC device through the device’s USB Mass Storage functionality. Once loaded, the PLC program can be run locally on the device.

Main Window



1. Create New Project.
2. Save Current Project
3. Open Existing Project File
4. Run Program Button
5. Debug Program Button
6. Open Simulated IO Window
7. Open Memory Bits Display
8. Undo Last Edit
9. Redo Previous Edit
10. Rung Control Menu Button
11. PLC Rung Input
12. Rung Input Annotation
13. PLC Rung Output
14. Program Resources Overview
15. Resource Annotation
16. Resource Status Flags
17. Debug Breakpoint
18. PLC Branch Input
19. Rung Comment
20. Rung Control Menu
21. Currently Debugged Rung
22. Current Program Run Time
23. Current RTC Values

Simulator Window

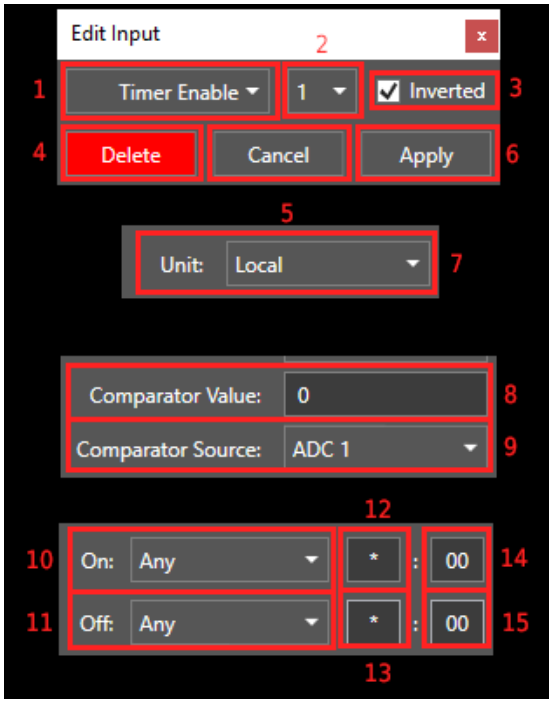


1. Local Simulated Unit
2. Active Digital Input
3. Inactive Digital Input
4. Analog Input
5. Active Digital Output
6. Inactive Digital Output
7. Real-Time Clock Overview
8. RTC Day Selection
9. RTC Hour Selection
10. RTC Minute Selection
11. Apply RTC Changes
12. Remove Simulated Unit

Notes

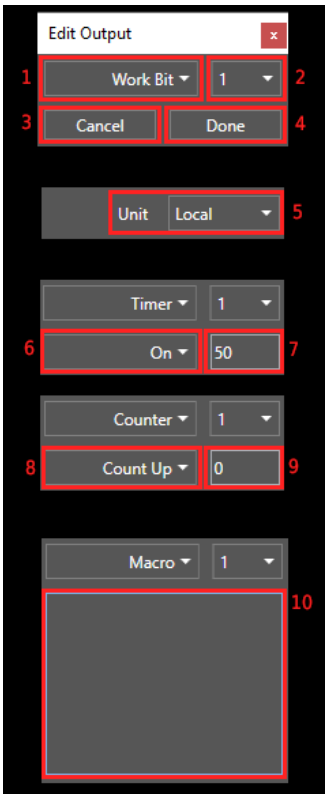
The TReX PLC Simulator window provides a view of all simulated TReX devices, as well as control over the Real-Time Clock of the simulated Local unit. Digital and analog inputs as well as digital outputs can be set using the provided controls. The simulated RTC does not change over time and must be manually set when the user wishes to trigger/clear alarms.

Input Configuration Window



1. Input Type Selection
2. Input Number Selection
3. Input Inversion Selection
4. Clear Input
5. Cancel Editing and Discard Changes
6. Apply Changes to Input
7. Input Unit Selection (Digital Inputs, Digital Outputs and Comparators Only)
8. Comparator Threshold Value (Comparators Only)
9. Comparator Source (Comparators Only)
10. Alarm On Day (Alarms Only)
11. Alarm On Hour (Alarms Only)
12. Alarm On Minute (Alarms Only)
13. Alarm Off Day (Alarms Only)
14. Alarm Off Hour (Alarms Only)
15. Alarm Off Minute (Alarms Only)

Output Editor Window



1. Output Type Selection
2. Output Number Selection
3. Discard Changes and Close Editor
4. Save Changes and Close Editor
5. Output Unit Selection (Digital Outputs Only)
6. Timer Type Selection (Timers Only)
7. Timer Trigger Time Selection (Timers Only)
8. Counter Type Selection (Counters Only)
9. Counter Trigger Value Selection (Counters Only)
10. Macro Editor (Macros Only)

Notes

The macro editor window supports up to 8 separate commands with the total length of all commands being 300 characters. Text input will not be accepted by the editor beyond this limit.

Debugging

1. Run Button
2. Stop Button
3. Pause Button
4. Step Button
5. Run Cycle Button

Notes

The Debug mode of operation includes several options for program execution. Initially, the Debug execution will begin in a paused state, allowing for single-stepped execution or single-cycle execution. While in the paused state, the “Pause” button is disabled.

Single-stepped execution involves executing a single rung when the “Step” button is pressed. The last rung executed is highlighted in red on the rung display. Pressing the “Step” button while a main rung is highlighted will result in the execution of the following main rung. This following rung will then be highlighted in red. Empty rungs and branches are skipped in single-step execution as they are ignored and executed simultaneously with their corresponding main rung respectively.

Single-cycle execution involves executing all remaining rungs in the program once when the “Run Cycle” button is pressed. For example, if the “Run Cycle” button is pressed while paused halfway through the rungs, only the remaining rungs of that cycle will be executed. If pressed while paused at the start of the PLC program, all rungs of the program will be executed.

Standard execution involves continuously running the PLC program until a rung with an enabled breakpoint is encountered. These breakpoints can be toggled any time before or during program execution. Once this breakpoint has been hit, the execution mode changes to single-stepped. Manually pausing the program will result in the program entering single-stepped execution at the start of the next cycle.

Project Examples

The WTE PLC Configuration Tool installation includes several example projects of varying complexity and usage of available resources. These examples are available in the “Examples” subdirectory of the program installation. Selecting “Load Project” for the first time will open this directory by default.

SCADA Support

SCADA (Supervisory Control And Data Acquisition) is a term used widely in many industries relating to monitoring and control systems. This section deals with the integration of the TReX into a SCADA system. This is an optional feature, that requires a feature key to be purchased.

Terminology

SCADA application:

This is a software package that is used to control and monitor devices. This could be free open source packages such as “Rapid SCADA” or “openSCADA”. Alternatively, this could be industry standard applications such as “WonderWare” or “LabView”.

SCADA system:

This is a system comprising of one or many TReX units monitoring equipment that the TReX units are connected to. This includes also the SCADA application.

MASTER:

This is the unit that is connected through Ethernet or another interface to a SCADA monitoring application.
This master unit can now control and hold the details of up to 10 TReX slaves. Input and output status of all units can be immediately requested or modified directly by the SCADA application.

To set the TReX as a master set MENU->TELEMETRY->MODE to MASTER.

SLAVE:

These TReX units are directly controlled by the TReX master. The slave’s primary function is to report input changes and/or operate its outputs upon a master request.

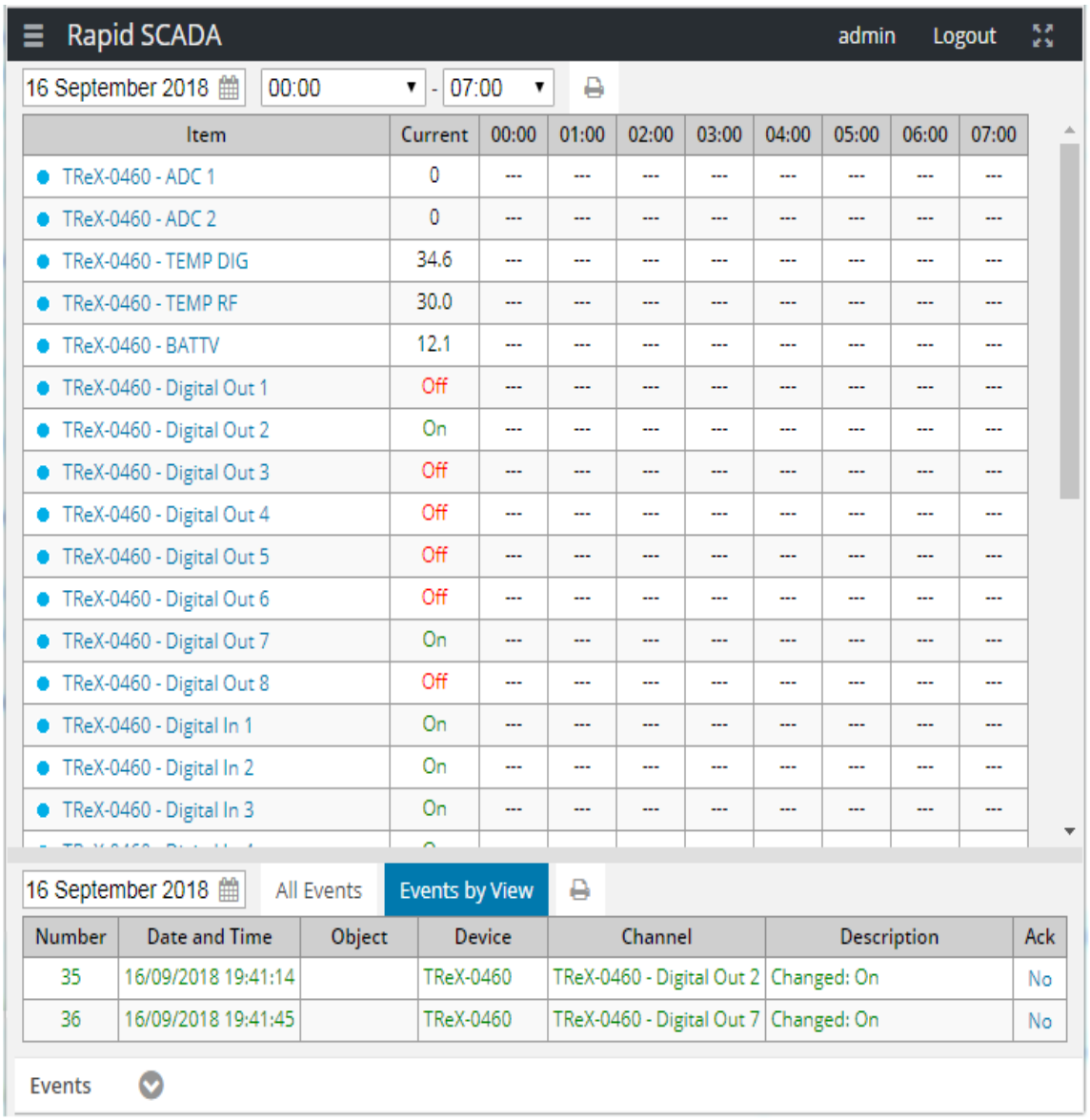
There may be up to 10 slave units, all located in different locations around a site, all monitoring and controlling different aspects of the SCADA system.

To set the TReX as a slave set MENU->TELEMETRY->MODE to SLAVE.

Working Example

As a simple working example shown below, web content is being served to a PC and mobile devices using the open source application “RapidSCADA”.

SCADA applications have the advantages to provide a means to notify through; email, paging messages, SMS or to generate alarms of critical system events.

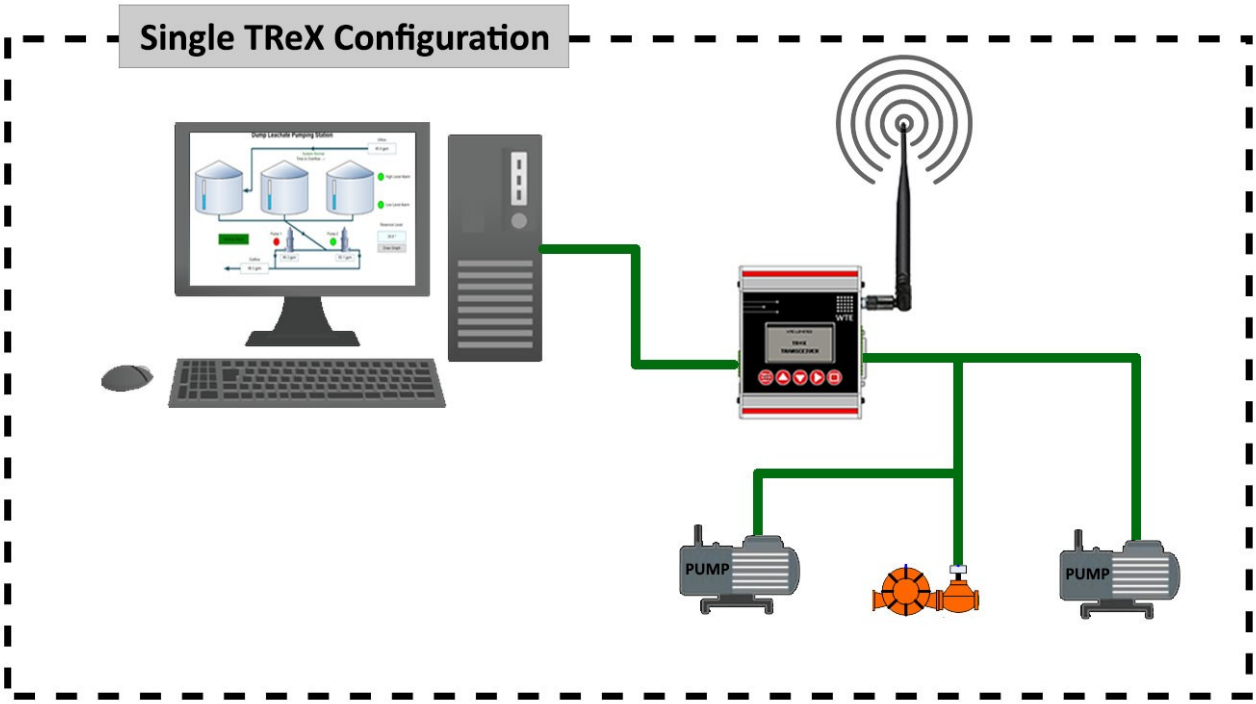


Item	Current	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00
TReX-0460 - ADC 1	0	---	---	---	---	---	---	---	---
TReX-0460 - ADC 2	0	---	---	---	---	---	---	---	---
TReX-0460 - TEMP DIG	34.6	---	---	---	---	---	---	---	---
TReX-0460 - TEMP RF	30.0	---	---	---	---	---	---	---	---
TReX-0460 - BATTV	12.1	---	---	---	---	---	---	---	---
TReX-0460 - Digital Out 1	Off	---	---	---	---	---	---	---	---
TReX-0460 - Digital Out 2	On	---	---	---	---	---	---	---	---
TReX-0460 - Digital Out 3	Off	---	---	---	---	---	---	---	---
TReX-0460 - Digital Out 4	Off	---	---	---	---	---	---	---	---
TReX-0460 - Digital Out 5	Off	---	---	---	---	---	---	---	---
TReX-0460 - Digital Out 6	Off	---	---	---	---	---	---	---	---
TReX-0460 - Digital Out 7	On	---	---	---	---	---	---	---	---
TReX-0460 - Digital Out 8	Off	---	---	---	---	---	---	---	---
TReX-0460 - Digital In 1	On	---	---	---	---	---	---	---	---
TReX-0460 - Digital In 2	On	---	---	---	---	---	---	---	---
TReX-0460 - Digital In 3	On	---	---	---	---	---	---	---	---

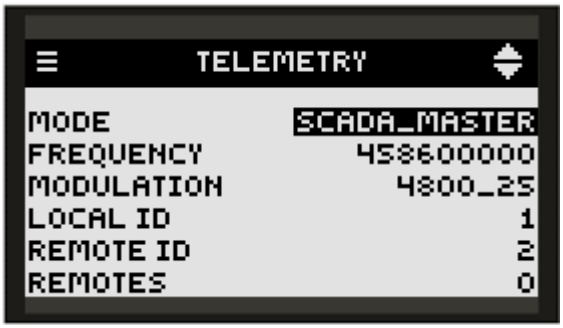
Number	Date and Time	Object	Device	Channel	Description	Ack
35	16/09/2018 19:41:14		TReX-0460	TReX-0460 - Digital Out 2	Changed: On	No
36	16/09/2018 19:41:45		TReX-0460	TReX-0460 - Digital Out 7	Changed: On	No

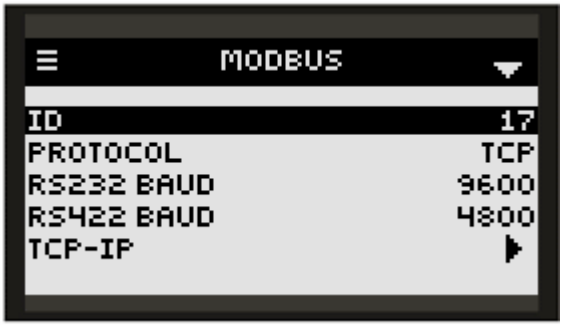
SCADA System Single TReX Configuration

This is a system that requires no expansion through use of SLAVE units.



Unit Configuration





Since this system configuration is only for a single TReX unit, the LOCAL ID and REMOTE ID fields are not used and can be set to anything. The MODBUS ID can be any value from 0-127 (except 42 or 87).

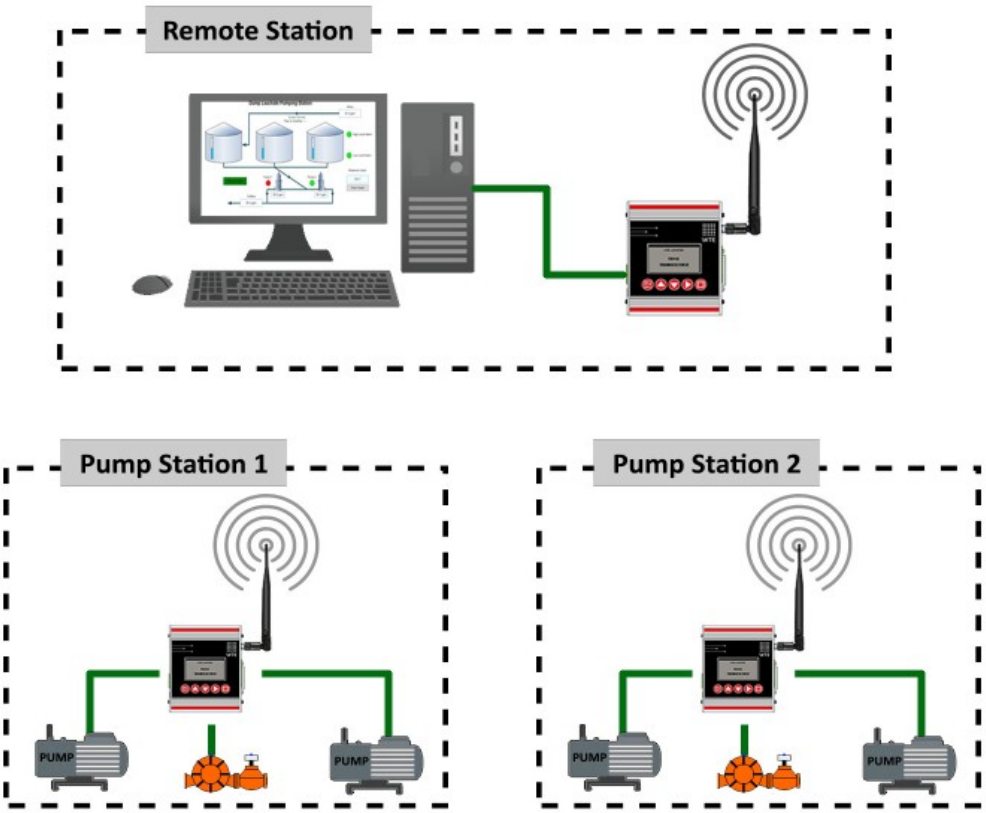
MENU->PROTOCOL->MODBUS is used to configure the key SCADA parameters, such as unit ID and the protocol. Typically, if an Ethernet connection is used, the TCP protocol will be used.

See **MODBUS Protocol** for more Modbus information**.**

SCADA System Multiple TReX Configuration

Up to 10 wireless SLAVES can be controlled by a MASTER.

A SCADA application will be able to monitor and control all TReX IO on the MASTER and SLAVE TReX units.



Simple Example

A remote station controlling two separate pump stations, where the “Remote Station” has a TReX units connected to a SCADA system and the “Pump Stations” may have several pumps and other I/O devices connected. Here the “Remote Station” is configured as MASTER and the “Pump Station” are configured as SLAVE units.

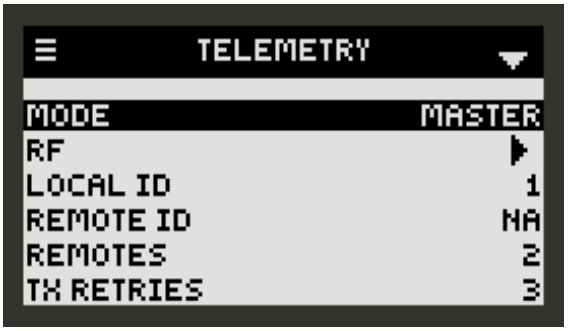
Example Configuration:

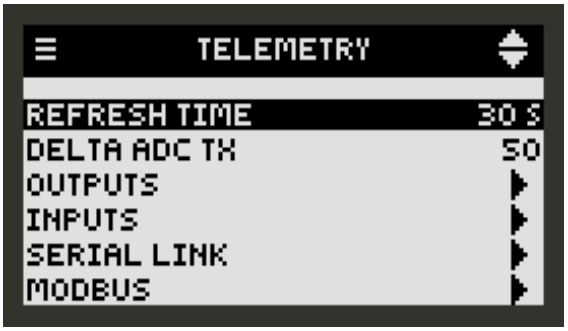
- “Remote Station” has a LOCAL ID configured to be 01.
- “Pump Station 1” SLAVE has a LOCAL ID of 02,
- “Pump Station 2” SLAVE has a LOCAL ID of 03,
- All Units have been configured to refresh I/O each 30 seconds (REFRESH TIME).

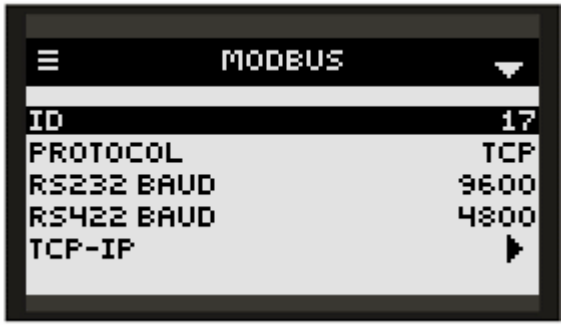
Note: Refreshing of SCADA status is immediate on any digital input change or any analogue input that changes by more than ADC counts configured in DELTA ADC TX.

Units Configuration

"Remote Station" Configuration



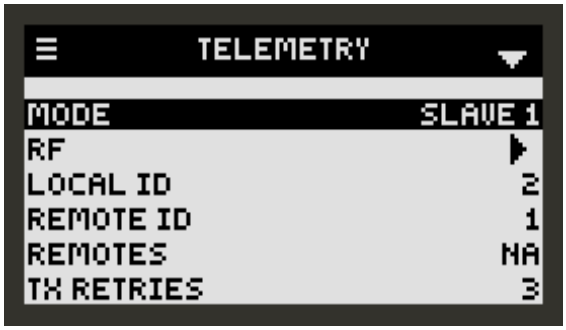


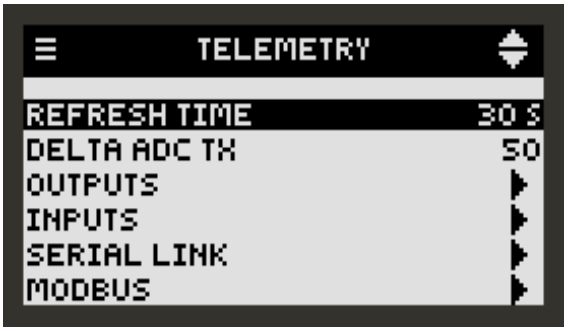


The LOCAL ID can configured to be any ID up to 240 (default "01"). When configured as a MASTER the first SLAVE unit ID is assumed have an ID that is one higher than the MASTER ID. This means that for a system, when an ID is selected by the MASTER, the next 9 unit IDs are allocated for connected SLAVE units 1-9. If the MASTER is configured to have an ID of 43, SLAVE 1 must be configured to have an ID of 44.

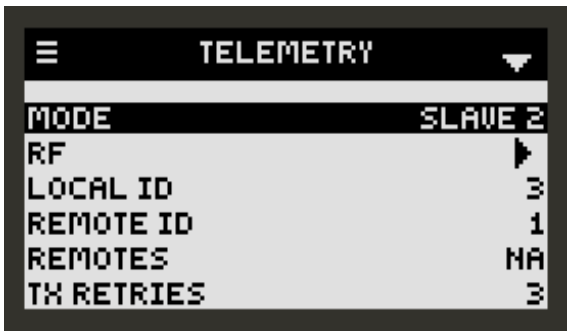
MODBUS ID can be any value from 0-127 (except 42 or 87).

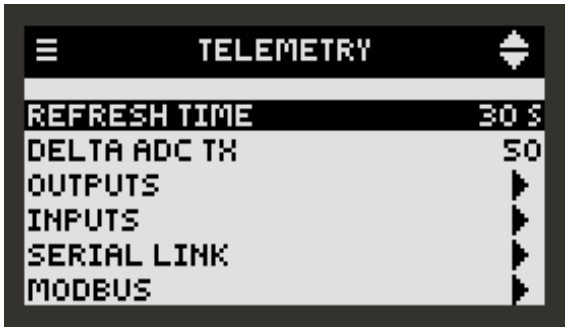
“Pump Station 1” Configuration





“Pump Station 2” Configuration





The MASTER unit has configured REMOTES to a value of 2 (meaning there are 2 SLAVE units). Note that first SLAVE ID must be set to a value one higher than the MASTER ID, and each SLAVE in the system must be consecutively numbered.

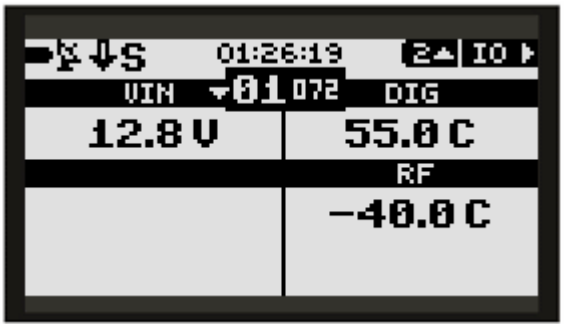
The SLAVE configuration is unique in that both the LOCAL ID and REMOTE ID need to be the same. In this configuration, the MASTER unit requires these settings in order to identify the SLAVE unit messages.

The SCADA application will report inputs 1-8 to be from “Remote Station”, inputs 9-16 from “Pump Station 1” and inputs 17-24 from “Pump Station 2”.

See **Modbus Protocol** for more information.

Viewing Multiple TReX Unit IO on the MASTER Unit.

The MASTER on the IO screens can view all system inputs and outputs without the need for a SCADA application. This is useful for debugging and installation.



Shown in this case is the number “01”, followed by “069”, where“01” in this case is the UNIT ID in the system. The “069” is a “link fail” counter used to determine loss of communication for a unit. This number is reset whenever a new message is decoded from a SLAVE unit.

Pressing the DOWN button will cycle through all the remote UNIT IDs in the system, displaying all system IO, link states, temperatures and battery voltages.

IO Mirror Operation

The IO MIRROR is the simplest self managed telemetry mode that mirrors the inputs of one TReX unit to the outputs of another TReX unit.

SCADA monitoring and control is not possible in this mode of operation (see **SCADA Configuration and Operation**). This mode is intended for a simple system that allows remote outputs to be controlled and inputs monitored without any supervising equipment.

When TELEMETRY->MODE is set to IO MIRROR the small "T" icon is displayed in the title bar.

The IO MIRROR mode can map a single TReX unit to another TReX unit or to many selectively configured TReX units.

When enabled, the REMOTE ID device outputs are mirrored to the state of LOCAL ID device inputs. In order for a REMOTE ID device to have its outputs changed through the MIRROR MODE, the output must be configured to be TELEMETRY. It is possible to restrict outputs(s) that are updated by DISABLING outputs on the REMOTE ID device.

REMOTE ID devices are automatically controlled using the **WTE output control protocol**. When there is any input change, or an analog input changes by more than a configured threshold amount, there is an immediate transmission that updates a REMOTE ID device outputs.

A periodic refresh time can also be configured to ensure that outputs and inputs remain synchronised. On a REMOTE ID device inputs may optionally be tied to outputs to allow the actual remote output state to be displayed on the originating ID unit.

Mirrored INPUTS use the same TX DEBOUNCE and TX COUNT configuration items as normal message inputs. To prevent inputs from being mirrored, set the TX COUNT to 0. In some cases multiple transmissions may be desired. The default configuration is to transmit an input after being debounced for 200mS.

After selecting a frequency to transmit on, the default settings will in many cases be enough for

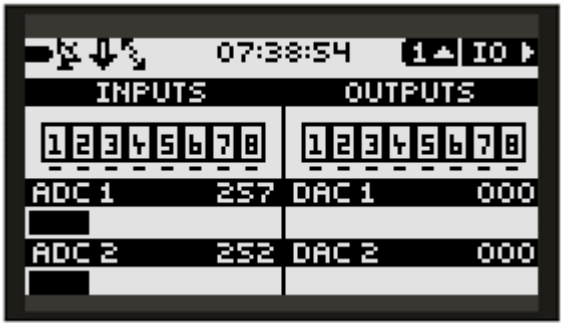
the system to be ready to test before deployment.

NOTE: Make sure the REMOTE ID of one device matches the LOCAL ID of the other.

Serial Link Operation

The TReX is well suited for use as a wireless point to point serial link.

When TELEMETRY->MODE is set to SERIAL LINK the small back to back arrow icon is displayed in the title bar.



Raw serial data in any format presented to the TReX is transmitted across the air and is output from a remote TReX serial port. The behaviour of this feature is the same as if a serial wire cable would be fitted between the units.

A typical application for this feature would be the writing information to remote LED signs. The TReX can write to many remote units simultaneously.

In order to transmit serial characters, the TReX needs to be configured to know which ASCII character should be used to invoke an immediate transmission (or if any), the maximum number of serial characters to transmit at any time and how long after a period of inactivity any buffered data should be transmitted.

The rate that data is transmitted across the air varies based on application. Typically, slower over the air transmitted rates such as 1200 or 2400 will result in higher sensitivity of the receiver, making the possible distance between each TReX greater. By default the transmission baud rate is 4800_6L allowing for use on 6.25kHz channels.

The TReX will typically allow up to 234 characters to be transmitted at a time, with buffering capability to allow several messages of this length to be queued for rapid transmission (up to approximately 1000 characters per burst).
If the buffering capacity of the TReX is exceeded then the TReX will respond with "FULL<CR>".

Prior to each transmission the channel checks if TReX is clear to transmit, meaning that in some cases transmissions could be slower depending on channel usage.

The TReX uses the default CAP code to identify each transmission, meaning that the TReX can either transmit to one or many other TReX units addressed individually or multicast to many at once.

It is possible to use RAW protocol without the SERIAL LINK option being enabled. Enabling SERIAL LINK prevents additional message filtering and file operations that may normally reduce throughput.

Once SERIAL LINK has been enabled through the menu, other than selecting the operating frequency, no further configuration will be required in most cases.

NOTE:
While operating using the RAW protocol, the TReX will **NOT** respond to any configuration commands. Configuration remains possible through the keypad, SD card ini file or web browser.

In order to quickly configure the point to point serial feature:

From the menu:
1. MENU->FACTORY->SYSTEM DEFAULTS
2. MENU->TELEMETRY->MODE – Set to SERIAL LINK
3. Exit from menu to save configuration.

The unit is now operating in a point to point serial link mode.

Configure RF aspects:
1. MENU->RF->FREQUENCY (to set transmit frequency)
2. MENU->RF->MODULATION (to set modulation transmit rate and channel usage).
3. MENU->SYSTEM->RS232 BAUD (to set serial baud rate – that should be a higher rate than the over the air transmit rate).
4. Exit from menu to save configuration.

Alert Handling

Use of Alerts is the TReX mechanism for providing notification of key events.

When an ALERT is triggered, there are three possible notifications:

- Visual: flashing bell icon in the top bar.
- Audible: Beep when SYSTEM->SOUND is set to ENABLED. Repeating beep at configurable interval when MENU->ALERTS->ALERT REPEAT is not set to DISABLED. When ALERT REPEAT is set to DISABLED, there will only be a single audible alert.
- ALERT output operation: MENU->ALERTS->ALERT OUT can specify an output that is operated when ANY alert is triggered. This allows for common monitoring of many outputs, also allowing the source of those alerts to be identified.

If the ALERT output has been specified and is not MONOSHOT, then this output may remain in a latched state. Many alert conditions are auto-clearing as described below. Once all ALERTS sources have been cleared (either automatically or manually) then the ALERT output will not longer operate and the audible beep will cease (if configured).

Output Alert	Description	Auto-Clearing	Alert Clearing Condition
RF	RF low power or antenna mismatch on transmit.	Yes	Next transmission that does not have low power or antenna mismatch detected.
TEMP	Over temperature specified in SYSTEM->OVERTEMP	Yes	No longer over temperature.
MAINS FAIL	Input message with MAINS FAIL is processed.	Yes	Input message with MAINS RESTORED is processed.
LINK	Link fail timer expires through the absence of received messages.	Yes	New message is received, resetting the link-fail timer.
BUSY	Channel is busy, checked every 100ms.	Yes	Channel is no longer busy.
MSG	Received a new message.	**No**	Pressing the ENTER button to acknowledge.
BATT	Battery voltage is **BELOW** the BATT input low voltage threshold, checked once a second.	Yes	Battery voltage is **ABOVE** the BATT input low voltage threshold, checked once a second.

Whenever an alert is raised the alert bell icon is displayed, except when in the menu. If an alert has been raised in the menu, the alert will be visible upon leaving the menu.

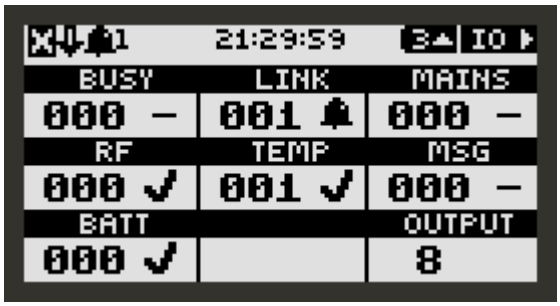
The Alert Summary IO screen shows at a glance the status of each alerting function. It also shows which ALERTS are ENABLED. The total number of alert activations for each ALERT source can be seen here. Alert counts are cleared on start-up.

In the following example there are 3 alert types of interest; BATT, TEMP and LINK FAIL that all need to notify a problem through a single output (in this case output 8). An audible alert is required repeating every 30 seconds.

1. Set ALERTS->BATT to ENABLED
2. Set ALERTS->TEMP to ENABLED
3. Set ALERTS->LINK FAIL to ENABLED
4. Set ALERTS->ALERT OUT to 8.
5. Set ALERTS->SOUND to ENABLED.
6. Set ALERTS->ALERT REPEAT to 30.

The alert configuration will be as follows (assuming initial state was the factory default state):

The alert summary screen shows:



Of interest is the tick under BATT and TEMP indicating that the ALERTS for these functions are enabled. The bell icon in the top bar shows there is an active alert (visible on all screens outside of the menu). Under LINK the bell shows that the LINK FAIL is currently active. The "001" indicates that a single alert has been raised since start-up. The TEMP tick means that the TReX is NOT over-temperature, and the BATT ticks means the voltage supplying the TReX is above the minium programmed BATT input threshold. Bottom right "OUTPUT" shows the output that is configured to operate during an alert condition.

Since there is at least one ALERT active, the main IO screen shows that output 8 has been operated.

Clearing Alerts

All alerts except the MSG alert are auto-clearing.

To clear a MSG alert:
Pressing the square “ENTER” key will clear MSG alerts (if not in the MENU). This will:

- Deactivate the ALERT output (if no other alerts are active).
- Disable the audible beep (if sound is enabled and no other alerts are active).
- Clear the bell from the top icon bar (if no other alerts are active).

Input Handling

Note: Please refer to **Input Output Hardware Connection** section on this manual for examples of how to connect the input and output pins on the TReX board.

The TReX supports 8 programmable inputs. Each input can be programmed with a short message up to 50 characters in length. Input messages must always be formatted as **WT Protocol** or the **WTE output control protocol**.

On start-up each input is read. By default only inputs that change from the start-up input state are processed. The expected initial state of each input can be configured, so that on start the input is not in its expected state there can be an immediate transmission. Outputs can be controlled through any input message if required (see **Controlling Outputs from Inputs**).

Commands relating to input handling (if preferred, all input options can be configured through the menu system):

***IN_INIT** specifies the expected level on start.

***IN_CONFIG_H** specifies all input transition to high level configuration parameters.

***IN_CONFIG_L** specifies all input transition to low level configuration parameters.

***IN_MSG_H** specifies the high level message that will be transmitted if configured.

***IN_MSG_L** specifies the low level message that will be transmitted if configured.

The *IN_CONFIG_H and *IN_CONFIG_L commands allow the input to specify:

- How many messages are transmitted once triggered.
- The debounce period (how long the input must be in a new state continuously in order to transmit) before the input is triggered.
- How long to wait until the message is retransmitted.
- If pending transmissions should be allowed to complete after state change.
- An independent resend timer for every input message allowing input messages to be indefinitely retransmitted if required.

The *IN_MSG_H and *IN_MSG_L commands allow the input to specify the message which will be transmitted when the input is triggered.

Full example:

In this example both inputs are configured to transmit only when moving from high to low (no high level transmissions). Transmit 5 times, 10 seconds between each transmission. Debounce period is to be configured to 2 seconds (input must have transitioned from a stable low level to constant high level for two whole seconds).

The protocol being used is WT protocol, and the message for each input message is “IN 1 LOW” and “IN 2 LOW”. Message is to be transmitted as POCSAG alphanumeric to cap code

1234560, beep level 1 and 512 baud.

Both Input 1 and 2 configured to disable all high level processing.

**IN_CONFIG_H=1:0,0,0,0,0<CR>*
**IN_CONFIG_H=2:0,0,0,0,0<CR>*

Both input 1 and 2 are configured as per the full example details above.

**IN_CONFIG_L=1:5,20,10,0,0<CR>*
**IN_CONFIG_L=2:5,20,10,0,0<CR>*

Both input 1 and 2 are configured as per the full example details above and in addition both inputs resend the programmed message once every 30 seconds (only while the input is low)

**IN_CONFIG_L=1:5,20,10,0,30<CR>*
**IN_CONFIG_L=2:5,20,10,0,30<CR>*

Configured messages to be transmitted once triggered.

**IN_MSG_L=1:WT1234560A10 IN 1 LOW<CR>*
**IN_MSG_L=2:WT1234560A10 IN 2 LOW<CR>*

High level messages can be set to anything since they are configured not to be used

**IN_MSG_H=1:<CR>*
**IN_MSG_H=2:<CR>*

For more details on command usage please refer to the Configuration section if required.

Controlling Outputs from Inputs

The simplest, and most reliable method is to enable the PLC feature, however alternatively, the following approach may be used.

Any input (including battery and analog inputs) can be used to control any output(s) if required. The **WTE output control protocol** can be used as the payload of any message.

Desired control solution 1:

To close output 2 when the battery voltage is low. The assumption in this case is that the unit ID is the default ID of 01.

The default low battery voltage message which is associated with input 9 is as follows.

*IN_MSG_L=9:WT1234560A13 BATT LOW<CR>

Change the message to:
*IN_MSG_L=9:[[01]2]<CR>
Output 2 will now close and will be latched or a mono-shot operation as configured.

Desired control solution 2:
To close output 2 when the battery voltage is low and also transmit a message. The assumption in this case is that the unit ID is the default ID of 01.

The default low battery voltage message which is associated with input 9 is as follows.
*IN_MSG_L=9:WT1234560A13 BATT LOW<CR>

Change the message to:
*IN_MSG_L=9:[[01]2]WT1234560A13 BATT LOW<CR>
Output 2 will now close and will be latched or a mono-shot operation as configured. In addition the following BATT LOW will be transmitted.

Output Handling

Note: Please refer to **Input Output Hardware Connection** section on this manual for examples of how to connect inputs and outputs to the TReX.

The TReX supports up to 8 outputs. One of these outputs can be shared with the ALERTS->ALERT OUT output.

Outputs are configured using the commands:
*OUT_CONFIG
*OUT_ID

The outputs are controlled through messages received that conform to the **WTE output control protocol**.

WTE Output Control Protocol

Introduction

This section describes how to control the outputs of WTE Products via transmission payloads.

The WTE protocol needs to be able to switch many outputs on, and many off in a single message. Receivers need to be able to be uniquely addressed, and in a manner that is maintainable.

The output control protocol can also be used to direct commands or protocol messages to specific remote units.

It may be likely that the payload is transmitted as part of a paging payload, such as POCSAG or FLEX, but ultimately the transport method is irrelevant as long as it is capable of transmitting the characters used by the protocol.

Once an output has been activated, it will remain in its activated state for its configured period. This may be many seconds, or permanently latched.

The control message can be placed in any position in the message payload, and there can be multiple control messages in the same payload.

Digital Output Format

The payload of a message must fit the following format in order to operate the unit outputs. Note that this description is extended below to describe how this format is extended to also allow control of analog outputs.

[[ID]EEEE-DDDD]

Where:

[is the character '['

] is the character ']'

ID is the OUT_ID that has been programmed (e.g. "01" or "Unit_A"). The ID may also be a comma separated list of units (e.g. [01,Unit_A,03])

E is the output to enable (1-8 for the TReX). Up to 2 outputs can be specified.

- is the hyphen character '-' All digits following the '-' are outputs that are disabled

D is the output to disable

Examples:

Consider an TReX configured with OUT_ID of “Unit_A” and both pins configured as outputs:

**OUT_ID=Unit_A<CR>*
**OUT_CONFIG=1:1,0<CR>*
**OUT_CONFIG=2:1,0<CR>*

Scenario 1: To turn output 1 ON and turn OFF output 2;
Message payload:
[[Unit_A]1-2]

Scenario 2: To turn output 2 ON and turn OFF output 1;
Message payload:
[[Unit_A]2-1]

Scenario 3: To turn output 1 and 2 ON;
Message payload:
[[Unit_A]12-]

Scenario 4: To turn output 1 and 2 OFF;
Message payload:
[[Unit_A]-12]

Consider that we have several TReX Units and each one is configured with a different OUT_ID; “Unit_A”, “Unit_B” and “Unit_C”
Scenario 5: To turn output 1 and 2 ON in the Unit_A:
Message payload:
[[Unit_A]12-]

Scenario 6: We want:
to turn output 1 and 2 ON in the Unit_A,
to turn output 1 ON and turn OFF output 2 on the Unit_B,
turn OFF output1 and 2 on the Unit_C;

Message payload:
[[Unit_A]12-] [[Unit_B]1-2] [[Unit_C]-12]

Scenario 7: To turn output 1 and 2 ON in the Unit_A and on Unit_B:
Message payload:
[[Unit_A,Unit_B]12-]

Analog & Digital Output Format

The WTE output control protocol allows the direct control of analog outputs.

[[ID]UZ[AA]CCC-OOOO]
Where:
[is the character '['
] is the character ']'
ID is the UNIT_ID that must match the TReX to be controlled..
U is the character 'U' and is used to mark that an analog or special output follows
Z is the analog output (1-2). 3 is used to write a digital output bitmap.
C is output to close (1-8). Up to 8 outputs can be specified.
- is the character '-'
O is the output to open
AA is the value to set an analog output to (0-1023). When a digital output bitmap value is used this value can be a value from 0-255. When an analog output is set to higher than 1023, the value 1023 is used.

When square brackets are after an analog output specifier ('U'), then the value specified is the DAC value to set. Note that both a digital output and analog output can have the same output number.

When analog outputs are controlled they must always be before any digital outputs.

Example 1:
Unit configured to have UNIT_ID of "UNIT-1". Digital outputs 2 and 4 are to be set, and output 1 cleared. Analog Output 2 is to have the DAC set a value of 927
Message payload:
[[UNIT-1]U2[927]24-1]

Example 2:
Unit configured to have UNIT_ID of 01. Analog Output 1 is to have the DAC set a value of 18, analog output 2 is to have a DAC value of 145.
Message payload:
[[01]U1[18]U2[145]]

Notes:

- The unit will only process the Output Control Protocol for the unit configured in the

OUT_ID and will ignore the other Output Control Protocol contained in the message
- Additional security to prevent false activation can be achieved through CAP restriction via the RX_RANGE and/or a more complex OUT_ID.

Remote Command Output Format

The WTE output control protocol allows the direct control of remote units. This allows specific TReX units to accept commands or protocols for processing "over the air".

[[ID]U0[AA]]
Where:
[is the character '['
] is the character ']'
ID is the UNIT_ID that must match the TReX to be controlled. ID may be a comma separated list of units (e.g. [01,04,06])
U0 are the characters "U0" (U followed by zero) and is used to indicate that directed content for processing follows.

Example applications for this may be:
- Restarting of a remote unit
- Changing configuration of a remote unit over the air
- Retransmitting a message at a different rate.

Example 1 - To restart a remote unit:
Remote unit configured to have UNIT_ID of "UNIT-10".
Message payload:
[[UNIT-10]U0[*REBOOT]]

Example 2 - To change a RIC range on a remote unit:
Remote unit configured to have UNIT_ID of "UNIT-10".
Message payload:
[[UNIT-10]U0[*RX_RANGE=1:1234560,1234567]]

Example 3 - To transmit a message only from a specific remote unit:
In this case, the remote unit is configured to accept WT protocol.
Remote unit configured to have UNIT_ID of "UNIT-10".
Message payload:
[[UNIT-10]U0[WT1234560A10 Test Message]]
The message transmitted by UNIT-10 will be "Test Message" at 512 baud, but the message

may have been received at a different configured baud rate.

Application of this may be:

A full network operating in a telemetry mode may be transmitting data at 9600 baud. This method allows a message to be sent through the network at high speed, yet still able to be retransmitted from a specific unit at a standard low rate for a common POCSAG belt pager.

WTE Ack and Confirm Protocol

Introduction

This section describes how to use this protocol to invoke automatic acknowledging and optionally manual confirmation of messages sent/received. This protocol can also be used to message TReX units to display confirmation prompts. The use of this protocol is the heart to making two-way paging or messaging possible.

Monitoring equipment can make decisions based on acknowledge responses whether to retransmit or notify a communications link issue. Acknowledgements can be either transmitted or sent through a TCP/IP connection.

A typical application for a confirmation request would be an emergency communications room messaging several ambulances with TReX units fitted. The message would provide an on-screen prompt requesting attendance to an event. Any ambulance can then accept the message, and details of the attending vehicle would then be sent to the communications room.

The **WTE Ack and Confirm Protocol** can be embedded into the payload of any message.

Typically the protocol message would be attached to the end of a message, so that paging messages would display normally for typical users.

Note: In order for a TReX unit to acknowledge any message, the receiving TReX RIC codes used must fall within allowed normal RX receive ranges.

Protocol Usage

-[TTT-A-XXX]
where:
- is the character '-' (marks the start of the ticket ID and ACK Mode)
[is the character '['
TTT is a 3 digit ticket id
A is the ACK Mode

1 = acknowledge required
2 = acknowledge and confirmation required
3 = confirmation without acknowledgement (when sent to many stations.)

- is the character '-' marking the start of the optional confirmation title.
XXX is the optional confirm title (e.g. "Accept?"). Not specifying this field results in default of "CONFIRM". This field is only meaningful when ACK mode is 2 or 3. Max length is 14

characters.
] is the character ']'

Responses are all transmitted using the default settings for modulation type and protocol. The payload is also sent directly out the serial port and TCP sockets for when acknowledgement is required via IP.

Note: In order for a TReX unit to acknowledge any message ***as an RF transmission****, there must be at least one entry in the RIC database.*

Typical Operation

The base-station TReX sends single messages, or many batched together as required.
The transmitter can send an auto incremented ticket ID, or the ticket ID can be manually selected as part of the Acknowledge and Confirm Protocol.

Using WT Protocol allows the use of the **Variable Content Macro **01** to be used to transmit with an automatically incrementing ticket ID.

Receiving TReX units can acknowledge multiple messages if messages have been received in a batch.
e.g. The remote TReX unit receives 3 messages all to be acknowledged (ticket IDs 345, 346 and 347). The following is transmitted.

ACK[345,346,347]

Upon reception of any message requiring confirmation, the TReX shifts from any screen currently on, and does not allow leaving of the confirmation message screen until the message has either been accepted or rejected. Any messages received while waiting for confirmation will be logged and can be inspected at a later time.

Example 1:
Message payload to have delivery acknowledged is transmitted.
Message Payload:

Bob, go to Pukeko Place urgently.-[345-1]<CR>

Remote TReX responds with:

ACK[345]

Example 2:
Message payload to have delivery acknowledged and confirmed is transmitted.

All units, go to Pukeko Place urgently.-[347-2-Turnout Y/N?]<CR>

The remote TReX unit immediately displays:

Remote TReX immediately responds with:

ACK[347]

If message has been accepted (by pressing the square "ENTER/ACCEPT" button) remote TReX responds with:

ACC[347-Unit 41]

Note that the "Unit 41"in the confirmation response is the TReX programmed unit ID.

Example 3:

Message is transmitted from base station using **WT Protocol** together with the **Acknowledge and Confirm Protocol** added to the end to the message.

*WT1234567A10 HEART ATTACK, 45 YO MALE, 12 PUKEKO PL.-[**01-3-ATTEND?]<CR>*

*Note: The **WT Protocol** must be used to automatically expand the **01 macro to an automatically incremented ticket id.*

The remote TReX unit immediately displays:

In this case, the received message has not requested delivery confirmation, only confirmation of acceptance.

Should the user ACCEPT the message to attend, the remote TReX transmits to the base-station the message:

ACC[666-Unit A]

where:
666 is the ticket id.
- is the character '-'
"Unit A" is the unit ID programmed through SYSTEM->ID

SOLT Transmitter Support

SOLT transmitters, produced in Korea, are a high quality brand of call-points buttons suitable for use for hospitality, nurse call and aged care systems.

Using the TReX, it is possible to produce a wide coverage solution at low cost for large installations.

See https://solteurope.com/

These products are compatible with the TReX. The TReX can receive these signals, and then retransmit as either messages for belt pagers or DMR radios at high power. Alternatively the received messages can be output via serial or Ethernet ports for secondary processing.

The TReX can hold a database of hundreds of SOLT transmitters IDs, that allows the message, the paging technology or DMR radio type to be specified.

To use SOLT devices:

1. Through the MENU, set RF to DUPLEX.
2. Set RF->RX->FREQUENCY to the frequency specified on the rear of the SOLT transmitter.
3. Set RF-RX_MODE to SOLT
4. Specify transmit frequency for belt pagers or DMR radios if required.
5. Create a text file SOLT.TXT and store on the TReX internal USB storage.

Creating a SOLT Translation Table.

To allow transmitter translations, a file "SOLT.TXT" must be added to the TReX. In this file a message must be associated with each transmitter ID and button. Hundreds of buttons can be supported in this file. As the file increases to support thousands of transmitters, a small delay before transmission may be observed.

Obtain the transmitter ID by pressing a SOLT transmitter button. There will be a screen pop-up displaying the transmitter ID and button type. If the file SOLT.TXT is not present or the ID is not found in that file, then the transmitter ID will also be sent out the serial port.

Default Serial Output Format:
WT**XXXXXXX**s**Y**0 SOLT ID:6748

Where:
XXXXXXX is the SOLT transmitter ID
Y is the SOLT button ID. Most SOLT transmitters will have an ID of 0. 6 button transmitters will have a button ID from 1-6.

SOLT.TXT Content

<TX ID>:<BUTTON_NUM>,<WT Protocol message content>

6748:1,WT1234560A10 table 2 Bill
6748:2,WT1234560A10 table 2 Drinks
42679:1,WT0001001D60 Assistance required

All messages are specified in the WT protocol allowing for many pager types, DMR radios to be supported (see **WT Protocol**). Also allows content to be redirected out the serial/TCP port.

RF Security

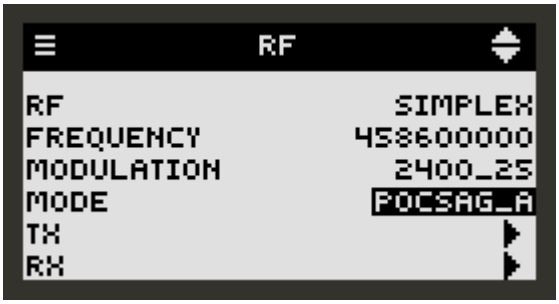
The TReX allows for AES 256-bit encryption to be used for transmitted data. Same content messages will change with each transmission due to an embedded unique timestamp.

A default key is loaded into the TReX, common to all units. This is for evaluation purposes only, and should be changed before the system is considered to be secure. For evaluation, steps 1 and 2 below can be omitted.

In order to create a secure radio link:

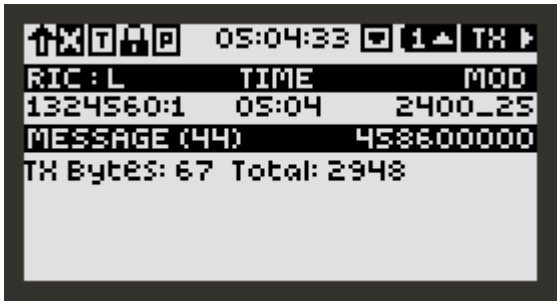
1. Generate a random 256 bit key. Use a key generator or use an online web service such as https://www.allkeysgenerator.com/Random/Security-Encryption-Key-Generator.aspx. The key must be hexadecimal in format and will be 64 characters long. This key must be used on all devices in the same system, and must be changed if the key has become publicly known.
2. Use the command ***RF_KEY** to enter the key, either using a terminal or adding the command to a configuration file.
   *Note: Reading back the key with ***RF_KEY?** will only display the first 4 characters of the key. All other configuration items can be set through the menu if required.*
3. Go to the RF->ENCRYPTION menu.
4. Select the desired encryption method and options.
5. Ensure the **LOCAL ID** is unique to the system – every transmitting TReX must have a different **LOCAL ID**. This ID is the same as TELEMETRY->LOCAL ID.

AES Encryption is only applied when using the transport options **POCSAG_A** or **WTE_EN**. **WTE_EN** must be used when 8 bit characters are being transmitted, such as when the point to point serial link is used. **WTE_EN** encrypted messages have the ability to be 20% shorter than the **POCSAG_A** transport method. **POCSAG_A** can be used in most cases when a standard format is required, or encryption for nationwide paging is desired. Both transport methods include forward error correction for high receiver sensitivity.



"Duplicate Reject" prevents repeat playback attacks where a malicious or nuisance user could record transmissions, and retransmit in an attempt to defeat security. Duplicate reject examines the encrypted time stamp in a transmission and only allows more recent time-stamped messages to be processed. Using this method all historic repeated messages from a transmitter can be rejected.
Note: The transmitter system DATE and TIME must be set and operating for the secure duplicate reject feature to work. The receiving TReX does NOT need to have the time set if it does not transmit.

When correctly configured, the padlock icon is displayed in the top icon bar. RX screen content is normally readable if correctly decrypted.



Secure Nationwide Paging

In order to transmit secure messages across an existing nationwide paging service (to be decoded by a TReX-460) the message must be encrypted by another TReX, and the encrypted message then provided to a nationwide paging service provider.

In order to obtain the encrypted message:

1. Configure encryption options
2. Ensure the same key is used that receiving TReX=460 will use.
3. Send the following command
   *ENCRYPT= **Secure Test Message**

The TReX will respond with 2 lines, each followed by <CR><LF> characters:

[231C931A]
E6C`U9VGVa^6gZJGcPCM?m<;^`@TO:7^APE=HI\J9f\0

Note: line 1 is a unique incrementing hexadecimal ticket number, line 2 is the actual encrypted message.

The nationwide paging service must be provided with:

RIC Code:

1234560 (can be **a**ny 7 digit RIC that the TReX is configured to receive).

Message to Transmit:

E6C`U9VGVa^6gZJGcPCM?m<;^`@TO:7^APE=HI\J9f\0

Note: Any '\' characters seen or used in encrypted messages should not to be confused as part of an escape sequence (such as \r).

The encrypted message may be tested on the TReX prior to sending to the paging service with the command:

***BYPASS=**[1234560:1]**E6C`U9VGVa^6gZJGcPCM?m<;^`@TO:7^APE=HI\J9f\0**

Note: In order to decode this encrypted message RF->ENCRYPTION must be set to ***ENABLED***

The message will be decrypted, and displayed on the RX screen.

If the selected output protocol is WTE, then the decoded message will also be returned out the serial port.

This method allows secure activation of TReX outputs or reception of sensitive information for processing or retransmission.

Transport Layer Security

The TReX has optional support for TLS 1.2 security connections using 128 bit AES encryption and 2048 bit RSA.

Transport Layer Security (TLS) is a commonly used protocol for encrypting data sent over a network connection. The main benefit of using TLS is protection against interception of sensitive data either through a local network or over the internet.

The TReX supports TLS communication when configured as either a server or a client, with the latter configuration supporting both standard TCP and MQTT encrypted communication.

Operating as a TLS server

Before encrypted data can be sent between a server and a client, a TLS handshake must take place between the two. In this handshake, the client sends a request to the server, the server sends back a certificate and the client generates session keys for both parties to encrypt and decrypt message data.

For the TReX to operate as a server using a TLS connection, several files are required. **While default files are provided with the device, these should not be considered secure and should only be used for testing and setup purposes. It is strongly recommended to either purchase a certificate from a trusted certificate authority or generate a certificate using the steps outlined below.**

Certificate Generation

Certificate Authority (CA) Certificate
A CA Certificate (or Root Certificate) is a certificate issued by a Certificate Authority that is used to verify the certificate used by the server. Generally, it is considered more secure to purchase both a CA certificate and a server certificate from a trusted CA. However, it is possible to locally generate a CA certificate using a free command-line software called OpenSSL.

First, a private key for the CA certificate must be generated. OpenSSL will request a passphrase for the private key. Remember this passphrase as it will be required to generate the CA certificate.

```
> openssl genrsa -des3 -out cakey.pem 2048

Generating RSA private key, 2048 bit long modulus (2 primes)
...........+++++
.............................................+++++
e is 65537 (0x010001)
Enter pass phrase for cakey.pem:
Verifying - Enter pass phrase for cakey.pem:
```

Next, this private key is used to generate the CA certificate. OpenSSL will request both the passphrase of the generated key as well as information related to the organisation that will be issuing the server certificate (i.e. the organisation using the TReX).

```
> openssl req -x509 -new -nodes -key cakey.pem -sha256 -days 365 -out ca.pem

Enter pass phrase for key.pem:
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:NZ
State or Province Name (full name) [Some-State]:Canterbury
Locality Name (eg, city) []:Christchurch
Organization Name (eg, company) [Internet Widgits Pty Ltd]:WTE Ltd
Organizational Unit Name (eg, section) []:IT Department
Common Name (e.g. server FQDN or YOUR name) []:WTE-TReX
Email Address []:info@wte.co.nz
```

This will generate a CA certificate file named *ca.pem*. If multiple TReX devices are being used as servers, this CA certificate only needs to be generated once.

Server Private Key and Certificate Signing Request

The next step is to generate a private key that will be used by the TReX server. This is done in a similar manner to the CA private key.

```
> openssl genrsa -aes256 -out key.pem 2048

Generating RSA private key, 4096 bit long modulus (2 primes)
.........++++
..............++++
e is 65537 (0x010001)
Enter pass phrase for key.pem:
Verifying - Enter pass phrase for key.pem:
```

This will generate a 2048-bit key file named “key.pem”. This key file will be encrypted. For the TReX to use the key, it must be decrypted with the following command:

```
> openssl rsa -in key.pem -out key.pem

Enter pass phrase for key.pem:
writing RSA key
```

With this decrypted private key, generate a Certificate Signing Request.

```
> openssl req -new -key key.pem -out server.csr

Enter pass phrase for key.pem:

Country Name (2 letter code) [AU]:NZ
State or Province Name (full name) [Some-State]:Canterbury
Locality Name (eg, city) []:Christchurch
Organization Name (eg, company) [Internet Widgits Pty Ltd]:WTE Ltd
Organizational Unit Name (eg, section) []:IT Department
```

```
Common Name (e.g. server FQDN or YOUR name) []:WTE-TReX
Email Address []:info@wte.co.nz

Please enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []:
An optional company name []:
```

The challenge password and optional company name fields can be left blank.

Server Certificate
Next, generate a server certificate for the TReX using the previously generated Server Private Key and Certificate Signing Request.

```
> openssl x509 -req -sha256 -days 365 -in server.csr -signkey key.pem -out
server.pem

Signature ok
subject=C = NZ, ST = Canterbury, L = Christchurch, O = WTE Ltd, OU = IT
Department, CN = WTE-TReX, emailAddress = info@wte.co.nz
Getting Private key
Enter pass phrase for key.pem:
```

Enter the passphrase used when generating the Server Private Key when prompted. This will generate a Server Certificate with the file name *server.pem*.

DH Parameters
The final file required by the TReX is a DH parameter file. This can be generated using OpenSSL.

```
> openssl dhparam -out dhparam.pem 1024

Generating DH parameters, 1024 bit long safe prime, generator 2
This is going to take a long time
...................+........+.............................
+...............................+.......................+............
+...........+.............+......................
```

When all required files have been generated, place *key.pem*, *server.pem* and *dhparam.pem* into the the internal storage of the TReX by connecting the device via USB to a computer and placing the files into the mass storage of the device.

Once the device has been set up and is operating as a TLS server, it can be tested using the following OpenSSL command (assuming that the device is connected to the same local network as the computer running OpenSSL and has an IP address of 192.168.1.22 and a configured TCP port of 5080).

```
> openssl s_client -host 192.168.1.22 -port 5080 -tls1_2
```

If the TReX is configured correctly, the OpenSSL client should display the handshake information and sending the command ***VER** through the OpenSSL terminal will result in the TReX version information being displayed.

When setting up multiple TReX devices, the only the Server Private Key, the Server Certificate Request, the Server Certificate and the DH Parameters need to be regenerated for each device.

The security of the generated server certificates is only as secure as the storage of the CA certificate and CA private key. Ensure that these files are not easily accessible. It is best practice to keep a log of all attempts to access these files.

In the event that any required files are missing or invalid, the TReX will reject any further attempts by the client to connect.

Operating as a TLS Client

When operating as a client, the TReX does not require any certificate or key files to be present in the internal storage as certificates are provided by the server. However, it should be ensured that the server being used supports the following cipher suites:

```
TLS_DHE_RSA_WITH_AES_128_CBC_SHA256   (0x67)
TLS_DHE_RSA_WITH_AES_128_CBC_SHA      (0x33)
TLS_DHE_RSA_WITH_3DES_EDE_CBC_SHA     (0x16)
```

No additional tasks need to be performed when using MQTT with TLS enabled. When connecting to a server the authentication process begins automatically. In the event of a failed connection, the TReX will attempt to reconnect after a period of five seconds.

Once a connection has been established, the TReX operates identically as when TLS is disabled. There is no additional formatting to the information sent or received on the application level.

Refer to the Specifications section for more information about the specific TLS protocol used.

Notes

When operating with a TLS connection, the connection to the web page interface is not encrypted and should not be considered secure.

As with standard TCP connections, the TReX device only supports a single TLS connection at a time when configured as a server. Care should be taken when integrating the device into a network that only approved and trusted clients are able to connect to the device.

TLS Connection Error Codes

Error Code	Error
1	Certificate file missing or invalid

2	Server key file missing or invalid
3	DH Parameters file missing or invalid
4	TLS Handshake failed

Repeater Operation Modes

The TReX is able to be used in a variety of repeater configurations depending on the application.

Store forward and DMR licenses are required for these modes of operation.

Store Forward
In this mode, a TReX can intercept a POCSAG paging message, either from a WTE transmitter or a third party paging transmitter. This message, after being received is then transmitted again. In this mode, the receiver must be configured to the same settings as the POCSAG message that is to be received, and the transmitted message is identical. The transmitted message may be on a different frequency if required. Duplicate reject and delay before retransmission is configurable. This is the simplest mode to configure for repeating POCSAG messages.

DMR Translate Repeat
This mode is the same as the Store Forward mode, but incoming POCSAG messages that are intercepted can be retransmitted as a DMR message. All DMR messages can be transmitted as a different "Group" ID if required. Concurrent transmission to POCSAG devices is possible.
Duplicate reject and delay before retransmission is configurable.

Multi-Site Repeat
This is the most useful and configuration method that should be used to control multiple sites when operated by a supervisory PC or system.
This mode allows any message to be sent to a wide coverage star system of repeating TReXs. Each message can be sent to all repeaters at high speed, and allows for many different paging types to be supported, as well as DMR messaging without the need to reconfigure any repeating TReX. Ability to temporarily change frequency for pagers and DMR radios is also possible.
Messages can be easily steered to all remote TReX units, or to a selection as required.
Duplicate reject and delay before retransmission is configurable.

Store Forward Operation

The TReX can operate as a stand-alone repeater to forward paging messages and also extend wireless serial operation.

Transmit and receive configuration should be configured to be the same when forwarding messages. *RX_PROTO should equal the *TX_PROTO and *RX_MODE should equal *TX_MODE.

Ensure that the RIC_DB and DMR_DB do not have any loaded entries. If

Typically the TReX would be configured as follows:

Delay of 2 second before forwarding, reject duplicate messages for 10 seconds.

**STORE_FWD=20,10<CR>*

Ensure all store forward units have RX_RANGES set to allow all possible CAP codes that are of interest to forward.

The duplicate reject feature is essential to use when the TReX is been used in a multi-hop store forward system. If this is set to 0, rejection of duplicated messages are not possible, and messages may bounce back and forward between repeaters.

The duplicate reject period, if used, ALWAYS must be of a longer duration than the store forward delay for reliable operation.

Multiple repeaters can be used, but increase message delivery time. Use of more than a single repeater in a system is generally less than ideal and typically more powerful transmitters should be used if multiple store forward repeaters are required.

See the Configuration section on this document for more details on command usage if required.

DMR Translate Repeat Operation

The TReX can operate as a stand-alone translator repeater to forward paging messages to support DMR radios. Without the need for any external equipment other than the TReX, legacy paging systems can support newer DMR radios by intercepting POCSAG paging messages and repeating in a translated DMR format (and optionally POCSAG concurrently).

In order to translate to DMR messages (configured through the MENU):

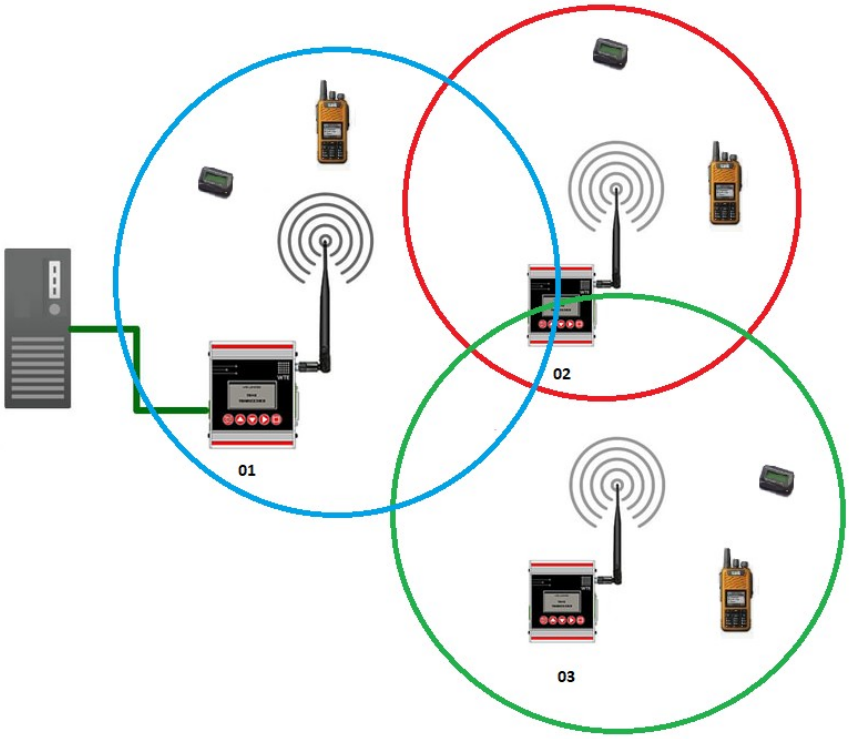
1. Set RF->RF to DUPLEX
2. Set RF->RX->FREQUENCY to the desired RX paging receiver frequency.
1. Set RF->RX->MODULATION to desired RX paging rate (e.g. 1200_12).
2. Set RF->RX->MODE to POCSAG_A
3. Set RF->RX->RIC RANGES to desired paging RIC range to receive.
4. Configure the DMR database. Set TX->DMR DB parameters.
    1. Set CC (Colour Code).
    2. Set TYPE (DMR Radio Type – refer to **DMR Message Format**) .
    3. Set DMR transmit frequency (may be different than the TX FREQUENCY).
    4. Load DMR group IDs. (At least one group must be configured in order to translate and transmit).
    5. Ensure the TX-DB is empty (the RIC DB should not populated unless transmission to these codes is also required).
5. Set STORE FWD->OPERATION to a non DISABLED value.
6. If concurrent forwarding to POCSAG devices is required:
    1. Set RF->TX->RIC DB to at least one forwarding POCSAG RIC address.
    2. Set RF->FREQUENCY to the frequency the POCSAG messages will be transmitted on.
    3. Set RF->MODULATION to desired TX paging rate (e.g. 1200_12).

This mode is similar to the Store Forward mode, but incoming POCSAG messages can be intercepted and retransmitted as a DMR messages. All DMR messages are transmitted as a "Group" ID using the DMR database.

If required, use the command *DMR_DB to serially configure DMR radio colour code, type and TX frequency.

Multi-Site Repeat Operation

The Multi-Site Repeat mode is the most flexible method to allow messages to be delivered to multiple radio technologies concurrently. This means messages can be sent to POCSAG pagers at different speeds and on different frequencies if required. DMR radios can be supported concurrently. Messages can be sent to all sites at high data rates for low latency, multi-site transmission. Continuous coverage across the site is shown through blue, green and red area crossover.



This mode of operation relies on the use of the WT Output Control protocol. Using this protocol, any message for transmission can be steered to some or all TReX units at the same time.

In the following examples the central controlling TReX unit is configured to be unit “01”. This TReX unit is managed either from a direct connection to a PC or through an Ethernet connection to a remote PC.

In this example units “02” and “03” are considered as repeaters. These units must have their receivers configured to a frequency and data rate that suits the installation (all units must be the same). This receiver rate may much higher than the repeater transmit rates. For the following examples, the rate between sites is fixed at 2400 baud, for a 12.5kHz channel.

Store and Forward does not need to be enabled, but if it is, the Store and forward delay and duplicate reject features both work normally. Without Store and Forward enabled there is no duplicate reject or delay after receiving and transmitting. A different delay for each repeater will result in improved performance and reliability.

Example 1:
Sending a DMR message "Hello World" to group ID 1001 on all sites

All TReX units, must receive the payload of:
[[01,02,03]U0[WT0001001D60 Hello World]]

This format is described in the user manual under output control protocol.

In order to achieve this, the controlling PC sends the following message to the central TReX transmitter:

WT*1234560***A1C** [[01,02,03]U0[WT0001001D60 Hello World]]

In italics the CAP code is arbitrary, and can be any code as long as it is within the RIC range of the repeater TReX units.

In bold is **A1C –** this sets the transmission to an arbitrarily chosen 2400 baud for a 12.5kHz channel (see WT Protocol for full details)

Example 2:
Sending a 512 baud, 25kHz channel POCSAG message "ASSIST" to RIC 1234555 on all sites

All units, must receive the payload of:
[[01,02,03]U0[WT1234555A10 ASSIST]]

In order to achieve this, the controlling PC sends the following message to the central TReX transmitters:

WT1234560A1C [[01,02,03]U0[WT1234555A10 ASSIST]]

Example 3:
Sending a 512 baud, 25kHz channel POCSAG message "ASSIST" to RIC 1234555 on site "03" ONLY.

All units, must receive the payload of:

[[*03*]U0[WT1234555A10 ASSIST]]

In order to achieve this, the controlling PC sends the following message to the central TReX transmitters:

WT1234560A1C [[*03*]U0[WT1234555A10 ASSIST]]

Example 4:
Sending a 512 baud, 25kHz channel POCSAG message "RETURN TO RECEPTION" to RIC 1234777 on all sites. In this example the pagers being messaged are on different frequency (458.60MHz in this case)

All units, must receive the payload of:

[[01,02,03]U0[*TX_FREQ=458600000]U0[WT1234777A10 RETURN TO RECEPTION]]

In order to achieve this, the controlling PC sends the following message to the central TReX transmitters:

WT1234560A1C [[01,02,03]U0[*TX_FREQ=458600000]U0[WT1234777A10 RETURN TO RECEPTION]]

Note:

*The transmitter frequency must be restored to the default frequency after use. The frequency change will not be saved to the configuration and is only temporary unless the *SAVE command is issued.*

Installation

The TReX should be situated away from direct sunlight, extreme vibration and heat sources, and high power transmission sources.

An external antenna correctly designed to operate at the intended frequency of operation will result in best performance. Dual VHF/UHF antennas may operate acceptably in some cases. Do not situate the antenna immediately next to the antenna of a high power transmission source – position greater than 2 M from any other antenna. Mount the external antenna with as much elevation as possible for best results (see "Antenna Elevation" below).

Maximum tolerated input power into the RF connector is 17 dBm. Levels above this will destroy the receiver RF input and invalidate the unit warranty.

Cables Supplied

By default NO cables are supplied on purchase. Because there are so many possible frequencies and variations for an installation, an antenna is NOT supplied by default. If an antenna is supplied, it will be a generic variety that will not perform as well as an antenna produced for the intended frequency of operation, or a high gain externally mounted type.

If cables are to be supplied, these must be ordered at time of purchase.

Connecting to the TReX

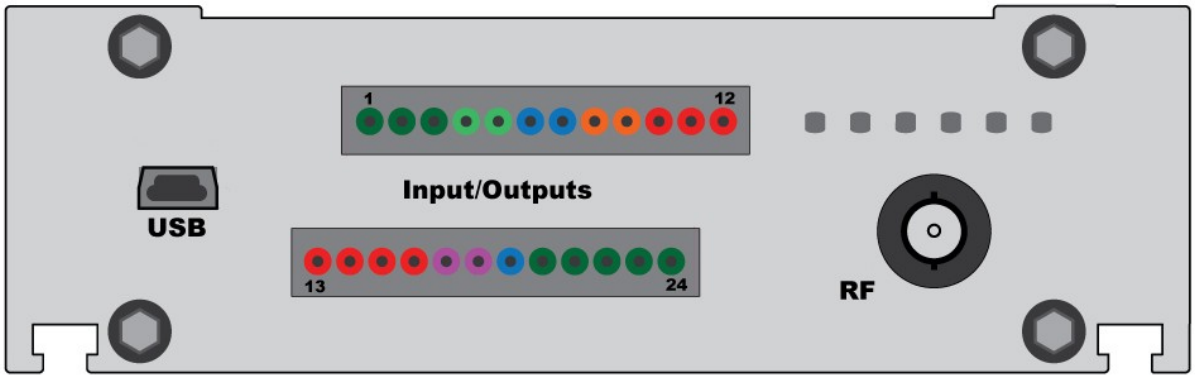
The minimum required connections for a usable system:

1. Connection to a 50 ohm antenna constructed for the frequency of interest. Mismatched antennas may result in increased current draw and reduced power output.
2. 13.8V, 3A supply connected to the power terminals

Connector Pin descriptions

RHS TREX-460-i8o1

(Right Panel)



RF

BNC connector (50 ohms)

USB

Mini type B connector

Input/Output Connector:

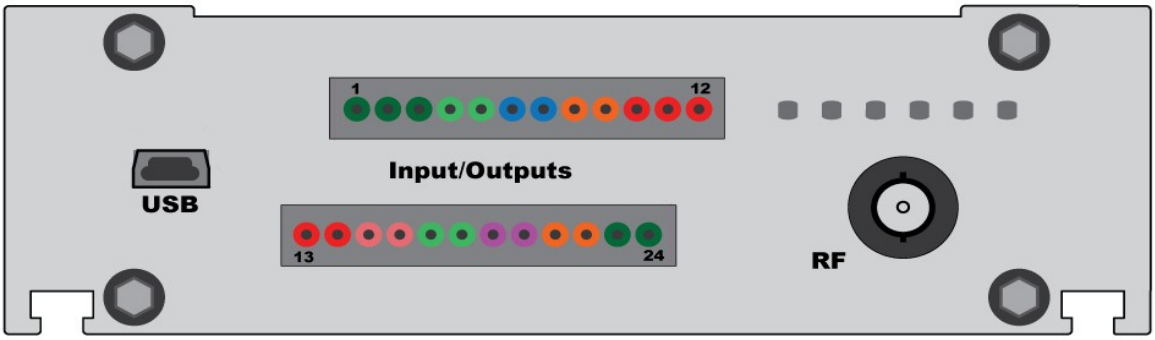
Inputs/Outputs Pin Number	Description
1	Input – Digital 1
2	Input – Digital 2
3	Input – Digital 3
4	Input – Analog 1
5	Input – Analog 2
6	GND
7	GND
8	Output – Analog 1
9	Output – Analog 2
10	Output – Digital 1
11	Output – Digital 2
12	Output – Digital 3

Note: The second connector with pins 13-24 are fitted upside down. This means that the screw terminals are pointing down and wiring must be secured before inserting the connector.

Inputs/Outputs Pin Number	Description
13	Output – Digital 7
14	Output – Digital 6
15	Output – Digital 5
16	Output – Digital 4
17	Relay CM
18	Relay (NO / NC)
19	GND
20	Input – Digital 8
21	Input – Digital 7
22	Input – Digital 6
23	Input – Digital 5
24	Input – Digital 4

RHS TREX-460-i8o8

(Right Panel)



RF

BNC connector (50 ohms)

USB

Mini type B connector

Input/Output Connector:

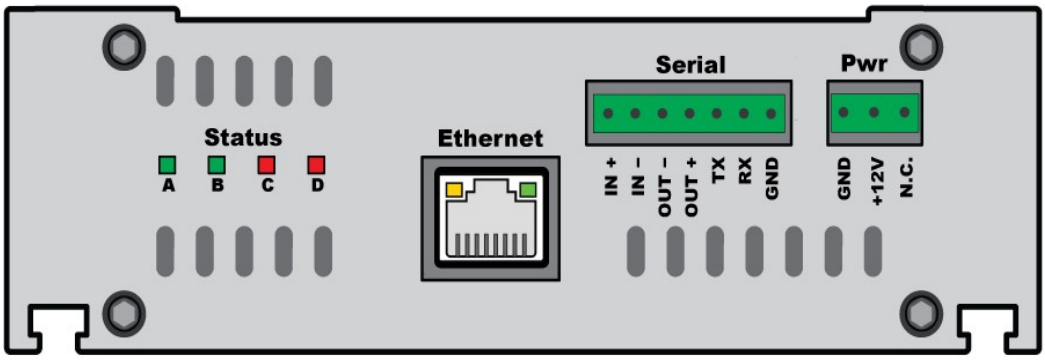
Inputs/Outputs Pin Number	Description
1	Input – Digital 1
2	Input – Digital 2
3	Input – Digital 3
4	Input – Analog 1
5	Input – Analog 2
6	GND
7	GND
8	Output – Analog 1
9	Output – Analog 2
10	Output – Digital 1
11	Output – Digital 2
12	Output – Digital 3

Note: The second connector with pins 13-24 are fitted upside down. This means that the screw terminals are pointing down and wiring must be secured before inserting the connector.

Inputs/Outputs Pin Number	Description
13	Relay 6 NO
14	Relay 6 CM
15	Relay 5 NO
16	Relay 5 CM
17	Relay 4 NO
18	Relay 4 CM
19	Relay 3 NO
20	Relay 3 CM
21	Relay 2 NO
22	Relay 2 CM
23	Relay 1 NO
24	Relay 1 CM

LHS TREX-460-i8o1

(Left Panel)



Serial Connector:

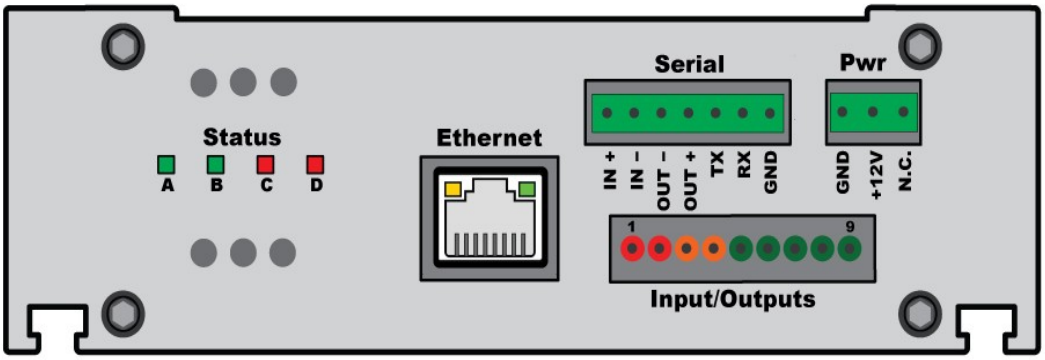
Serial Connector Pin Number	Description
1	RS422 RX+ (**IN+**)
2	RS422 RX- (**IN-**)
3	RS422 TX- (**OUT-**)
4	RS422 TX+ (**OUT+**)
5	RS232 TX
6	RS232 RX
7	Ground (**GND**)

Power Connector:

Power Connector Pin Number	Description
1	Ground (**GND**)
2	**+13.8V**
3	Not Connected (**N.C.**)

LHS TREX-460-i8o8

(Left Panel)



Serial Connector:

Serial Connector Pin Number	Description
1	RS422 RX+ (**IN+**)
2	RS422 RX- (**IN-**)
3	RS422 TX- (**OUT-**)
4	RS422 TX+ (**OUT+**)
5	RS232 TX
6	RS232 RX
7	Ground (**GND**)

Power Connector:

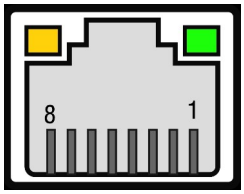
Power Connector Pin Number	Description
1	Ground (**GND**)
2	**+13.8V**
3	Not Connected (**N.C.**)

Input/Output Connector:

Note: The second connector with pins 1-9 are fitted upside down. This means that the screw terminals are pointing down and wiring must be secured before inserting the connector.

Inputs/Outputs Pin Number	Description
1	Relay 7 NO
2	Relay 7 CM
3	Relay 8 NO
4	Relay 8 CM
5	Input – Digital 4
6	Input – Digital 5
7	Input – Digital 6
8	Input – Digital 7
9	Input – Digital 8

Ethernet Connector:



Connector Pin Number	Description
1	TX+
2	TX-
3	RX+
4	NC
5	NC
6	RX-
7	NC
8	NC

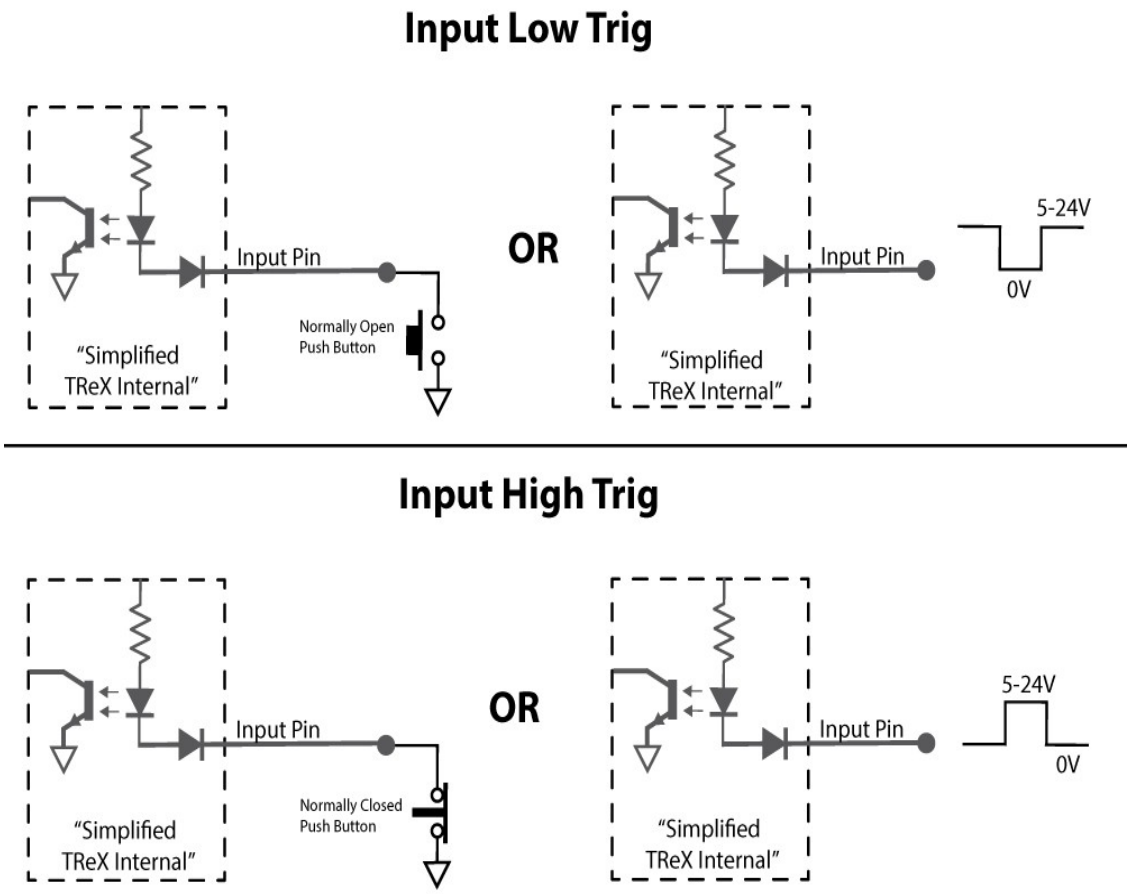
Note: pins: 4 and 5 are connected to ground via a 75R resistor
7 and 8 are connected to ground via a 75R resistor

Do not connect a Power over Ethernet (PoE) connection to the TReX Ethernet port as this will result in damage.

Input Output Hardware Connection

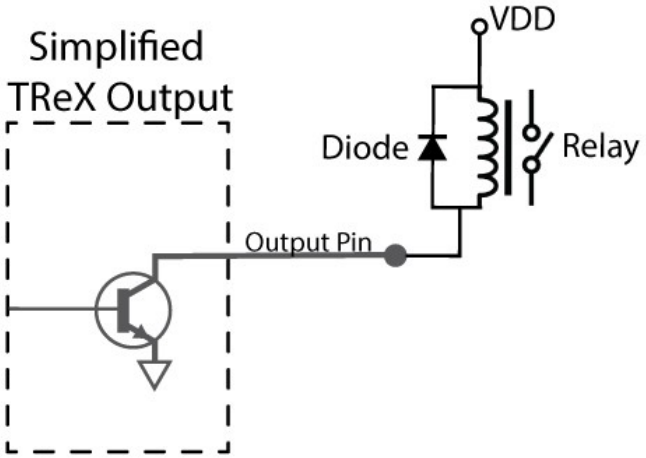
Examples of how to connect external devices to the TReX input/output pins.

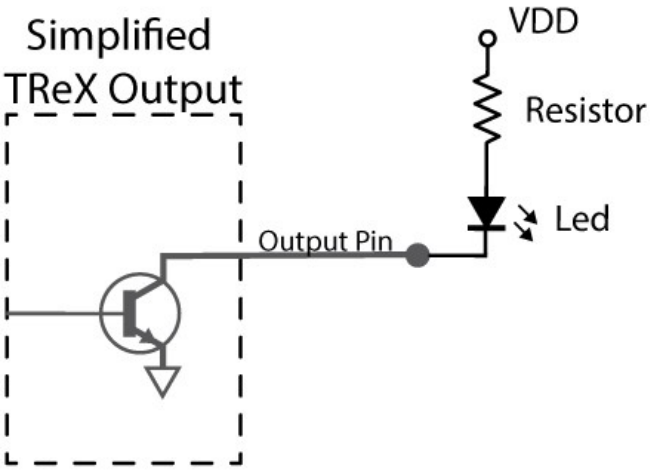
Inputs



Outputs

Care must be taken to ensure the sinking output current does not exceed 100mA. When using inductive loads, such as relay coils, flyback diodes must be fitted to prevent damage to the TReX. VDD is voltage source externally provided between 5 and 24VDC depending on the control application.





Serial Connections

RS-232

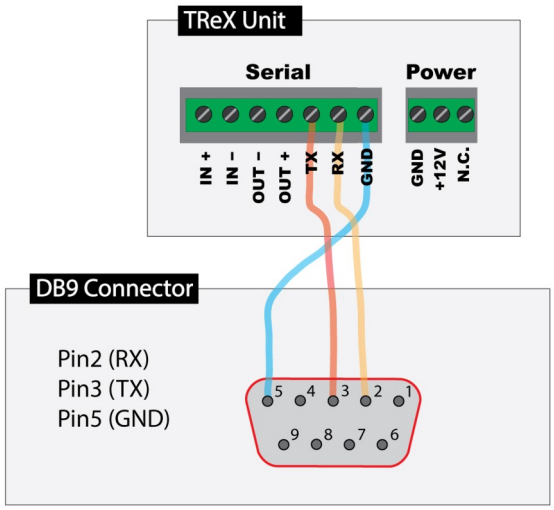


Illustration 1: TReX RS-232 DB9 Connector as DTE

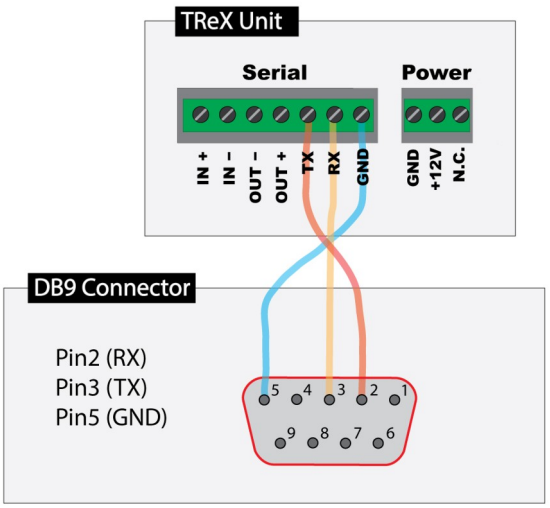


Illustration 2: TReX RS-232 DB9 Connector as DCE

RS-422/RS-485

RS-422 and RS-485 use a differential electrical signal, as opposed to unbalanced signals referenced to ground as used by RS-232. Differential transmission uses two lines each for transmit and receive signals which results in greater noise immunity and longer distances between devices. These advantages make RS-422/RS-485 a better fit for industrial applications.

RS-422 is point to point interface that allows for up to 10 receivers but only a single transmitter. This would be a common serial interface for NMEA devices all sharing GPS data from a single GPS receiver for example.

RS-485 is a multipoint interface that allows each device to be a transmitter and also a receiver. This interface also allows for more devices to be connected on a common serial bus. Because each device on the same bus can transmit, each device must be capable of setting all transmit lines to a high impedance state when not in use to ensure that all devices have the ability to transmit. RS-485 interfaces can be presented as 4 or 2 wires. When there are 2 wires required, the RS-485 device must also be able to isolate its own receiver when transmitting to prevent looping data back to itself.

The TReX satisfies the requirements for both 4 and 2 wire RS-485 communications. The TReX will also be able to operate on a RS-422 bus.

Point To Point Connection

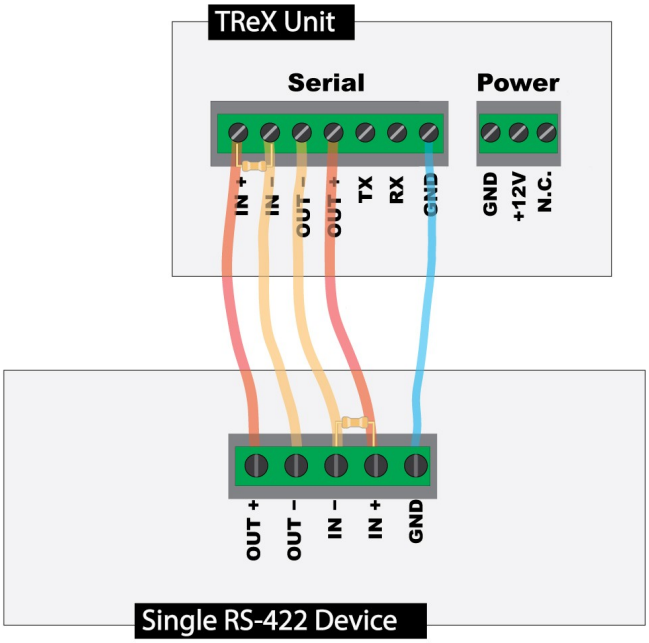


Illustration 3: TReX RS-422 Point to Point Connection

Multi-Point Connection

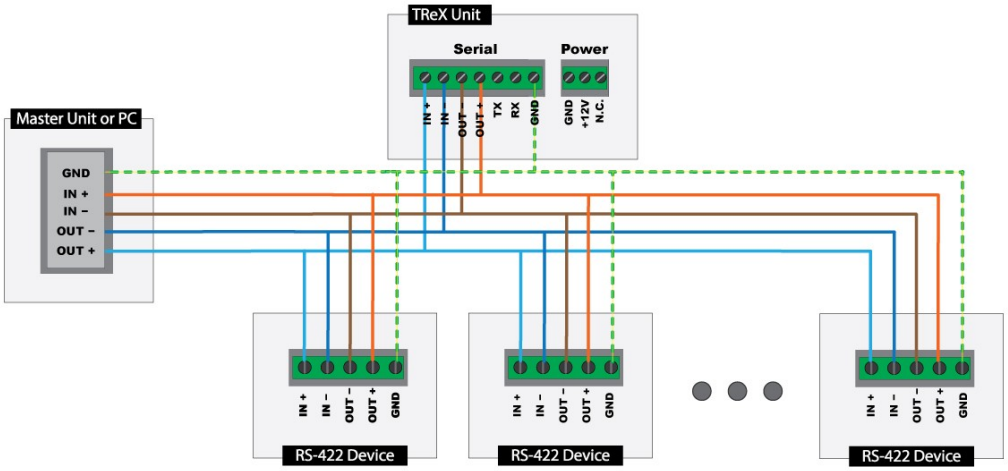


Illustration 4: TReX RS-485/RS-422 Multi-Point

Note: *this configuration only applies if driving less than 10 listeners/receivers when using RS-422 devices or less than 32 devices for RS-485 devices.*

2 Wire Connection

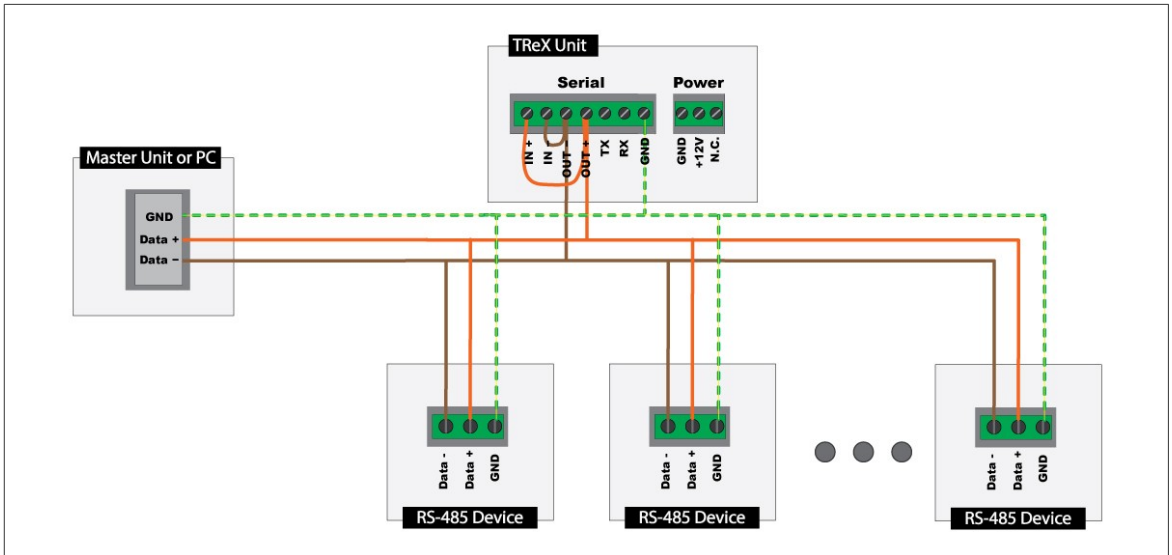


Illustration 5: TReX RS-485 2 Wire Multi-Point

Note: *the TReX must have wire links fitted as shown in order to operate correctly in this configuration.*

Bus Terminating Resistor

RS422/RS485 may require the fitting of a terminating resistor. The purpose of termination is to match the impedance of a transmission line to the hardware impedance of the interface it is connected to. There is more than one way to add termination to an RS485/422 serial connection. The most commonly used is DC Termination, accomplished by attaching a resistor between the signal lines on the extreme ends of the transmission line.

The rule of thumb for termination is:

- If the propagation delay of the data line is much less than one bit (pulse) width, termination is not needed.

This assumes reflections will damp out in several trips back and forth on the data line.

Typically for slow speeds of 9600bps or below, no termination resistor is required.

If termination is required a resistor value of 120Ω or greater should be used, and no more than 2 termination resistors should be used, one at each end of the RS422 transmission line.

Do not use termination resistors with a value of less than 90Ω.

There are many online references available to calculate these resistors if required.

RF Connections

A 50 ohm matched load must be fitted to the TReX antenna port.

Note: Earth the antenna tower, feeders and lightning protection devices in accordance with the appropriate local and national standards. Use grounding kits as specified or supplied by the coaxial cable manufacturer to properly ground or bond the cable outer.

!CAUTION
When the TReX is operating, there is RF energy radiated from the antenna. Do not stand in front of the antenna while the radio is operating (see the 'RF Exposure Warning')

!CAUTION
Lightning will destroy electronic equipment. To avoid this risk, install primary lightning protection devices on any interfaces that are reticulated in the local cable network. Install a coaxial surge suppressor on the radio antenna port.

Power Connections

Power to the TReX is achieved via the power connector as described in the section 16.3.Connecting to the TReX|

!WARNING
EXPLOSION HAZARD TReX was **NOT** designed to operate and/or be connected to voltages above what has been specified. **Failure to follow these instructions can result in death or serious injury**

Ethernet Interface

The TReX supports a 10/100 Base-T Ethernet connection.

To simplify network setup, the TReX supports auto-negotiation and auto-sensing MDI/MDIX crossover.

General	Interface	RJ45
	Cabling	CAT-5/6 UTP, supports auto MDIX (Standard Ethernet)
	Bandwidth allocation	The Ethernet capacity maximum is determined by the available radio link capacity.
	Ethernet mode	10Base-T or 100Base-TX Full duplex or half duplex (Auto-negotiating and auto-sensing)
Diagnostics	Green LED	Off: No data present on the interface. On: Data present on the interface.
	Orange LED	Off: no Ethernet connection On: Ethernet signal received

TReX Firmware Upgrade

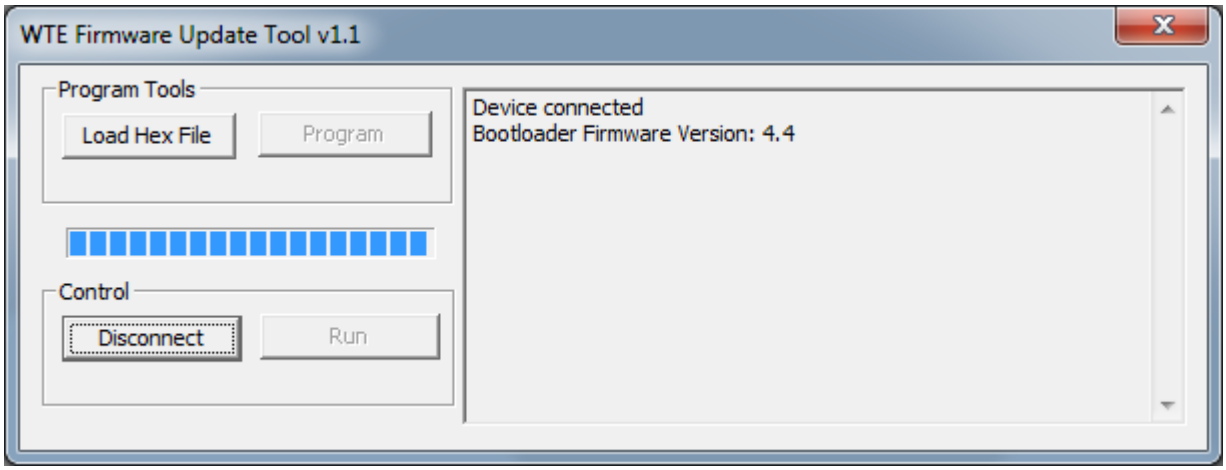
In order to update the TReX primary firmware the following is required:

1. The WTE Firmware Update Tool (available from https://www.wte.co.nz/tools.html or provided if required from info@wte.co.nz).
2. One USB mini B cable.
3. An appropriate encrypted hex file supplied by WTE Limited. Valid TReX hex files take the form **emzTReX-**vXXXX.hex

Note: Attempting to load a hex file not intended for use with the TReX will render the TReX inoperable. Uploading firmware should only be performed if instructed to do so by WTE Limited or an authorised agent.

Firmware Upgrade Utility

This bootloader software has been customised by WTE to simplify the firmware replacement process for the TReX, This application automatically handles erasing and verifying of uploaded firmware. This utility does not perform any decryption function (decryption is carried out by the TReX itself).

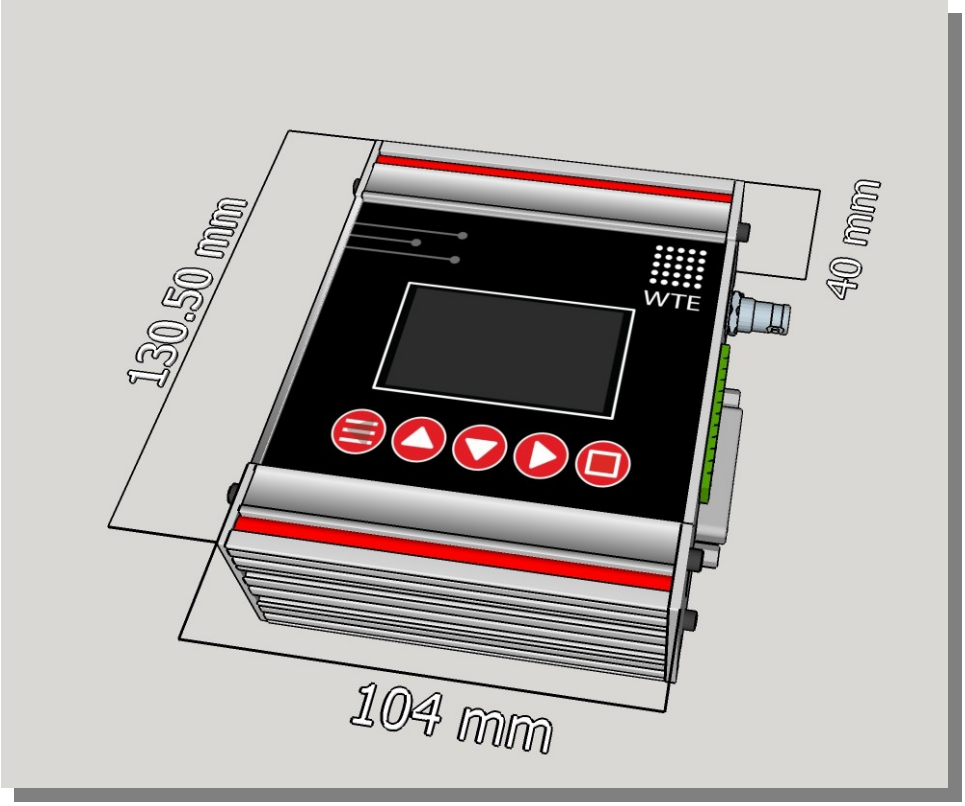


Upgrade Process

1. Run the application WTE-UBL.exe – this is the WTE Firmware Update Tool as shown above.
2. **BEFORE** applying power to the TReX, press the "UP" button, and **HOLD** the button down.
3. Apply power to the TReX.
4. The TReX backlight will flash on and off (approximately once every second) and display "MAIN BOOTLOADER" – **keep the "UP" button pressed**. You now have 10 seconds to press the PC application "Connect" button on the WTE Firmware Update Tool before the TReX exits the bootloader mode of operation.
5. Press the WTE Firmware Update Tool "Connect" button. If connected, the PC application will display the message saying "Device Connected". The TReX backlight will now stay constantly on.
6. You can now **RELEASE** the TReX "UP" button.
7. On the PC application press the "Load Hex File" button.
8. Select the supplied TReX hex file. NOTE: the firmware used must MATCH the TReX receiver variant. A TReX can only be used with TReX encrypted firmware. Failure to comply will leave the device inoperable.
9. Press the WTE Firmware Update Tool "Program" button.
10. Wait for the WTE Firmware Update Tool to indicate that programming has been completed.
11. If successful, the TReX will automatically restart. If the USB cable is still connected, the "USB CONNECTED" screen may be displayed.
12. Remove the USB cable, and the TReX will restart again in its normal mode of operation.
13. If the TReX does not correctly start, then repeat this procedure.

Physical Dimensions

TReX physical dimensions are 104mm x 130.5mm x 40mm (Length x Width x Height)
Weight: 550 grams



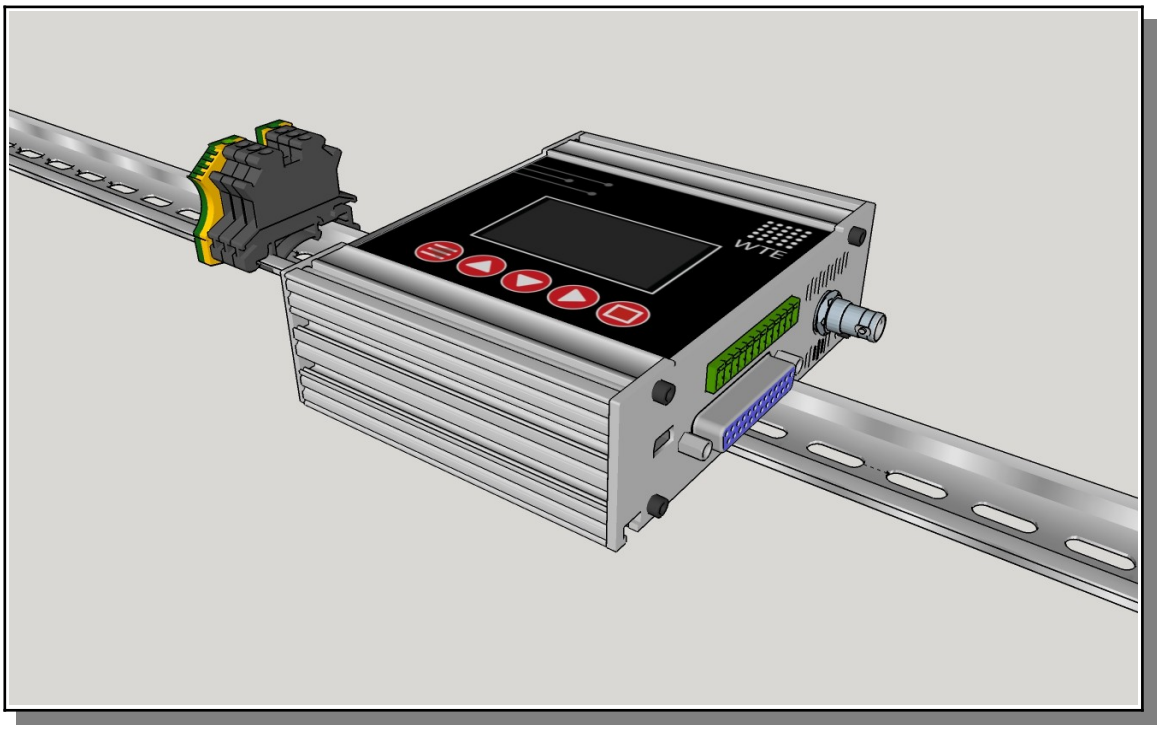
Mounting Hardware

The TReX enclosure was designed to be mounted via:

- DIN Rails
- Left or Right M4 nuts and bolts channels
- Top or Bottom M4 nuts and bolts channels
- Supplied nut slot inserts.

Please look the following images and descriptions to correctly mount the TReX radio

DIN Rail



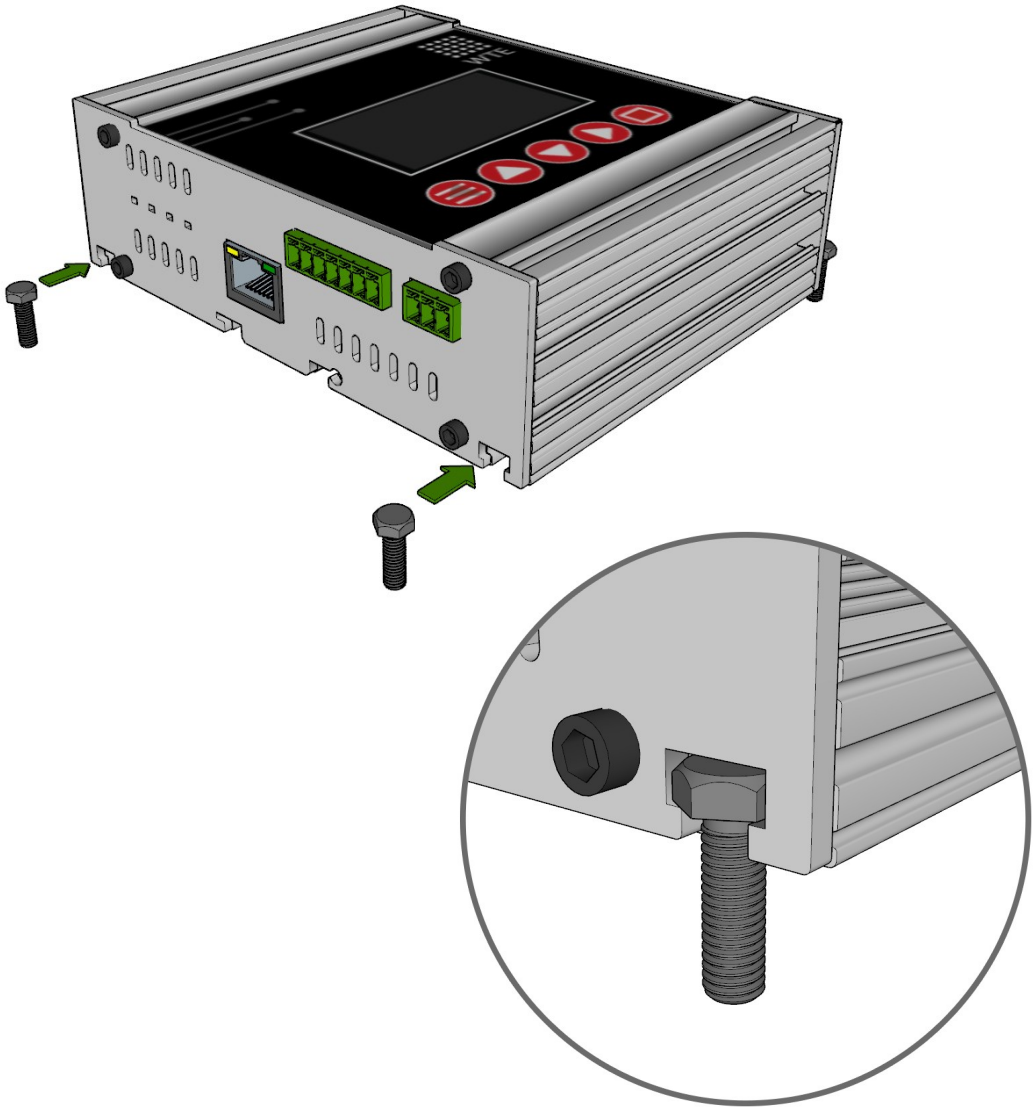
Inbuilt into the TReX custom extrusion there is a DIN rail slot (patent pending) for easy snap fit DIN rail mounting. After location on the DIN rail, 2.5mm locking pins may optionally be fitted from each end plate if desired (a 2.5mm split pin is a perfect fit).

Mounting Channels

The TReX has channel strips on the front, rear, top and bottom. In order to access the front, top and bottom channels (less common mounting option) the end plate on the power cable side will need first to be removed using a hex key. Mounting from the rear does not require the removal of the end plate.

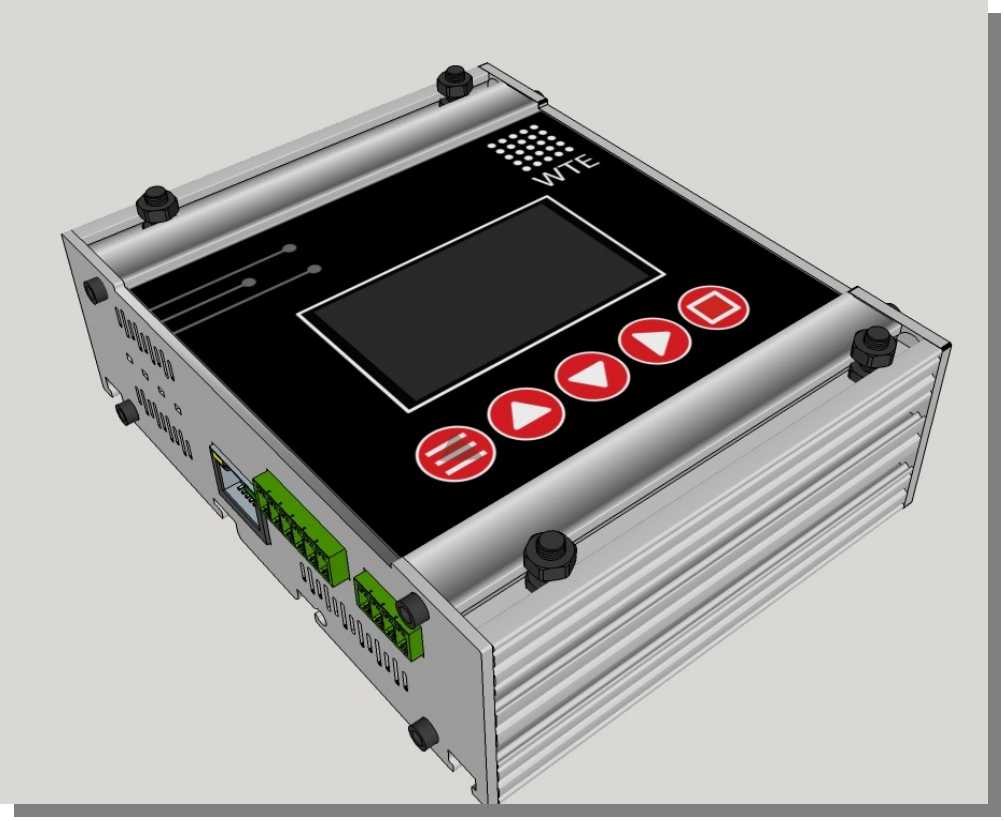
The mounting channel allows an **M4 bolt** head or **M4 nut** to lock inside, as shown bellow.

If an M4 nut is used inside the channels (instead of a M4 bolt head) attention must be taken to NOT use a bolt or screw longer than the channels depth. Not paying attention to this detail may result in damage to the TReX and invalidate the product warranty.

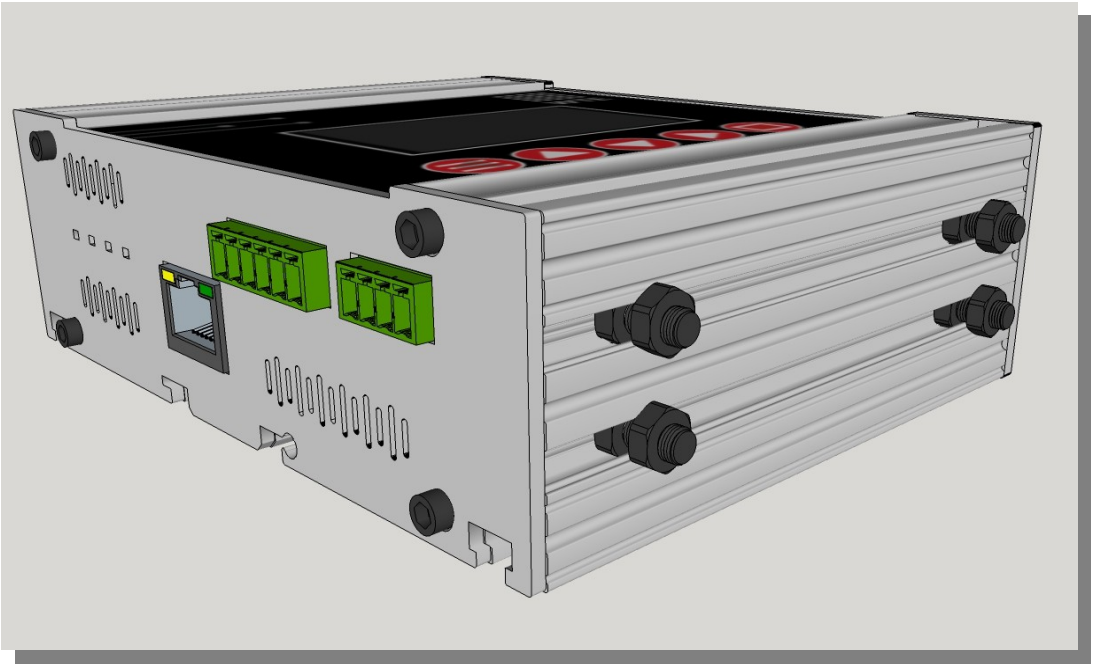


TOP Mount

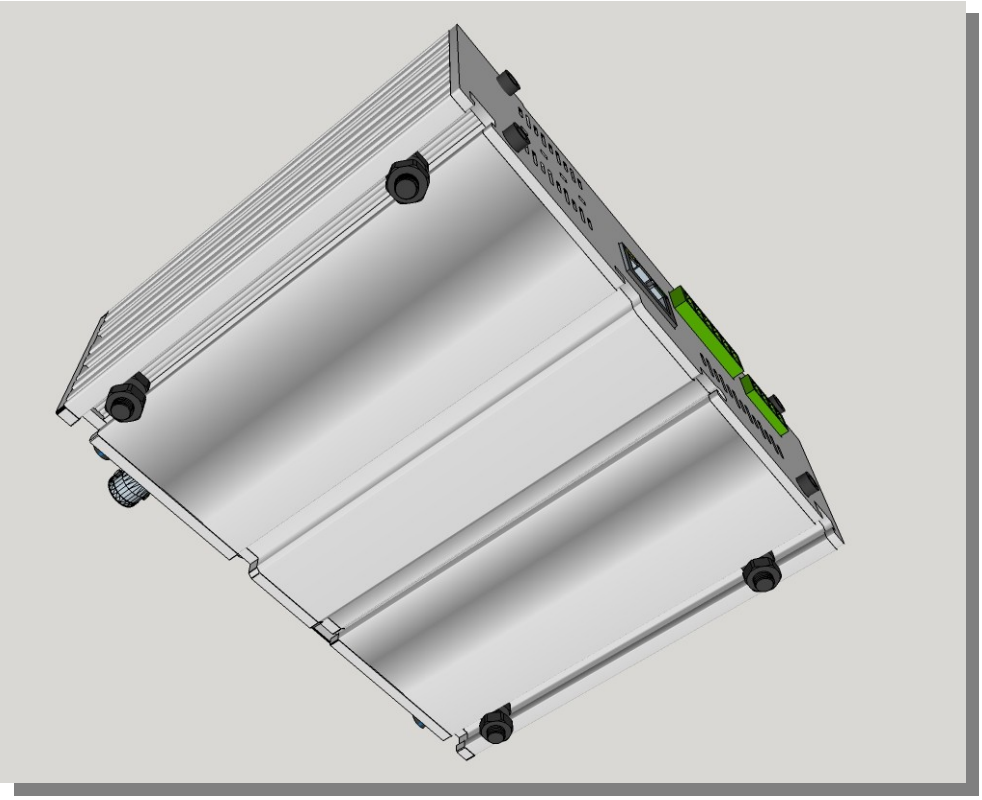
The flush mount option is suitable for an installation such as onto the front panel of a case or cabinet.



SIDE Mount



Bottom Mount

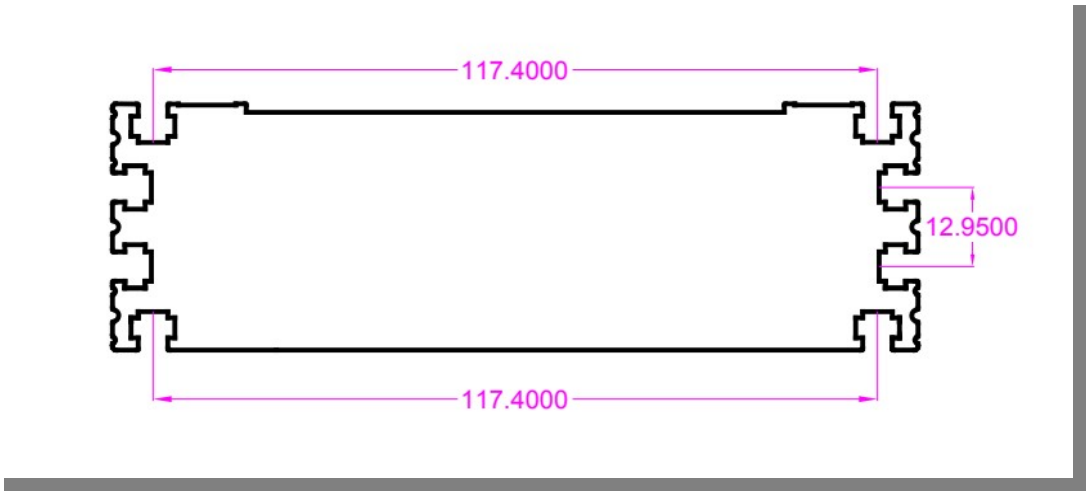


Mount Bolts Dimensions

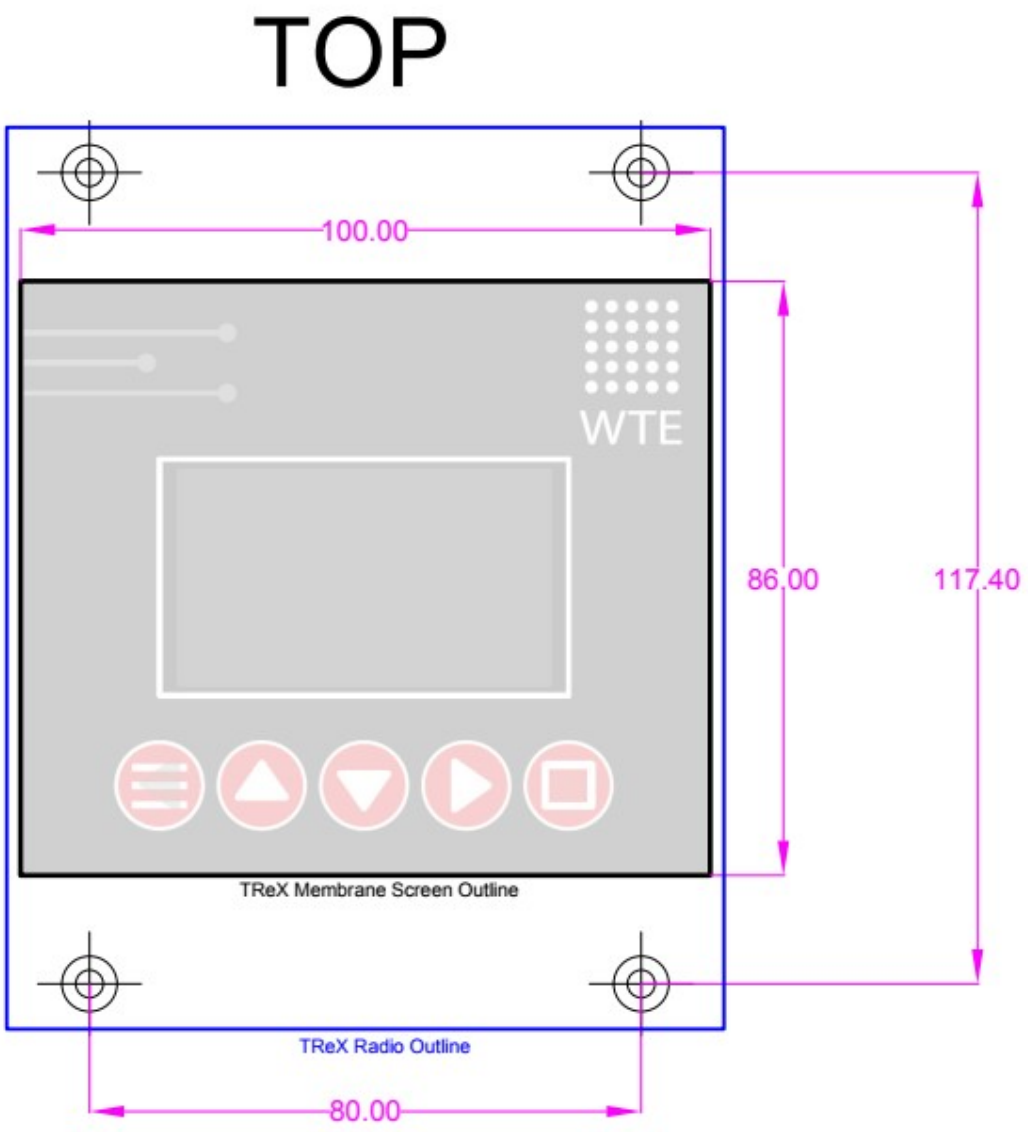
Both top and bottom are symmetric as are the left and right sides of the TReX radio, this allows a wide range of mounting configurations.

The channels space from centre to centre in the top and bottom of the radio is 117.40mm

Dimension are in millimetres



Top and Bottom Drilling Template



Note:

- All dimensions are in millimetres.
- The drilling template will need to be scaled depending on your printer settings.

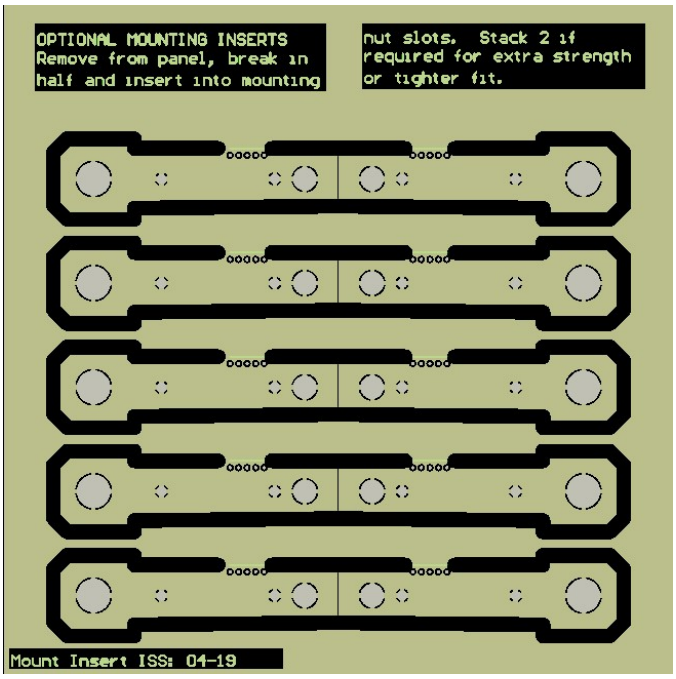
Side Drilling Template

Note:

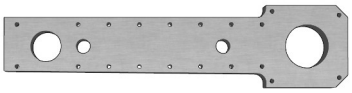
- All dimensions are in millimetres.
- The drilling template will need to be scaled depending on your printer settings.
- Depending on installation, not all mounting points may be required.

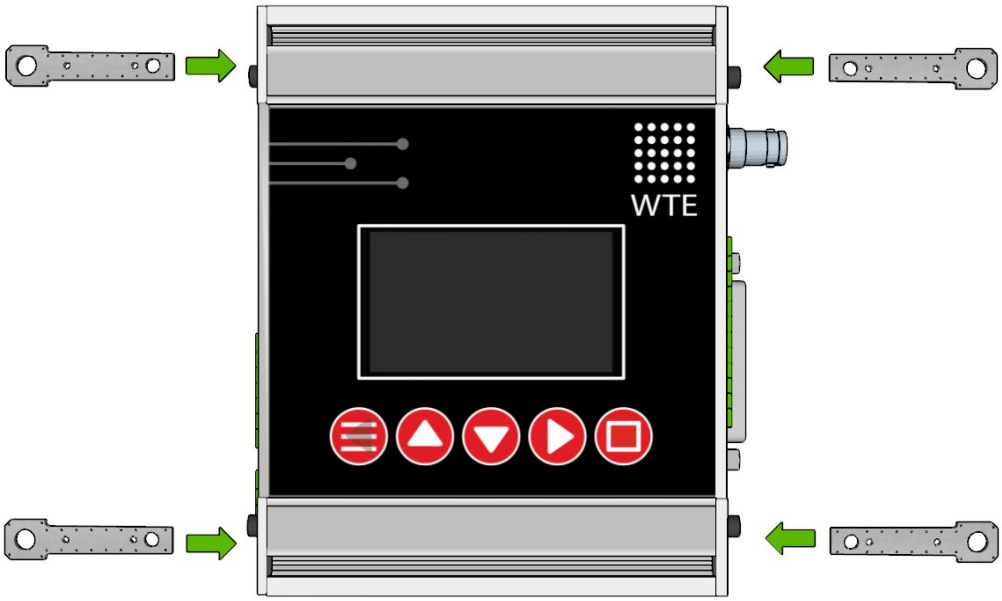
Optional Mounting Inserts

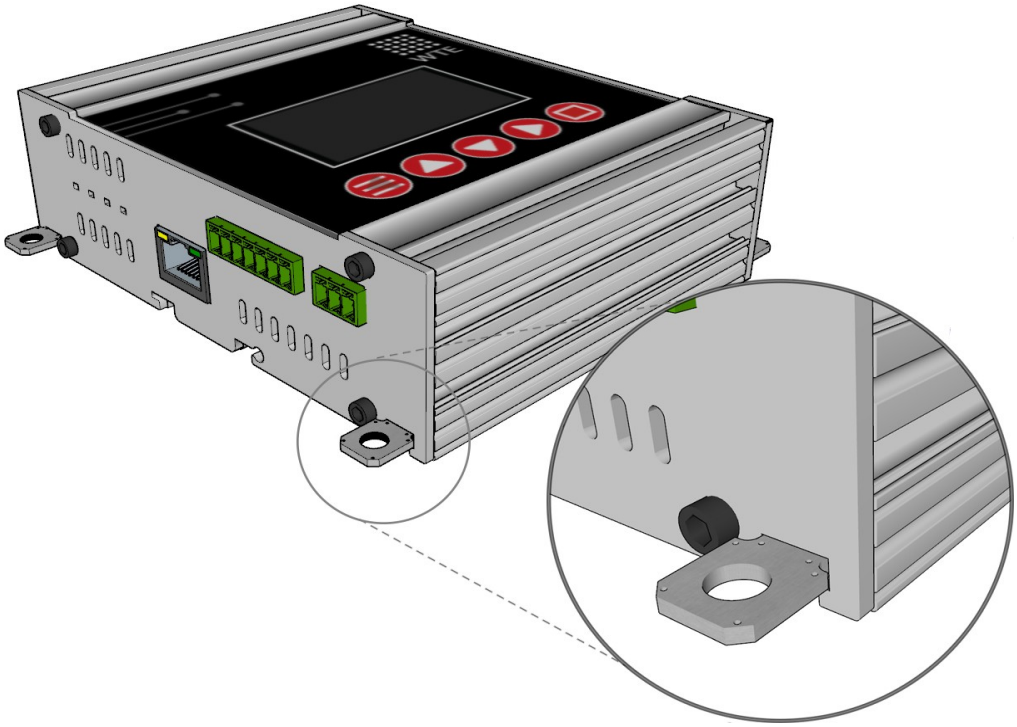
The optional mount inserts, provided with the TReX, can be used to mount the TReX to a panel/enclosure using M4 Screws as shown bellow.



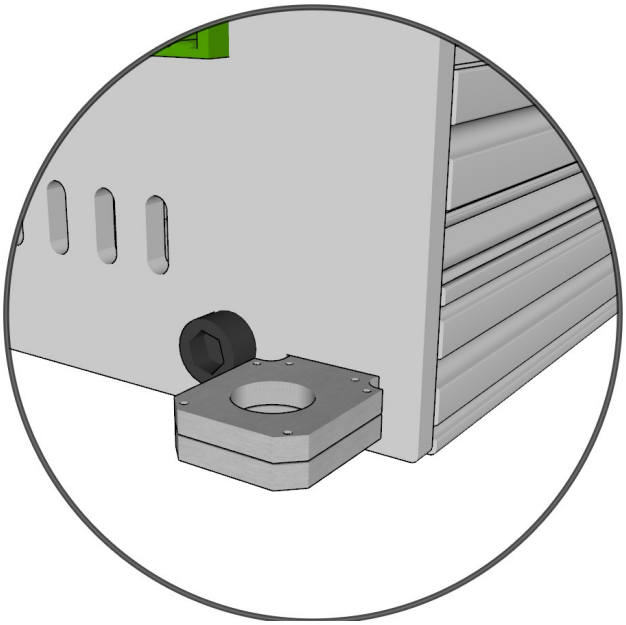
Remove all the insert mounts from the panel in order to use.

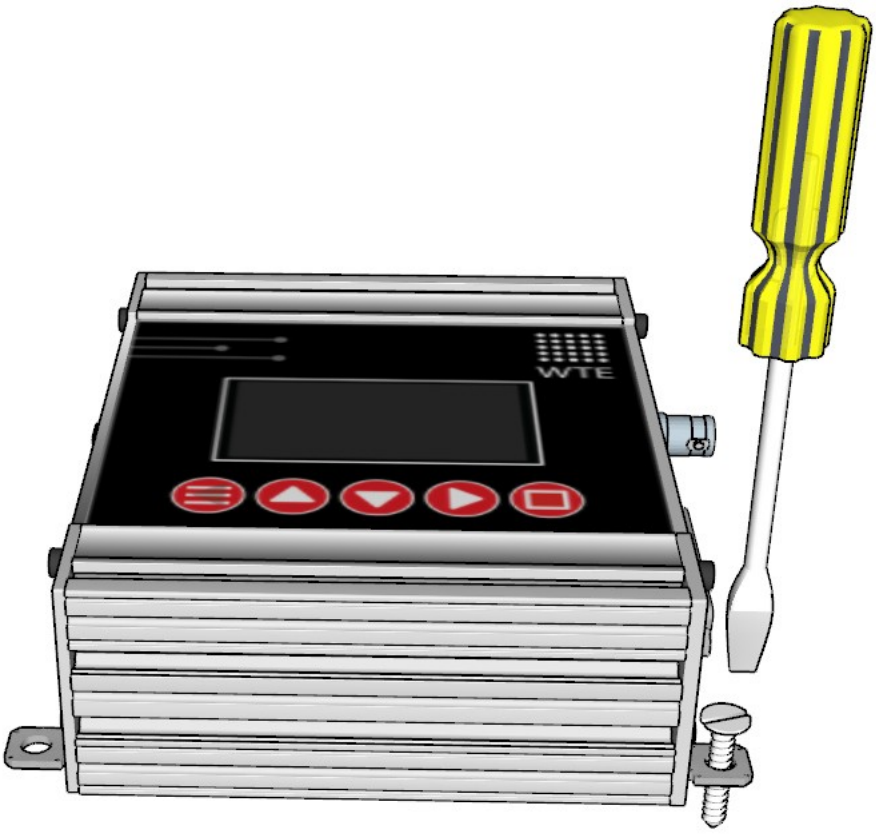



WTE



Optionally two mounting inserts can be used for extra strength.





Omni or Directional Antenna

It is common in radio systems to consider an omni or directional antenna. Both have their advantages and disadvantages as follows.

If in doubt, consult a local antenna specialist who will be able to advise and construct an antenna best suited to your application.

Omni antenna

Omni antenna have the advantage of transmitting and receiving signals equally well in all horizontal directions. This means that if the transmitter or the receiver moves, the antenna will not need to be changed/adjusted to compensate.

This is the common antenna used in cellular phones and handhelds radios.

Directional antenna

Directional antenna have the ability to focus energy in a particular direction. This advantage increasing the maximum distance between transmitter and receiver units. Since the signals are focused/concentrated into a direction it also increase the overall performance of the system.

This is mainly used for fixed transmitter and receiver locations.

Antenna Elevation

As with any radio receiver, raising the height of either the transmitter or receiver antenna will result in dramatic improvements to the maximum possible receive distance. Although a high power transmission will increase distance, the installed height of the receiver antenna is the key to a high performing system.

When close to the ground the major obstacle to overcome, since radio signals are mainly "line of sight", is the curvature of the earth. The typical distance to expect can be approximately calculated as follows:

$$D=\sqrt{\frac{2r_0h_f}{6076.1\beta_0}}$$

Where:

D is the distance to the horizon in NM,

r_0 is the mean radius of the earth (3440.1 NM),

h_f is the height of your antenna,

β_0 (0.8279) accounts for terrestrial refraction.

This formula can be simplified to:

$$d=1.17*\sqrt{h_f}$$

Where:

d = range in nautical miles,

h_f = the height of your antenna in feet.

Working with metric units this formula becomes:

$$km=2.17*\sqrt{0.305*h_m}$$

Where:

km = range in kilometres,

h_m = the height of your antenna in metres.

Therefore:

Antenna Elevation (metres)	Clear Line of Sight Distance (km)
1	1.2
5	2.7
100	12

The Antenna Elevation is the combined elevation of both the transmitter and the receiver (transmitter at 1m and receiver at 9m will behave similarly as the transmitter at 5m and receiver at 5m.

Changes in power level will help to address a less than ideal antenna or poor line of sight conditions.
When line of sight or elevation is poor, the range can also be approximately doubled with every 6dB increase in link budget (either increase in TX power, or increase in RX sensitivity).

From testing, these ranges can be expected from a **20dBm** transmitter at the indicated elevation.
The TReX has an output power of **36dBm** (4W).

(credit to www.offshoreblue.com for some range calculation details)

Disclaimer

THE RESPONSIBILITY LIES COMPLETELY ON THE USER TO ENSURE THAT THIS DEVICE IS TESTED, THROUGH METHODS THAT ARE APPROPRIATE, TO CONFIRM THAT ALL SYSTEM COMPONENTS (THAT THIS DEVICE AND PC SOFTWARE MAY BE PART OF) ARE WORKING CORRECTLY.

This document has been prepared in good faith and produced to assist in the use of this product, however WTE Limited reserves the right to modify, add or remove features without notice.

FLEX™ is a trademark of Motorola, Inc. This unit does not transmit any information in the FLEX format.

When product is supplied, it is the user who is responsible for payment of any customs fees/taxes that are imposed on importation.

Please note that the maximum permitted transmit power level may vary from country to country. It is the users responsibility to ensure local regulations are adhered to.

In no event shall WTE Limited be liable for any incidental, special, indirect or consequential damages, harm to any person, lost profits or lost data, harm to your equipment, cost of procurement of substitute goods, technology or services, any claims by third parties (including but not limited to any defense thereof), any claims for indemnity or contribution, or other similar costs.
The maximum financial liability is limited to the price paid for the supplied product.

No User-Serviceable Components. There are no user-serviceable components within the radio.

This product has been certified for use in multiple markets. The modulation at 32K baud is compliant under FCC only – it is the responsibility of the user to ensure that this modulation is used in FCC territories only.

RoHS and WEEE Compliance
TReX is fully compliant with the European Commission's RoHS (Restriction of Certain Hazardous
Substances in Electrical and Electronic Equipment) and WEEE (Waste Electrical and Electronic Equipment) environmental directives.

Restriction of hazardous substances (RoHS)
The RoHS Directive prohibits the sale in the European Union of electronic equipment containing these hazardous substances: lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs).

End-of-life recycling programme (WEEE)

The WEEE Directive concerns the recovery, reuse, and recycling of electronic and electrical equipment. Under the Directive, used equipment must be marked, collected separately, and disposed of properly.

Manufacturing marking and labels

TReX serial number can found on the unit, also serial number and model information are displayed on start-up or accessible via:
MENU->SYSTEM->FACTORY.

FCC Regulations allow for electronic labelling.
FCC details can be found via:
MENU->SYSTEM->REGULATORY

*Note: Publication number 784748-D02, FCC-Part 90 allows for devices with integrated display to not require a printed label on the device holding this information.

Maintenance

No User-Serviceable Components. Servicing is only to be performed by WTE Limited, or agent appointed by WTE Limited. Servicing outside of the warranty period is at the discretion of WTE Limited.

Product End Of Life

It is your responsibility to dispose of your waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of your waste equipment at the time of disposal will help conserve natural resources and help ensure that it is recycled in a manner that protects human health and the environment. For more information about where you can drop off your waste equipment for recycling contact your local dealer or city council

Please recycle this device responsibly. The TReX has a residual scrap value that includes 400g of Aluminium.

Product Warranty

WTE Limited products are warranted for a period of 12 months after purchase date against faulty workmanship or materials. Return the product, all freight paid by the customer and the product will be repaired or replaced.

The product warranty will be invalidated through evidence of:

- Unauthorised work carried out.
- Tampering, including evidence of removal of internal electronics from the case.
- Installation in wet or corrosive environments.
- Exposure to impact or excessive vibration.
- Use or installation outside of the specified operating parameters.

Abbreviations and Glossary

CAP (CAPCODE) - Channel Access Protocol (CAP) code

RIC -(Radio Identification Code) - an address used in the POCSAG protocol for pagers

POCSAG (Post Office Code Standardisation Advisory Group)- A standard set of code and signalling formats for radio paging.

USB (Universal Serial Bus) - A common interface that enables communication between devices and a host controller such as a personal computer (PC).

ASCII American Standard Code for Information Interchange

BER Bit Error Rate

CBC Cipher Block Chaining

DCE Data Communications Equipment

DMR Digital Mobile Radio

DTE Data Radio Equipment

EMC Electro-Magnetic Compatibility

EMI Electro-Magnetic Interference

ESD Electro-Static Discharge

ETSI European Telecommunications Standards Institute

FW Firmware

HW Hardware

IP Internet Protocol

I/O Input/Output

PLC Programmable Logic Controller

RBW Resolution Bandwidth

RTU Remote Terminal Unit

DMR Digital Mobile Radio

AES Advanced Encryption Standard

RTC Real Time Clock

ISP Internet Service Provider

kbit/s Kilobits per second

kHz Kilohertz

LAN Local Area Network

LED Light Emitting Diode

mA Milliamps

MAC Media Access Control

Mbit/s Megabits per second

MHz Megahertz

mS milliseconds

PC Personal Computer

RF Radio Frequency

RoHS Restriction of Hazardous Substances

RSSI Received Signal Strength Indication

RX Receiver

SCADA Supervisory Control and Data Acquisition

TCP/IP Transmission Control Protocol/Internet Protocol

TCXO Temperature Compensated Crystal Oscillator

TMR Trunk Mobile Radio

TX Transmitter

UTP Unshielded Twisted Pair

VDC Volts DC

WEEE Waste Electrical and Electronic Equipment

IoT Internet of Things.

Specifications

Transmit and Receive Frequency Range:

- 421MHz – 480MHz

Spectrum Analyser (Optional):

- Frequency range: 142-175, 350 - 499 MHz
- RBW: 500Hz, 1kHz and 25kHz
- Span: 3MHz, 120kHz and 24kHz
- Continual or peak display.
- Min signal -120dBm, max signal -10dBm.
- Input Power accuracy: 421-480MHz +/-2 dB, 142-175MHz -8dB.

Supply Voltage

- Nominal 13.8V. Min 10.8. Max 15.6V.
- Must be supplied with a DC power lead less than 3m in length in order to comply with ETSI EN 301-489-1.
- Supply cable should be of a cross sectional area of at least 1mm²

Operating Current at 13.8V:

- Ethernet plus TX standby and RX – 240mA
- RX only - 65mA
- TX standby plus RX – 90mA
- TX standby (RX disabled) – 65mA
- TX operating at 4W – Additional 1.0A (for correctly matched antenna). Current limit software set. Default max current 1.5A.
- Backlight on – additional 55mA.
- External fusing should be 2A.

Digital Inputs:

- To operate pull to ground or may be driven high or low. High level from 5-24V. Low Level less than 1V.

Analog Inputs:

- 2. 0-16 V. Input impedance approx. 50K. Slope and offset configurable (e.g. to support 1-5V or 1-10V).

Digital Outputs:

- 8 open drain. Max allowed supply voltage 24V. Max rated current 100mA. Digital outputs are NOT short circuit protected.

Analog Outputs:

- 2. 0-10V (for 12V supply voltage).
- Output impedance 5 ohms.
- Max current 30mA. May be configured for 4-20mA operation. Minimum loop resistance 100 ohms, maximum 500 ohms. If loop resistance is too low, a 100 ohm series resistor should be fitted.
- Configurable. to support 1-5V, 1-10V or non-standard currents up to 30mA.

- Short circuit protected. Short circuit current approximately 35mA.

Real Time Clock Calendar:

- Super Capacitor backup minimum 3 days
- Accuracy 20PPM over full temperature range

Serial Protocols Supported:

- Modbus RTU
- Modbus TCP
- WTE
- MQTT
- PET/TAP
- ESPA 4.4.4
- Multitone
- Scope
- SAL
- Ascom
- TPP
- TNPP
- TNPPB-NZFS
- AMPAC
- KENTEC

PLC Support (optional):

- Program Rungs: 250
- Timers: 32, 100ms timebase. Max time 99999 s.
- Counters: 16, max count rate, 100Hz. Max count 999999.
- Logging: Timestamped to internal SD card on any physical output change. Logging delay is 10ms per log entry. Logging will affect the ladder scan time. Typical min 100,000 logged events.
- Entire Ladder Scan Interval:
  - 10ms under normal PLC operation. The scan interval is the same regardless of number of program rungs used.
- Alarms: 16 Weekly/daily/hourly
- Analog Comparators: 16.
- Work Control Bits: 64
- Hold Bits 16 (retained on power off for up to 1 week, min 3 days).
- Radio completely reconfigurable via PLC program control.
- Program controlled macros: 64 (any transmission protocol message or TReX command).
- Program control of up to 9 remote TReX slave units.
- Serial match strings: 4, reprogrammable under PLC control.
- Output and Input max update rate is determined by **Telemetry Remote I/O Update Time**.

Telemetry Remote I/O Update Time (typical):

- 32K baud 4GFSK – 70 ms
- 16K baud 4GFSK – 100 ms
- 9600 baud 4GFSK – 128 ms
- 9600 baud GFSK – 168 ms
- 4800 baud 4GFSK – 212 ms
- 4800 baud GFSK – 292 ms
- 2400 baud FSK – 550 ms
- 1200 baud FSK – 1.05 s
- 512 baud FSK – 2.4 s

Input Message Length:

- Input max configured message length 50 characters. Max message length via serial port 300 characters.**Temperature Limits:**
- Operating -30 to + 55 degrees Celsius ambient.
- Storage/Transit -70 to +70 degrees Celsius.

Output Alerting:

- High/low supply voltage.
- High temperature.
- RF Power fault
- Antenna fault
- Comms link fail

Max Rx Input Power:

- 17dBm. Direct connection above 17dBm (50mW) will destroy the receiver.

Receiver at 450.5MHz, 512 baud 12.5kHz (compliant with EN300113):

- Sensitivity: -122dBm. Desensitised at frequency multiples of 26MHz (and within 50kHz).
- Selectivity @ +/- 1 channel: 61dB
- Blocking at 1MHz offset: Tolerates -20dBm
- Co-channel Rejection Ratio: Rejects unwanted signal at -4dB
- Error Behaviour at high signal levels: Decodes wanted signal at +13dBm.

Antenna Connector:

- BNC

Firmware

- Field upgradable.

Communication Interfaces:

- 1 x RS232
- 1 x RS422/485 (2 or 4 wire)
- 1 x Ethernet (TCP/IP)

FLEX™ Decode Support:

- Decoding of all Alphanumeric and numeric messages at 1600 baud (2 level only).

POCSAG Encode and Decode Support:

- Alphanumeric, numeric or tone only including batched.
- Deviation, 4.5 kHz, 2.25 kHz or 1.1 kHz depending on channel spacing selected.
- Rates – 512, 1200, 2400, 4800 and 9600.
- AES 128-bit and AES 256-bit encryption.

DMR Support:

- Partial ETSI TS 102 361-1 (Tier 1 direct mode).
- Text Message Types:
  - Short message, unconfirmed
  - UDP compressed header, unconfirmed.
- Max message length 90 characters.
- Tested and compatible DMR radios:

  Hytera – PD565, PD665
  Kirisun DP770, TM840H
  Motorola SL4010e

Modulations Supported and Approved:

25kHz Channel Width:
512 baud (FSK), 1200 (FSK), 1600 (FSK), 2400 (GFSK), 4800 (2GFSK), 9600 (GFSK), 9600 (4GFSK), 16K (4GFSK), 32K (4GFSK only permitted for use in USA).

12.5kHz Channel Width:
512 baud (FSK), 1200 (FSK), 2400 (GFSK), 4800 (GFSK), 9600 (GFSK), 9600 (4GFSK), 16K (4GFSK)

6.25kHz Channel Width:
512 baud (FSK), 1200 (GFSK), 2400 (GFSK), 4800 (4GFSK)

RF Link Security

- AES 128 or AES 256 with cipher block chaining.
- Uniquely identified transmissions with replay attack protection.
- Encryption over data links and paging messages.

Optional Ethernet Transport Layer Security:

- TLS version 1.2.
- Max AES key size 128 bits. (256 bit on request).

Ethernet Connection:

- Permitted simultaneous connections = 1.
- Web configuration and monitoring.
- TCP socket (both client and server) for both message protocol support and configuration.
- Cable length should be less than 3m in length in order to comply with ETSI EN 301-489-1.

Mechanical:

- Length: 104mm or 125mm including BNC connector
- Width: 131mm
- Height: 41mm
- Weight: 550grams

Mounting:
- Rack
- Wall
- DIN rail

IP rating:
- IP51.

Environmental:
- Operating temperature range: -40 to +70˚ C (-40 to +158˚ F)
- Storage temperature range: -40 to +80˚ C (-40 to +176˚ F)
- Operating humidity: Maximum 95% non-condensing
- Acoustic noise emission. No emission when sounder is disabled. Maximum sound output from sounder is less than 80dBA.

Compliance Standards:
- EN 300 113 (base-station and portable/mobile compliant).
- EN 301 489
- ETSI TS 102 361-1 (DMR modulation and TDMA bursts)
- EN 60950 + IEC 62368-1
- EN 50385
- FCC part 90
- AS/NZ 4768

Laboratory Testing
- Base-station and mobile compliant, testing completed 8/2/2019.
- DMR modulation aspects, testing completed 17/12/20

Declaration of Conformity

Manufacturer:

Wireless Technologies (WTE Limited)
Christchurch, New Zealand

WTE Limited hereby declares the TReX Telemetry, Data and Messaging Transceiver satisfies all the technical regulations applicable to the product within the scope of Directive 2014/53/EU (Radio Equipment Directive) of the European Parliament and Councils.

The products covered by this declaration:
WTE – TReX 460
WTE – TReX 461

The basis on which conformity is being declared:
The products identified above comply with the above directive, and WTE Limited has created a technical construction file which includes reports: 190101.1, 190101.2, 190101.3 and 190101.4 from the EMC Competent Body: EMC Technologies (NZ) Ltd.

The manufacturer has applied the following harmonised standards:

- **ETSI EN 300 113 v2.2.1 (2016-12)**
  Land Mobile Service; Radio equipment intended for the transmission of data using constant envelope modulation and having an antenna connector (for base-stations and mobile-stations).

- **EN 301 489-1 V2.1.1 (2017-02)** Electro Magnetic Compatibility (EMC) standard for radio equipment and services.

- **EN 60950-1:2006** Safety of information technology equipment

- **EN 50385:2017** RF exposure compliance for base station equipment.

The CE mark was first applied in: April 2019

Contact:
Shannon Reardon or Rodrigo Pellizzari
info@wte.co.nz
Date: 25/04/2019

Shannon Reardon
Engineer/Director

Rodrigo Pellizzari
Engineer/Director