MReX-5IO-DMR
TELEMETRY and MESSAGING
TRANSCEIVER

User Manual

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Introduction

Thank you for choosing the MReX-5IO-DMR.

The MReX-5IO-DMR is a multi-band, very high sensitivity transceiver for the transmission and reception of DMR and POCSAG messages and also for general telemetry use.

The MReX-5IO-DMR may be provided with DMR only functionality, or additionally with POCSAG depending on licensing options.

Typical Applications

- Control of outputs using messages sent from programmed DMR handheld radios. Typical applications include access to secure areas, opening gates, operating lights, and similar functions using leading-brand DMR radios.
- Point-to-point serial links.
- Simple interfacing of I/O with telemetry systems.
- Monitoring of security and other critical events. Transmission of DMR and POCSAG messages directly to legacy systems and DMR handheld radios.

MReX-5IO-DMR Features

- Available in 2 models:
    - MReX-5IO-DMR-160/900 - 137 to 174 MHz, 860 to 870 MHz and 902 to 928 MHz
    - MReX-5IO-DMR-460/900 - 421 to 480 MHz, 860 to 870 MHz and 902 to 928 MHz
- Data rates supported from 512 baud to 128kbps with frequency hopping options.
- Sends and receives 512, 1200 and 2400 baud POCSAG paging messages.
- Transmits DMR messages and receives data messages directly from most DMR radios (Hytera, Motorola, Tait, Kirisun and many others).
- Store and forward repeater operation with configurable duplicate reject (optional).
- Point-to-point wireless serial link enabling a transparent serial connection.
- Military grade AES-256 secure encrypted RF communication.
- Up to 5 inputs. Two inputs may be reconfigured to be outputs.
- Two relay outputs.
- RS232 and USB-C connection interfaces.
- Configured inputs can be programmed to send POCSAG and DMR messages simultaneously when triggered.
- Configured outputs can be controlled via paging or DMR messages.
- Periodic message support to ensure link integrity.
- Firmware upgradable.
- High stability 0.5ppm reference oscillator.
- Output power up to 100mW.
- High sensitivity receiver (-130dBm at 512 baud and -119dBm for DMR).
- Wide range of approved channel spacings from 6.25kHz to 500kHz depending on selected frequencies and regional configuration.
- Support for many international free-to-air frequencies and optionally licensed channels.

MReX-5IO-DMR Benefits:

- Long-range, reliable DMR performance
  Allows a high-power standard DMR radio to transmit directly to the MReX-5IO-DMR high sensitivity receiver for dependable communication over extended distances.
- Works with standard DMR infrastructure
  Built around proven DMR technology, making integration with existing radio systems straightforward and cost-effective.
- Simple installation
  Fast to deploy with minimal wiring, setup time, and system complexity.
- Easy to configure and commission
  Designed for quick setup, allowing installers and integrators to get the system running with less effort.
- Low power receiver operation
  Market-leading low power consumption helps reduce energy use and supports efficient long-term operation.
- Ideal for remote and off-grid sites
  Low receiver power requirements make it well suited to solar-powered, battery-backed, and hard-to-access locations.
- Lower total system cost
  Reduces infrastructure, installation, and ongoing operating costs compared with more complex wireless or wired alternatives.
- Proven reliability for critical applications
  Engineered for dependable operation where message delivery and system uptime matter.
- Fast path to deployment
  Standard radio-based operation means users can implement solutions quickly without needing a complex custom network.
- Scalable solution
  Suitable for small installations through to larger multi-site deployments.

Product Variants

This manual provides operating instructions for all MReX-5IO-DMR variants.

There are 2 main separately approved modules:

MReX-5IO-DMR 160/900:

Allows operation from 137MHz-174MHz, 863MHz-870MHz and 902MHz-928MHz.

MReX-5IO-DMR 460/900:

Allows operation from 421MHz-480MHz, 863MHz-870MHz and 902MHz-928MHz.

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 draw attention to information that clarifies or simplifies a procedure.

!	This is the safety alert symbol. It is used to alert you 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.

!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

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 8 cm from all persons to satisfy RF exposure compliance.

DO NOT:

- Operate the transmitter when someone is within 8cm of the antenna. EN50383 regulatory limits have deemed that 8cm 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 15cm 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.

!WARNING
THIS EQUIPMENT IS NOT INTENDED FOR MAINS VOLTAGES The MReX-5IO-DMR was **NOT** designed to operate and/or be connected directly to live main voltages. The MReX-5IO-DMR 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 MReX-5IO-DMR 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 MReX-5IO-DMR 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
- Care when stacking MReX-5IO-DMR boxes must be taken to not damage part of the radio, such as connectors.

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.

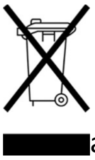
This device must be operated as supplied by the equipment supplier. Any changes or modifications made to the device without the written consent of the equipment supplier may void the user's authority to operate the device.

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 11cm 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 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 the dealer from whom you originally purchased the product.

Operation

NOTICE
This product will not be able to transmit on any frequency until the operating region has been set. The region setting will restrict permitted frequencies and power levels. Set the region with the serial command ***REGION**

When the MReX-5IO-DMR is operating normally the green status LED provides an indication of the operating state:

Green Status LED	Operating State
Flashes once per second	Normal, receiving if enabled and able to accept commands.
Flashes rapidly, 4 times a second	Serial Link mode, unable to accept configuration commands.
Held on for approx one second	Receiver decoding a message.

When transmitting, the red LED will illuminate for the full duration of the transmission.

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

After start-up the MReX-5IO-DMR enters its receive and decode mode of operation, waits for commands to be entered serially for processing or inputs to be triggered. These may be either protocol messages to be transmitted or commands related to the configuration of the device.

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 output is driven high or low, or for a particular period of time depending on configuration. The output is controlled via the **WTE Output Control Protocol** message that is received and decoded.

Ensure an antenna is attached before transmitting.

Startup Serial Output

When the MReX Plus powers on, it immediately outputs a **sign-on message** via the serial port at **9600:8-N-1** or the baud rate configured by the *SYS_BAUD command. This message provides useful information for confirming operation and identifying the firmware version, unit type, and enabled features.

This section outlines what users should expect to see on a terminal during normal startup, and how to interpret the output.

Typical Sign-On Output:

```
WTE MReX+ SF 460/900 v1.53 SN:151 [255] REGION:LICENSED
```

Output Field Breakdown

Field	Example	Description
SF 460/900	**SF 460/900**	Product name and variant. Identifies the hardware variant or firmware type.
V1.53	**V1.53**	Firmware version currently running.
SN:3573	**SN:3573**	Unique serial number of the unit.
[32]	**[32]**	Indicates which licenses have been set, used for product support purposes.
REGION	**NZ**	Initially UNSET, the REGION is set to the area being used in or to LICENSED if a specific frequency has been licensed for use.

Configuration Window Notice

For 15 seconds after power-up, the unit enters a configuration window during which commands can be entered. After this period, certain modes (like RAW or `LINK`) lock out configuration for safety.

Additional Serial Terminal Output:

If the DMR receiver is enabled and operating:

DMR RX FREQ:432875000 ID:1006 CC:5

indicating the operating frequency, programmed DMR ID and colour code.

This message confirms that the unit has exited the configuration period and entered full operational mode. It is especially relevant in RAW or encrypted LINK modes where commands are no longer accepted.

What to Do If You See Nothing

If no output appears on your serial terminal:

Problem	Suggested Solution
Garbled text	Check baud rate: should be **9600 8-N-1** or configured baud rate.
No text at all	Check cable wiring (TX/RX reversed?), ensure unit is powered

---

Advanced Usage Tips

- **Use `*VER<CR>`** to re-display the sign-on message at any time.
- **Use `*CONFIG<CR>`** to list all current configuration parameters after startup.

DMR Messaging

The MReX-5IO-DMR implements the ETSI TS 102 361-1 DMR air interface for data and text messaging, supporting direct receive, decode, output control, and optional store-and-forward operation.

The MReX-5IO-DMR receives DMR data messages directly from most DMR radios. Transmissions from DMR radios can be configured to control MReX-5IO-DMR outputs, serially output as WT formatted protocol messages or output serially in full to allow use with third-party systems. When the store forward licence has been applied, DMR messages can be received, filtered and retransmitted as either DMR or POCSAG messages.

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 MReX-5IO-DMR concurrently supports POCSAG and DMR messaging, allowing an input to send messages to both legacy paging systems and newer DMR radios. The MReX-5IO-DMR does not support concurrent reception of both POCSAG and DMR messages.

Enabling DMR Operation

1. Set unit to defaults.

   ***DEFAULTS**
2. Set the operating region.

   ***REGION=LICENSED** (if a licenced frequency is being used)
3. Set DMR known operating FREQUENCY

   ***TX_FREQ=432000000**
4. *Set DMR baud rate and modulation

   ***TX_BAUD=9600_RRC_12**
5. Save configuration

   ***SAVE**
6. Restart and apply settings

   ***REBOOT**

The default DMR ID is 1006 and colour code is configured to receive on all. The default setting allows the unit to ACK when its ID of 1006 is addressed, but also receive messages from all DMR radios from ID of 8-2000000 (set by default RX_RANGE). By default configuring TX_FREQ and TX_BAUD also configures RX_FREQ and RX_BAUD.

On start will now display:

DMR RX FREQ:432000000 ID:1006 CC:ALL

Receiving DMR Messages

Received DMR Messages will be serially output in WT Protocol format such as:

WT0000202D82 Message from DMR Radio\r

Transmitting DMR Messages

Transmitting DMR messages can be performed serially sending WT Protocol formatted messages such as:

WT0001004D60 DMR Test Message\r

*Note: No messages can be transmitted until the operating region has been set, using the *REGION command.*

Once basic operation has been confirmed use ***DMR_OPTS** and ***RX_RANGE** to set DMR ID and Colour Code. See WT Protocol and DMR Message Format for more information on sending and receiving DMR messages.

Low Current Receive Operation

MReX-5IO-DMR products support a low current receive mode that significantly reduces operating current.

DMR: Operating current is reduced to approximately 900 µA.
POCSAG: Operating current can be as low as 100 µA.

For battery-powered systems (e.g., using AA cells), this enables continuous receive operation for up to 3 months in DMR mode and over one year in POCSAG applications. This may be useful for difficult remote repeater applications where a solar panel or external power source is not possible.

Enabling Low Power Mode:
To enable low power receive mode, issue the following command:

***RX_ENABLE=3,0\r**

Note: This mode is not compatible with high data rate modulations.

Waking the MReX from Low Power Mode:
While in deep sleep, command processing is limited. External systems should wake the MReX by repeatedly sending a simple command such as:

***VER\r**

Continue sending the command until a response is received. Once awake, the unit will remain responsive for 60 seconds after each command is processed.

Serial Output Behaviour:
Even in low power mode, serial output from the module is still active. Periodic messages can be sent as normal. This may be desired as part of a system health status check.

For example, the following command sends "OK" via the UART every 5 seconds, regardless of the power state:

***TX_PERIODIC=5,WTS OK\r**

AES Radio Security

The MReX-5IO-DMR 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. Secure RF communication on the MReX-5IO-DMR is fully compatible with that of the TReX family of products. See **AES Encryption** for operating information.

A default key is loaded into the MReX-5IO-DMR, 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. 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. The WTE Serial Terminal from https://www.wte.co.nz/tools.html can be used to generate this key if required.
2. Use the command ***RF_KEY** to enter the key and configure other secure RF settings, 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.*

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. **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.

A duplicate reject timeout can be configured using ***RF_KEY**, which allows for duplicate reject histories to be cleared after a certain amount of time since receiving a valid message from a specific device. This is useful in the event that a device within the network loses power and resets its timestamp. This has a default value of 1 hour or 3600 seconds but can be set as high as ~8 hours (30000 seconds) or disabled entirely (by setting value to 0). For maximum system reliability it is recommended to use this setting in conjunction with a periodic transmission (see ***TX_PERIODIC**), with the duplicate reject timeout value set higher than the transmission period.

Configuration

Parameters can be changed using any common serial terminal program. A serial terminal program that also allows saving and loading of configuration files can be downloaded from wte.co.nz/tools.html

Start-up operation is 9600:8-N-1 by default, but can be set to another rate with the *SYS_BAUD command.

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>.

Some examples specify a single space character, shown as <SPACE>.

All commands that accept a value, can have that value read back by using the '?' suffix. E.g.

**TX_FREQ?*

Returns

**TX_FREQ=460000000* (for example)

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*

To find the first range only, usage would be:

**RX_RANGE?1<CR>*

Returns

**RX_RANGE=1:8,2000000*

Note: 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.

Transmit Commands

*REGION

***REGION** sets the operating region and ensures that the unit does not transmit on frequencies or power levels that may be in breach of regulatory requirements. Valid REGIONS are **NZ**, **EU**, **UK**, **USA** and **LICENSED**. When using **LICENSED** any frequency and power level may be set, therefore the user is responsible for legal requirements being met before transmitting.

Typical Use:

**REGION=EU<CR>*

Region	Default Frequency	Frequency Range	Power Level
NZ	865.0MHz	160.1MHz - 160.6MHz	100mW
		458.54MHz - 458.61MHz	100mW
		466.8MHz – 466.825MHz	100mW
		864.0MHz – 868.0MHz	100mW
		915.0MHz - 928.0MHz	100mW
EU & UK	869.5MHz	868.0MHz - 868.6MHz	25mw
		868.7MHz - 869.2MHz	25mW
		869.4MHz - 869.65MHz	100mW
		869.65MHz - 869.7MHz	5mW
		869.7MHz - 870.0MHz	25mW
USA	902.5MHz	902.0MHz - 915.0MHz	100mW
LICENSED		137.0MHz - 174.0MHz	100mW
		421.0MHz - 480.0MHz	100mW
		860.0MHz - 870.0MHz	100mW
		915.5MHz - 928.0MHz	100mW
UNSET		No Transmission	---

Note that USA uses a frequency hopping transmission which starts hopping at the specified frequency. Frequency hopping may extend up to 928.0MHz

*TX_FREQ

***TX_FREQ** specifies the transmit frequency in Hz. Valid ranges are 137MHz-174MHz, 421MHz-480MHz, 860MHz-870MHz, 902MHz-915MHz and 916MHz-928MHz. If the existing *TX_BAUD setting is not supported by the configured frequency, the *TX_BAUD will be reset to the first valid baud rate.

Typical Use:

**TX_FREQ=158600000<CR>*

*TX_PROTO

***TX_PROTO** specifies the protocol to apply for serial input. Accepts WTE and RAW. RAW is used for the point to point serial link operation if available.

Typical usage:

**TX_PROTO=WTE<CR>*

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

*TX_BAUD

***TX_BAUD** Specifies the baud rate and channel width of the transmitter when using a protocol that does not permit a baud rate and channel width to be specified.

**_6 indicates a specified baud rate with a 6.25kHz channel spacing.

**_12 indicates a specified baud rate with a 12.5kHz channel spacing.

**_25 indicates a specified baud rate with a 25kHz channel spacing.

**_50 indicates a specified baud rate with a 50kHz channel spacing.

**_200 indicates a specified baud rate with a 200kHz channel spacing.

**_500 indicates a specified baud rate with a 500kHz channel spacing.

**_HOP indicates a specified baud rate using frequency hopping.

When frequency 137-174MHz accepts:

512_12, 1200_12, 4800_12, 4800-4L_6, 9600_RRC_12

When frequency 421-480MHz accepts:

512_12, 1200_12, 4800_12, 4800-4L_6, 9600_RRC_12

When frequency 860-870 accepts:

1200-25, 4800-25, 16K_50

When frequency 916-928 MHz accepts:

1200-25, 4800-25, 16K_50, 64K_200

When frequency 902-915 MHz accepts:

4800_25_HOP, 128K_500_HOP

Typical usage:

**TX_BAUD=512_12<CR>*

*TX_MODE

***TX_MODE** specifies the transport method of the transmitter (how the information is transmitted over the air).

- POSCAG_A must be used in order to transmit alphanumeric messages.
- POSCAG_N must be used in order to transmit numeric messages.
- WTE_EN must be used in order to transmit 8 bit characters (POSCAG_A transmits 7 bit characters only).
- DMR used when messages are to be transmitted using DMR slot bursts. This setting is automatically applied when the TX_BAUD is configured to 9600_RRC_12.

Accepts POSCAG_A, POCSAG_N, DMR and WTE_EN.

Typical usage:

**TX_MODE=POSCAG_A<CR>*

*TX_PREAMBLE

***TX_PREAMBLE** set the preamble length in multiples of 32 bits. Does not apply to DMR messaging (use DMR_CSBK instead).

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). 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 halve the channel activity.

Typical usage:

**TX_PREAMBLE=18<CR>*

*TX_PERIODIC

***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.

**TX_PERIODIC=TT,MMMM<CR>*

where:

TT is the time in seconds between transmissions (0-65535. 0 disables the feature).

MMMM is the periodic message to transmit (up to 50 characters). If this argument is not specified, the periodic message will be triggered in TT seconds. This is useful for testing a configured periodic message.

Typical usage:

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

*TX_LEVEL

***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

***TX_CAP** specifies the default code used to identify transmissions (same as the RIC code). The TX_CAP code would only be used by protocols that do not require the CAP code to be specified. This code can be any number between 8 and 2000000.

Typical usage:

**TX_CAP=1234567<CR>*

*CH_BUSY

***CH_BUSY** Enables the BUSY alert and channel busy level for the configured channel. When a transmission is attempted, the channel is first checked. If activity on the channel exceeds this power level, the transmission will be delayed until the channel is clear. After a period of 5 seconds of the channel being busy, the transmission will proceed regardless.   In order to set a good channel busy level, the channel noise floor can be inspected using the *RSSI command.

*CH_BUSY=BB

Where:

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

In this example the channel will be considered “busy” if the channel signal strength is above -90dBm.

Typical usage:

**CH_BUSY=-90<CR>*

*TX_PWR

***TX_PWR** sets the transmitter Power in 0.1 dBm steps. This is the maximum power level that will be used. *REGION has been set and a frequency does not permit a high power level, the lower regional power level will be applied.

Examples:

Setting MReX-5IO-DMR to transmit 10dBm

**TX_PWR=100<CR>*

Setting MReX-5IO-DMR to transmit at 17dBm

**TX_PWR=170<CR>*

Setting MReX-5IO-DMR to transmit at 20dBm

**TX_PWR=200<CR>*

Receive Commands

*RX_FREQ

***RX_FREQ** specifies the receive frequency in Hz. Valid ranges are 137MHz-174MHz, 421MHz-480MHz, 860MHz-870MHz, 902MHz-915MHz and 916MHz-928MHz. If the existing *RX_BAUD setting is not supported by the selected frequency, the *RX_BAUD will be reset to the first valid baud rate.

**RX_FREQ=160000000<CR>*

*RX_BAUD

***RX_BAUD** specifies the baud rate and channel width of the receiver.

When frequency 137-174MHz accepts:

512_12, 1200_12, 4800_12, 4800-4L_6, 9600_RRC_12

When frequency 421-480MHz accepts:

512_12, 1200_12, 4800_12, 4800-4L_6, 9600_RRC_12

When frequency 860-870 accepts:

1200-25, 4800-25, 16K_50

When frequency 916-928 MHz accepts:

1200-25, 4800-25, 16K_50, 64K_200

When frequency 902-915 MHz accepts:

4800_25_HOP, 128K_500_HOP

*RX_PROTO

***RX_PROTO** specifies the protocol to apply for serial output, accepts WTE, RAW and DMR.

When *RX_MODE=DMR is selected, *RX_PROTO determines whether decoded messages (WT), raw frames (DMR), or serial passthrough (RAW) are output.

See protocol section for more detail on protocols and configuration. E.g.

**RX_PROTO=WTE<CR>*

*RX_MODE

***RX_MODE** specifies the transport method of the receiver (how the information is received over the air).

- POSCAG_A must be used in order to receive alphanumeric messages.
- POSCAG_N must be used in order to receive numeric messages.
- WTE_EN must be used in order to receive 8 bit characters (POSCAG_A transmits 7 bit characters only).
- DMR must be used in order to receive DMR messages. On startup, if RX_BAUD has been set to 9600_RRC_12, *RX_MODE will automatically be set to DMR.

Accepts POSCAG_A, POCSAG_N, WTE_EN, DMR and FLEX. E.g.

**RX_MODE=POSCAG_A<CR>*

*RX_RANGE

***RX_RANGE** specifies up to 4 CAP and ID RX ranges for POCSAG and DMR decoding. Messages received with CAP or DMR ID codes not allowed on the RX_RANGE will be discarded by the receiver.

When receiving DMR messages, RX ranges apply to DMR group or individual IDs. Messages outside configured ranges are discarded. There is one exception when receiving DMR messages – messages can still be received on the DMR ID configured using the *DMR_OPTS command. Only the DMR ID configured in the DMR_OPTS command will be used to acknowledge a confirmed type DMR transmission.

*RX_RANGE=N:LLLLLLL,HHHHHHH (where N is the range between 1 and 4, LLLLLLL is the lowest cap code to match, HHHHHHH is the highest). E.g.

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

*RX_ENABLE

***RX_ENABLE** controls the receiver.

First parameter is the receive mode (0=off, 1=normal, 3=low power).

The second optional parameter is for factory use only.

Typical Usage:

RX_ENABLE=1,0<CR>

Base Commands

*REBOOT

***REBOOT** forces the unit to immediately restart.

Usage:

**REBOOT<CR>*

*CONFIG

***CONFIG** displays current configuration.

**CONFIG<CR>*

*SAVE

***SAVE** saves all configuration settings (all config changes are restored on start-up).

Usage:

**SAVE <CR>*

*LIST

***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

***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>*

*RF_KEY

Sets RF link encryption key details, including the 32 or 64 character AES keys and encryption options. This command is only available for products that support AES encryption.

**RF_KEY=A,B,C,DDDD,E<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 (associated with parameter **E**). The need for this option is negated by application data including a timestamp in a payload for inspection.

DDDD is the shared 128 or 256 bit key. This is a random hex sequence that must be 32(for 128 bit) or 64 (for 256 bit) hexadecimal characters in length. All MReX-5IO-DMR and TReX devices in a system must share this key. Typically a 64 character key is loaded, and only half of that key is used for 128 bit encryption (making switching between 128 and 256 bit encryption simpler).

E is the duplicate reject record max age in seconds (0-30000), associated with parameter **C**. This allows for connections between devices to be reset in the event that a device restarts and loses its current message sequence. It is recommended to set this higher than any configured periodic message duration. Setting to 0 disables duplicate reject ageing (all units in a system must therefore be manually restarted in order to achieve resynchronisation).

Typical usage:

*RF_KEY=1,0,0,452948404D635166546A576E5A7234753777217A25432A462D4A614E64526755,3600<CR>

*RF_KEY?

Typical response:

*RF_KEY=1,1,1,-4529****,3600

Note: only the first 4 characters of the key are displayed, although the full key is stored.

*RAW_CONFIG

Sets configuration items allowing the point to point serial link to be optimised if required. See **RAW Protocol** for details.

*RF_ID

Configures the unit ID number used by the RF AES to identify the device. This should be unique within the network of devices to avoid conflicts with the duplicate reject system. This feature prevents “replay” attacks. Applications typically have their own mechanisms to prevent these attacks, therefore this option normally would not be required.

**RF_ID=A*

Where:

A is the individual ID to use (0-255).

Typical usage:

***RF_ID=1<CR>**

*VER

***VER** sends the MReX-5IO-DMR sign on message back to the user. This is useful to determine the model and serial number of the unit.

Usage:

**VER<CR>*

Typical response:

WTE MReX+ SF 460/900 v1.50 AES SN:151 [255] REGION:NZ

*IO

Returns all input and output states.

Typical usage:

**IO<CR>*

Typical output:

IO=I:01000 O:00

In this typical output, there are 5 inputs shown. Output states follow (valid only if outputs are is configured)

*BYPASS

Allows messages to be entered via serial to simulate as if decoded across the air. This can be useful for testing.

Commands take the format:

***BYPASS**=[1234567:1]Message_Payload

Where:

[is the character '['

1234567 is the simulated RIC

: is the character ':'

1 is the beep level of the messages

] is the character ']'

Message_Payload is any message to inject as if received across the air.

This message will now be processed according to the configured RX_PROTO configuration.

Typical Usage 1:

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

"Test Message" will be added to the received message serial output, as if received across the air.

Typical Usage 2:

**BYPASS=[1234567:1][[01]U0[*REBOOT]]<CR>*

The unit will reboot the unit, please refer to WTE Output Control Protocol section on this manual for more information.

*RSSI

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

Usage:

**RSSI<CR>*

*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:

1 – Enable Carrier only,

2 – Enable Carrier with random modulation,

3 – Enable 101010 modulation,

0 – Disable Carrier

y is the time in seconds which the MReX-5IO-DMR will be transmitting for.

Example carrier only for 60 seconds:

**LAB=1<CR>*

Example carrier only for 20 seconds:

**LAB=1,20<CR>*

*BATT_MSG

***BATT_MSG** is the message that is transmitted when the supply voltage has been determined to be too low. This is most useful when powered from a battery, therefore applicable only to the MReX-5IO-DMR module or products with battery packs. The low level voltage is set to 2.2V for MReX-ULP products (contain NiMh cells) and 2.6V for all other MReX-5IO-DMR products that use alkaline cells. Do not configure and use for MReX-5IO-DMR products with external power supplies.

Usage:

**BATT_MSG=WT1234560A10 LOW BATTERY<CR>*

*SYS_BAUD

***SYS_BAUD** is the UART baud rate. Any change is not applied until *SAVE is issued, then the unit is restarted. UART settings are all N:8:1. Valid values are 9600, 38400, 115200 and 256000. Default value after setting to defaults is 9600.

Usage:

**SYS_BAUD=115200<CR>*

*DMR_OPTS

***DMR_OPTS** allows configuration of DMR specific parameters.

*DMR_OPTS syntax:

**DMR_OPTS =AA,BB,CC,DD,EE,FF<CR>*

Where:

AA is the DMR ID of the unit. If set to 0, the DMR ID is the unit 5 digit serial number. All transmissions will use this as the source ID. Note that when receiving DMR messages the MReX will accept messages that either match this ID or any ID specified in the RX_RANGE commands. This allows for many common group IDs to be configured. Colour code match must also be valid.

BB is the colour code. If set to -1, the unit will respond to all colour code transmissions. This parameter is only used when receiving DMR transmissions.

CC is the DMR retransmission count. This parameter is optional and is only used for confirmed DMR transmissions and will only be transmitted if the transmission has not be acknowledged.

DD is the delay in 100ms increments between sending each retransmission. This parameter is optional.

EE is reserved and for factory use only. Do not change.

FF is reserved and for factory use only. Do not change.

Usage:

**DMR_OPTS=1009,6<CR>*

Sets DMR ID to 1009 with a colour code of 6.

*DMR_CSBK

***DMR_CSBK** allows modification of CSBK preamble lengths and CSBK bursts used to wake DMR receivers for different DMR message and packet types.

*DMR_CSBK syntax:

**DMR_CSBK =AA,BB,CC<CR>*

Where:

AA is the number of CSBK preamble bursts leading unconfirmed (group) messages. By default this is 14, typical for many DMR transmitters. By increasing, WTE DMR receivers can wake less often, saving more power at the cost of longer delivery times.

BB is the number of CSBK preamble bursts leading confirmed (individual) messages. By default this is 6, typical for many DMR transmitters.

CC is the number of CSBK preamble bursts leading status and acknowledge packets. By default this is 1. The DMR specification allows for this value to be 0, but some DMR radios may prefer having a value between 1 and 3, which allows for improved receiver alignment.

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. This is a licensed optional feature.

> **Note:** In order to forward messages the decoded message CAP or DMR ID 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>*

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.

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

*IN_INIT

***IN_INIT** specifies the configuration of the initial input expected state. If unset (2) then on start the current input level is used. If configured to opposite to the start level, then a transmission on start will be immediate.

*IN_INIT=I:B
Where:

I = The input to configure (1-5 valid)
B = the initial expected state (0-2). Set to 0 for an expected state of LOW, 1 for HIGH or 2 for the current input state.

*IN_CONFIG_L

***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

Where:

I = The input to configure (1-5 valid)

: = the colon character ':'

N = number of transmissions (1-254. Set to 0 to disable. Set to 255 to transmit until input state changes)

, = the comma character ','

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

, = the comma character ','

R = time in seconds between retransmissions.

Example. Configure input 1 to send two message after input is debounced by 300 milliseconds and repeat/retransmit this message 4 times.

**IN_CONFIG_L=1:2,3,4<CR>*

*IN_CONFIG_H

***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

Where:

I = The input to configure (1-5 valid)

: = the colon character ':'

N = number of transmissions (1-254. Set to 0 to disable. Set to 255 to transmit until input state changes)

, = the comma character ','

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

, = the comma character ','

R = time in seconds between retransmissions.

Example:

**IN_CONFIG_H=1:1,10,15<CR>*

*IN_MSG_L

***IN_MSG_L** specifies the input low level message that will be transmitted if configured.

**IN_MSG_L=I:MMMMM*

Where:

I = The input to configure (1-5 valid)

: = the colon character ':'

MMMMM = message to be transmitted (typically formatted as WT Protocol)

Example:

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

*IN_MSG_H

***IN_MSG_H** specifies the input high level message that will be transmitted if configured.

**IN_MSG_H=I:MMMMM*

Where:

I = The input to configure (1-5 valid)

: = the colon character ‘:’

MMMMM = message to be transmitted (typically formatted as WT Protocol)

Example:

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

Output Commands

The output commands allows the output to be enabled (disabling input 1). 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 MReX-5IO-DMR board.

*OUT_CONFIG

***OUT_CONFIG** specifies all output configuration items, usage as follows:

*OUT_CONFIG=O:E,T,A,B,L *<CR>*

Where:

O = The output to configure (only 1 or 2 valid)

: = the character ':'

E = 1 to enable the set GPIO pin to an output, 0 to enable the set GPIO pin to an input.

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.

A = if configured, when T has been configured will close the output for this period before remaining off for the B. This cycles until the T period has expired. Allows for a the output to flash ON/OFF.

B = Used with A. Specifies the output open period before closing again for the A period, until the T duration has expired.

L = Link fail operation. Each message directed to the unit ID will reset an output link fail timer for this period. When configured, the output will close on start, until a message is received. The output will close again should the timer expire. Set in 100ms increments. Relies on a periodic message being received that opens the output.

Example:

**OUT_CONFIG=1:1,100,0,0,0<CR>*

*UNIT_ID

***UNIT_ID** specifies the output unit ID

*UNIT_ID=XX<CR>

where:

XX are any characters (up to 12 either numeric or alphanumeric) that are used to uniquely address each MReX-5IO-DMR 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.

Example:

**UNIT_ID=01<CR>*

Note: Inputs can still be enabled while the GPIO is configured to be an output. This has been allowed to permit a message to be received, then reply immediately with a preprogrammed message that has been configured on that same pin. In this manner the MReX-5IO-DMR can transmit any message reporting when an output has changed state.

Protocols

Serial input into and out of the MReX-5IO-DMR can be formatted differently by selecting an appropriate protocol.

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 paging or DMR messaging) to be used and a variety of baud rates.

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

D = DMR Text Message (directed to a group)

d = DMR Text Message (directed to an individual)

W= POCSAG WTE (WTE 8 bit format allowing all 8 bit characters to be transmitted)

B is the Level 1-9. Note that POCSAG only supports levels 1-4 which is the same as the "Beep Level".

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

Automatically Applied:

The "-' character can be used to automatically apply the baud rate set by the *TX_BAUD command. e.g. WT1234560A1- Test Message

137MHz – 174MHz:

12.5 kHz Channel Space Settings

A = 512 Baud FSK

B = 1200 Baud FSK

D = 9600 Baud RRC 4FSK

6.25 kHz Channel Space Settings

d = 4800 Baud 4 Level GFSK

421MHz – 480MHz:

12.5 kHz Channel Space Settings

A = 512 Baud 2 Level FSK

B = 1200 Baud 2 Level FSK

D = 9600 Baud RRC 4FSK

6.25 kHz Channel Space Settings

d = 4800 Baud 4 Level GFSK

860MHz – 870MHz or 915MHz-928MHz:

25 kHz Channel Space Settings

M = 1200 Baud 2 Level GFSK

N = 4800 Baud 2 Level GFSK

D= 9600 Baud RRC 4FSK

50 kHz Channel Space Settings

O = 16K Baud 2 Level GFSK

200 kHz Channel Space Settings

P = 64K Baud 2 Level GFSK *(not available from 860-870MHz)*

902MHz to 915MHz:

25kHz Channel Space Settings

X = 4800 Baud 2 Level GFSK, frequency hopping.

500kHz Channel Space Settings

Y = 128K Baud 2 Level GFSK, frequency hopping.

<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"

WT1234567A1A<SPACE>TEST<CR>

After processing/transmitting responds with:

WT[NNN]<CR>

where:

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

WT[017]<CR>

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.

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.

Serial Output Support

Alternatively, the WT Output Protocol can be used to send messages over the device’s UART. This is useful for systems that implement wired connections between units.

Message format:

WTS<SPACE>MMMMMM<CR>

Where:

WTS are the 3 characters WTS.

MMMM is the payload, up to 240 characters.

Example:

To send the message “TEST” over the device’s RS422 connection.

WTS<SPACE>TEST<CR>

The message “TEST” will be sent over the device’s UART connection. No other reply will be sent.

DMR Message Format

The WT Protocol can be used for sending DMR text messages. The protocol allows for an ID (group or individual), colour code, radio type and message to be specified. When accepting DMR messages, the WT Protocol has been extended to allow either 7 or 8 digits to allow the full range of possible DMR IDs.

Different DMR radio manufacturers frequently have differing DMR implementations that often allow only same-brand communication.

The WT protocol uses the commonly used “baud” field to set the DMR radio type to support some of these manufacturer differences. 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:

WT**NNNNNNNNABC** TEST\r or

WT**NNNNNNNNABC**

where:

NNNNNNN is a 7 or 8 digit code that is a unit group or individual DMR ID.

A is “D” if the message is unconfirmed or “d” if the message is confirmed (will retransmit if ACK not received).

B is the colour code.

C is the radio 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, Motorola, Tait and others.

Type ‘S’ – This a “status” message.

Motorola Radio Usage:

No messages are transmitted using any Motorola proprietary 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)

WT0001001D60<SPACE>TEST MESSAGE<CR>

Example:

To send a DMR confirmed message to individual ID 104, colour code 6 with payload of “TEST MESSAGE” and to a type ‘2’ radio (Motorola)

WT0000104d62<SPACE>TEST MESSAGE<CR>

DMR Status Format

The DMR status message is a short header packet transmission, typically assigned to some DMR radios for proprietary applications. The status transmission can either be a confirmed (group) or unconfirmed (individual) message. For DMR radios that require receiver alignment, the *DMR_CSBK command can be used to provide a configurable number of leading CSBK bursts for a more robust solution.

Basic Status Format:

WT**NNNNNNNABC VV**\r

where:

NNNNNNN is a 7 or 8 digit code that is a unit group or individual DMR ID.

A is "D" if the message is unconfirmed or "d" if the message is confirmed (will retransmit if ACK not received).

B is the colour code.

C is 'S' – This a "status" message.

VV is a value between 0 and 1023

To send a DMR status unconfirmed message to group ID 1001, colour code 6 with value of 64.

WT0001001D6S<SPACE>64<CR>

To send a DMR status confirmed message to group ID 1001, colour code 6 with value of 64.

WT0001001d6S<SPACE>64<CR>

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 temperature. Any number of macros can be used in any location of the message until the max message length has been reached. Different WTE products support a different number of variable content macros.

Macro Tag	Description	Example Output
**05	Battery Voltage	3.15
**06	Temperature (degrees Celsius)	23.4
**SN	Serial Number	0151
**01	Transmit sequential number	AB6F (rotates after FFFF)
**03	All inputs hex bitmap	001F (5 inputs set high)
**I	Input level 2	1 or 0
**i	Input 2 level Inverted	0 or 1

Example 1:

To transmit the battery 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 3.15V

Example 2:

To transmit the battery voltage periodically, program the periodic message with:

*WT1234567A10<SPACE>Unit 34 Batt **05V<CR>*

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

Unit 34 Batt 3.15V

RAW Protocol

The optional 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 command is used with RAW protocol:

*RAW_CONFIG

***RAW_CONFIG** specifies all RAW protocol parameters.

Format:

*RAW_CONFIG=A,BBB,CC,D<CR>

Where:

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

BBB specifies the number of characters to transmit at once. Messages exceeding the length can still be sent, but there will be a small delay between each transmission. Transmission delays may be longer than expected if the MReX-5IO-DMR determines that the channel is busy.

CC specifies an immediate transmission character (0 if unused). Decimal value of ASCII character (e.g. 13 for \r)

D optional parameter that allows input 5 to be used to control the enabling of the protocol. When using a point to point serial link, if this parameter is set to 1, pulling the input to ground will enable the serial link and releasing the input will disable the serial link. This allows the unit to accept serial commands for processing or transmit any serial serial data. By default this setting is 0.

Example:

**RAW_CONFIG=4,100,13<CR>*

DMR Protocol

The DMR Protocol is used when serially outputting received DMR frames without decoding. To decode DMR frames and allow output control the WT protocol should be selected. WT protocol is also used for DMR transmissions.

The DMR protocol may be useful for third-party systems, or for network analysis to have access to full DMR frames. This protocol allows access to all non-voice messages and packet types.

In order to use, ensure that ***RX_PROTO=DMR** has been configured. Also ensure that the UART baud rate is at least 115200 to ensure data is not lost.

Below is typical output when receiving a short data message. This output is only useful to users with familiarity of the DMR specification. No bit correction has been applied, nor any decoding of any kind. The data has been formated as:
CACH<SPACE>PAYLOAD<SPACE>SYNC<SPACE>PAYLOAD

Data is organised 2 bits per symbol as specified in the DMR specification (see ETSI TS 102 361-1).

The following is a text message data transmission from a mobile DMR transmitter (SYNC pattern D5D7F77FD757).

```
0BC082 50FE42258CDC0E342408C51298E D5D7F77FD757 A051600486609404685D1361352
23C088 509A42A58DC40E0C2069CDB098E D5D7F77FD757 A05DE20E866C940868D512C9356
2BC082 50DA42278CD80C14225841F098E D5D7F77FD757 A05AE00D8262943268891259360
0FC088 40BE42A98DC80F04220949B298E D5D7F77FD757 A057A614827B9452488952D1B45
03C082 40FE422B8CD40D1C2038C5F298E D5D7F77FD757 A050A4178675946848D55241B73
03C088 409A42AB8DCC0D242459CD5098E D5D7F77FD757 A05C261D86799464485D53E9B77
0BC082 40DA42298CD00F3C2668411098E D5D7F77FD757 A05B241E8277945E48015379B41
0BC080 40DB42E38DC40F0C2659459298E D5D7F77FD757 A05E62078A7D945648C51379B62
2BC082 409B42618CD80D142468C9D298E D5D7F77FD757 A05960048E73946C489913E9B54
2BC080 40FF42E18DC00D2C2009C17098E D5D7F77FD757 A055E20E8E7F946048111241B50
0BC082 40BF42638CDC0F3422384D3098E D5D7F77FD757 A052E00D8A71945A484D12D1B66
23C088 40B842E18C540F142079419298E D5D7F77FD757 A05E66040A598474480153C9350
2BC082 40F842638D480D0C2248CDD298E D5D7F77FD757 A05964070E57844E485D5359366
03C088 409C42E38C500D342629C57098E D5D7F77FD757 A055E60D0E5B844248D552F1362
0BC082 40DC42618D4C0F2C2418493098E D5D7F77FD757 A052E40E0A55847848895261354
03C088 40DD42AB8C580F1C24294DB298E D5D7F77FD757 A057A217025F8470484D1261377
03C082 40DC42618D4C0F2C2418493098E D5D7F77FD757 A052E40E0A55847848895261354
23C088 40DD42AB8C580F1C24294DB298E D5D7F77FD757 A057A217025F8470484D1261377
2BC08A 097482DF22EC421E90A9978259A D5D7F77FD757 3F4E805B2013A352D5FC07B2011
0BC088 009E45A82A704AC824E002A099C D5D7F77FD757 0584CE5A02B61470720084A0427
2BC082 009280DB00B806900890108019C D5D7F77FD757 05AE601680F4013E008100F8089
```

Serial Link Operation

In this application, the RAW protocol is used with a transport format that allows any ASCII character to be transmitted. Raw serial data in any format presented to the MReX-5IO-DMR is transmitted across the air and is output from one or more remote MReX-5IO-DMR units. The behaviour of this feature is the same as if a serial wire cable would be fitted between the units.

This feature is optional and included with WTE products that support AES encryption. The link is best suited for small amounts of serial data, less than 148 bytes in a burst. The MReX-5IO-DMR should have UART data rates set to a lower rate than the RF transmission rate to reduce buffering or lost data.

A typical application for this feature would be the writing information to remote LED signs or replacing long physically connected serial cables. The MReX-5IO-DMR 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, 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. 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 MReX-5IO-DMR greater. By default data is transmitted at 16K bps.

Prior to each transmission the MReX-5IO-DMR checks it is clear to transmit, meaning that in some cases transmissions could be slower depending on channel usage.

The MReX-5IO-DMR uses the default CAP code to identify each transmission, meaning that the MReX-5IO-DMR can either transmit to one or many other TReX units addressed individually or multicast to many at once.

NOTE:

While operating using the RAW protocol, the MReX-5IO-DMR will NOT respond to any configuration commands 10 seconds after start-up. This is to prevent accidental misconfiguration during normal operation.

After the 10 second start-up delay the MReX-5IO-DMR green status LED will begin to flash rapidly to indicate that the serial link is active.
Within the first 10 seconds of operation, after processing any valid command, a further 10 seconds is allowed for processing any additional configuration commands.

Serial Link Default Configuration

The simplest way to configure a point to point serial link is to use the commands to apply a default configuration. Note that after issuing the ***LINK** command, if configuration has not been completed within 10 seconds, the serial link will be activated, and no further configuration until restart will be possible.

1. Connect a serial cable to the MReX-5IO-DMR, using a tool such as the free WTE Serial Terminal.

   Available here: https://www.wte.co.nz/tools.html
2. Cycle power to the MReX-5IO-DMR, and confirm a sign on string such as “WTE MReX-5IO-DMR vX.xx LINK AES SN:3573 [32]” is seen.
3. Issue the command ***DEFAULTS** to reset to factory default settings.
4. Issue the command ***REGION=XX** to set the region that the unit is being used in.
5. Issue the command ***LINK=0,1** to apply a default serial link default.

   The default configuration that will be automatically applied:

   **TX_PROTO=RAW<CR>*
   **TX_MODE=WTE_EN<CR>*
   **TX_CAP=1324560<CR>*
   **TX_BAUD=16K_50<CR>*
   **RX_PROTO=RAW<CR>*
   **RX_MODE=WTE_EN<CR>*
   **RX_BAUD=16K_50<CR>*
   **RX_RANGE=1:1324560, 1324560<CR>*
   **RAW_CONFIG=4,147,0<CR>*
   **TX_FREQ=869400000<CR>*
   **RX_FREQ=869400000<CR>*
   **IN_CONFIG_L=1:0,5,5*
   **IN_CONFIG_L=2:0,5,5*
   **IN_CONFIG_L=3:0,5,5*
   **IN_CONFIG_L=4:0,5,5*
   **IN_CONFIG_L=5:0,5,5*
6. Set the operating frequency if required (default is 433.5MHz). Use the commands ***TX_-**

FREQ and ***RX_FREQ** to change frequency.

7. Issue ***SAVE** to commit the changes.
8. Either restart the unit using ***REBOOT**, or activate the link immediately using ***LINK=1**

IMPORTANT NOTES:

***TX_CAP** *transmission ID code* can used to modify the code that units transmit and receive on. For most efficient transmission the CAP code should be any number that can be divisible by 8 without remainder.

***RAW_CONFIG** *inactivity timeout* Transmission timer is reset after receiving every character, to allow transmission to wait this full period after the last character. By default this is 100mS.

***RAW_CONFIG** *immediate transmission character* accepts decimal value from 0-255 to configure a character such as 13 to immediately transmit on a '\r' character system. Setting *RAW_END=0 waits until the RAW_TIMEOUT period expires before transmission

Testing the Serial Link

At least 2 MReX-5IO-DMR units are required (one to transmit and one to receive) with a serial connection to each unit. For test purposes, connecting each unit to the WTE Serial Terminal App will be sufficient. The objective is to confirm that data can be sent from one serial terminal window to another.

1. Apply power to the MReX-5IO-DMR, and confirm a sign-on string such as "WTE MReX-5IO-DMR v1.53 LINK AES SN:3573 [32]" is seen.
2. Wait 10 seconds for the green status LED to start flashing rapidly. Note that prior to the fast flashing state being seen, each MReX-5IO-DMR will normally accept any configuration command. Each command received will reset the 10 second startup delay (allowing further commands to be received).
3. Confirm that the green LED has transitioned to a faster flashing rate. This indicates that the serial link is active.
4. Send any serial data from the serial terminal. Start with a few characters.
5. Confirm the red LED is lit after receiving serial data on the connected MReX-5IO-DMR, indicating that a transmission took place.
6. Confirm that the serial data is received on the remote MReX-5IO-DMR unit (shown on WTE Serial Terminal).

Optimising the Serial Link on Start

The 10 second configuration startup delay may not be suitable for some users. This may be improved by:

1. Connecting Input 5 of the MReX-5IO-DMR to GND on start. This will skip the 10 second configuration start delay, immediately moving to an operating serial link state. No unit configuration will be possible, however the unit bootloader will still allow new firmware to be uploaded if required on start.

   Note: In order to use input 5 for this purpose the command

   ****RAW_CONFIG** must be issued to set a value of 1 for parameter 4.*

2. Issue the command ***LINK=1** when the sign-on string from the MReX-5IO-DMR is seen on start. This will force the MReX-5IO-DMR to skip the 10 second configuration delay immediately moving to the point to point serial link operating state.

Disabling the Serial Link

1. Cycle power to the MReX-5IO-DMR
2. Issue the command ***DEFAULTS**<CR>
3. Issue the command ***SAVE**<CR>
4. Issue the command ***REBOOT**<CR>

Frequency Hopping Operation

The MReX-5IO-DMR is approved for frequency hopping which can be used for general telemetry or a point to point serial link. USA, NZ and LICENSED regions permit frequency hopping. The highest starting frequency for frequency hopping is 915.5MHz.

Some regions support both frequency hopping and fixed frequency operation within a frequency range (such as NZ). New Zealand supports unlicensed operation from 915-928MHz. In this case setting TX_FREQ to 915.5MHz will enable frequency hopping, but setting TX_FREQ above 915.5MHz will use a single fixed frequency.

1. Set to unit defaults

   ***DEFAULTS**

2. Set to operating region.

   ***REGION=USA**

3. Choose a starting frequency between 902.5MHz and 915.5MHz. The MReX uses a minimum 25 hops, each spaced 500kHz apart. The MReX-5IO-DMR will hop out to a maximum frequency of 927.5MHz.

   ***TX_FREQ=902500000**

4. Set the operating data rate. The 4800 baud rate has a much higher sensitivity, for longer operating range.

   ***TX_BAUD=4800_25_HOP** (or 128K_500_HOP)

5. Save the settings.

   ***SAVE**

6. Restart the unit

   ***REBOOT**

Basic Testing of Frequency Hopping

Configure 2 units identically. Once configured, serially issue the following test message.

Send the following message.

WT1234567A1- Hopping Test\r

Each transmission will hop to another frequency and use that channel if not occupied.

AES Encryption

AES military grade encryption is optional and allows for all transmissions to be encrypted. This applies for telemetry control applications and also when using the point to point serial link.

The simplest method to setup and configure AES encryption is to test with the serial point to point link.

1. Configure a point to point serial link using the steps shown previously.
2. Apply the command ***RF_KEY=1,0,0,45E83E4B90A53A2CB970FB08A1713400E18CDAC6037945EEEA713992B3AED190,3600**
3. Issue the command ***SAVE**
4. Send serial data and confirm normal operation.

This will apply 128 bit AES encryption. The example key should be the same on all devices in a system. The example key is suitable for both 128 bit and 256 bit encryption.

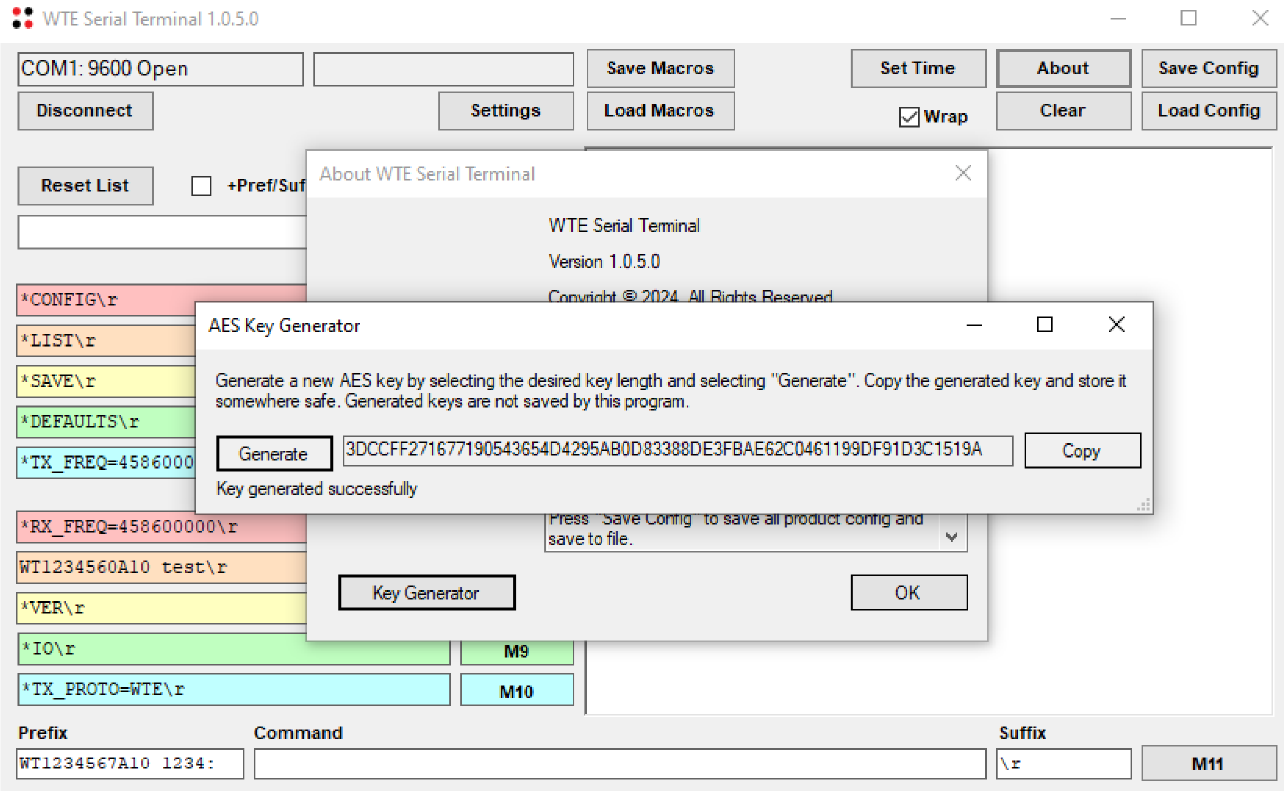
To disable AES encryption (but keep the key):

1. ***RF_KEY=0**
2. ***SAVE**

To enable 256 bit AES encryption using the same key:

1. ***RF_KEY=1,1**
2. ***SAVE**

The WTE Serial Terminal has a built-in AES key generator that can be used if required to generate new keys. The generator is found on the “About” screen as shown below.


WTE Serial Terminal 1.0.5.0
COM1: 9600 Open
Save Macros
Set Time
About
Save Config
Disconnect
Settings
Load Macros
Wrap
Clear
Load Config
Reset List
+Pref/Suf
*CONFIG\r
*LIST\r
*SAVE\r
*DEFAULTS\r
*RX_FREQ=458600000\r
WT1234560A10 test\r
*VER\r
*IO\r
*TX_PROTO=WTE\r
M9
M10
About WTE Serial Terminal
WTE Serial Terminal
Version 1.0.5.0
AES Key Generator
Generate a new AES key by selecting the desired key length and selecting "Generate". Copy the generated key and store it somewhere safe. Generated keys are not saved by this program.
Generate
3DCCFF271677190543654D4295AB0D83388DE3FBAE62C0461199DF91D3C1519A
Copy
Key generated successfully
save to file.
Key Generator
OK
Prefix
Command
Suffix
WT1234567A10 1234:
\r
M11

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 MReX-5IO-DMR board.

The MReX-5IO-DMR supports 5 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**.

By default IO pins are all configured as inputs. The output function is determined by the *OUT_CONFIG command. See "**Output Handling**".

On start-up each input is read. Only inputs that change from the start-up input state are processed.

Commands relating to input handling:

***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.

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<CR>

*IN_CONFIG_H=2:0,0,0<CR>

Both input 1 and 2 are configured as per the full example details above.

*IN_CONFIG_L=1:5,20,10<CR>

*IN_CONFIG_L=2:5,20,10<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.

Output Handling

> **Note:** Please refer to **Input Output Hardware Connection** section on this manual for examples of how to connect the input and output pin on the MReX-5IO-DMR board.

All inputs can be configured to be outputs. Input/Output 1 additionally drives a separate open collector output pin to control loads of up to 100mA. Input/Output 2 can be reconfigured as a driven output, with a maximum sink current of 5mA and a maximum output voltage of 3.3V. All outputs operating from input pins have a 1K output impedance sourcing a maximum of 3.3mA.

There are 2 additional LED output pins. These are both open drain, allowing LEDs to be driven up to 100mA from a source voltage of up to 12V.

Outputs are configured using the commands:

*OUT_CONFIG

*UNIT_ID

The outputs are controlled through messages received that conform to the **WTE output control protocol**.

> **NOTE:** 2 Inputs can be configured to operate at the same time as outputs, allowing preprogrammed input messages to be transmitted when a message has been received to change the state of an output.

OUTPUT PIN HARDWARE

The MReX-5IO-DMR output pins can sink a maximum of 50mA. If a larger load need to driven from this pin a current/voltage driver must be connected to the MReX-5IO-DMR module. Please refer to **Input Output Hardware Connection** section of this manual.

WTE Output Control Protocol

Introduction

This section describes how to control the outputs of WTE Products via transmission payloads. These payloads may be transmitted by third-party POCSAG or DMR transmitters.

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.

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.

Format

The payload of a message must fit the following format in order to operate the unit outputs. Note that this is a general format used by WTE products that may have many more than two a single outputs.

[[ID]EEEE-DDDD]

Where:

[is the character '['

] is the character ']'

ID is the UNIT_ID that has been programmed (e.g "01" or "Unit_A").

E are the outputs to enable

- is the hyphen character '-' All digits following the '-' are outputs that are disabled

D is the output to disable

Examples:

Consider an MReX-5IO-DMR configured with UNIT_ID of "Unit_A" and pins 1 and 2 configured as outputs:

**UNIT_ID=Unit_A<CR>*

**OUT_CONFIG=1:1,0<CR>*

**OUT_CONFIG=2:1,0<CR>*

Scenario 1: To turn output 1 ON;

Message payload:

[[Unit_A]1]

Scenario 2: To turn OFF output 1;

Message payload:

[[Unit_A]-1]

Consider that we have several MReX-5IO-DMR Units and each one is configured with a different UNIT_ID; “Unit_A”, “Unit_B” and “Unit_C”

Scenario 3: To turn output 1 for Unit_A:

Message payload:

[[Unit_A]1]

Scenario 4: We want:

to turn output 1 ON in the Unit_A,

to turn output 1 ON on the Unit_B,

turn OFF output1 Unit_C;

Message payload:

[[Unit_A]1] [[Unit_B]1] [[Unit_C]-1]

Scenario 5: To turn output 1 and output 2 ON;

Message payload:

[[Unit_A]12]

Scenario 6: To turn output 1 ON and output 2 OFF;

Message payload:

[[Unit_A]1-2]

Scenario 7: To turn output 1 and output 2 OFF;

Message payload:

[[Unit_A]-12]

Notes:

- The unit will only process the Output Control Protocol for the unit configured in the UNIT_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 UNIT_ID.

Remote Command Output Format

The WTE output control protocol allows the direct control of remote units. This allows specific MReX-5IO-DMR units to accept commands or protocols for processing "over the air". Care must be taken issuing commands that leave the MReX-5IO-DMR unable to process further remote commands (such as changing frequency, RIC range, modulation settings).

[[ID]U0[AA]]

Where:

[is the character '['

] is the character ']'

ID is the *UNIT_ID* that must match the MReX-5IO-DMR to be controlled.

U0 are the characters "U0" (U followed by zero) and is used to indicate that directed content for processing follows.

Examples:

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.

Store Forward Operation

The MReX-5IO-DMR can operate as a stand-alone repeater to forward paging messages and also extend wireless serial operation. This is an optional feature for the MReX-5IO-DMR that is not supplied by default.

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.

Typically the MReX-5IO-DMR 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 key to use when the MReX-5IO-DMR 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.

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.

Installation

The MReX-5IO-DMR should be situated away from direct sunlight, extreme vibration and heat sources, and high power transmission sources.

An external aerial correctly designed to operate at your intended frequency of operation will result in best performance. Do not situate the aerial immediately next to the aerial of a high power transmission source – position greater than 2 M from any other aerial. Mount the external aerial with as much elevation as possible for best results (see “Aerial Elevation” below).

Maximum tolerated input power into the RF connector is 13 dBm. Levels above this will destroy the receiver RF input and invalidate the unit warranty.

The MReX-5IO-DMR is a static sensitive system module, and not intended for use without protect-ive devices on inputs or output.

ESD precautions must be observed at all times when handling.

Cables Supplied

By default NO cables are supplied on purchase. Because there are so many possible frequencies and variations in installation an aerial is NOT supplied by default. If an aerial is supplied, it will be a generic variety that will not perform as well as an aerial produced for the intended frequency of operation, or a high gain externally mounted type.

If cables are to be supplied, they must be ordered at time of purchase.

Connecting to the MReX-5IO-DMR

The minimum required connections for a usable system:

1. Connection to an antenna.
2. Power supply of 5-9 VDC.

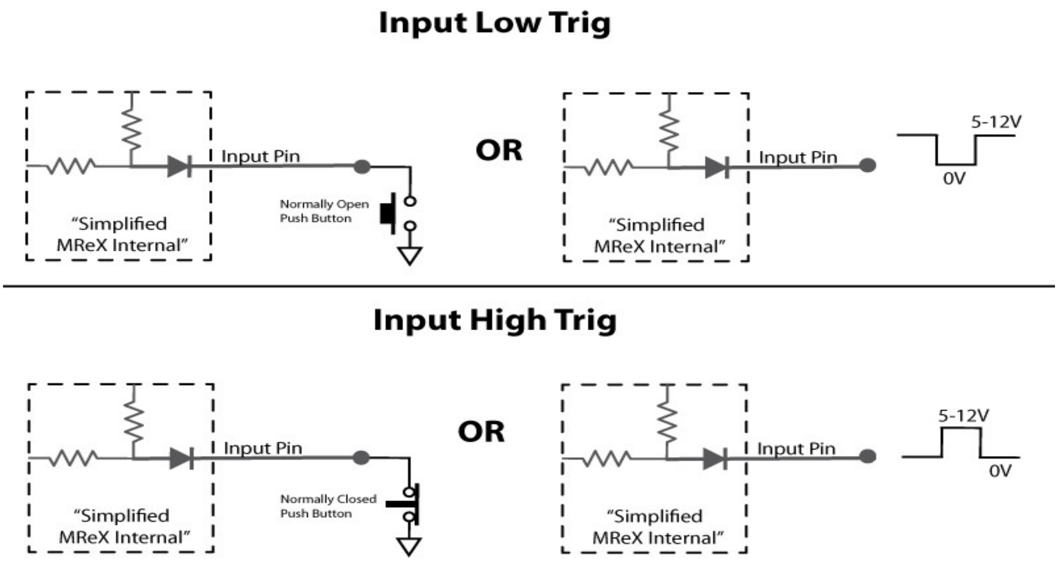
SMA connector is female type. For USA markets the connect type supplied will be RP SMA. This is required to meet FCC regulations. The module must be connect to a 50 ohm antenna designed for use at the intended frequency of operation.

There are multiple GND connection terminals available. A minimum of one must be used for the supply GND.

Input Hardware Connection

Example:

Inputs are driven high or low from an external source. Inputs will tolerate up to 12V as a high input level. The external driving source must have a 0V GND common to the MReX.



Output Hardware Connections

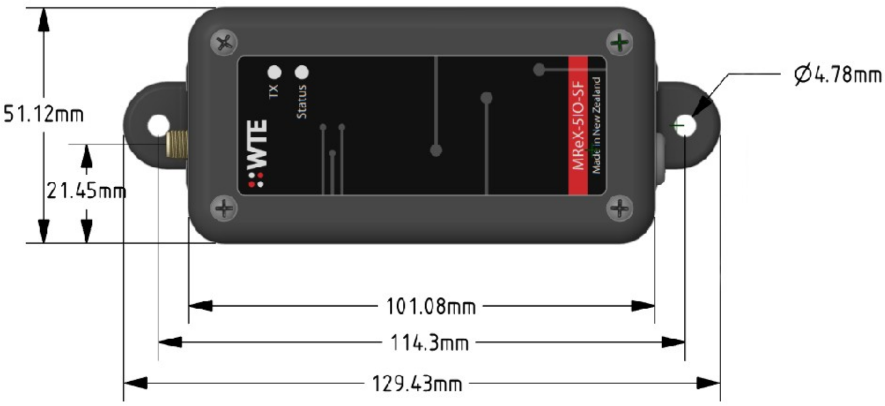
Output 1 and 2 relays have normally closed and normally open contacts exposed. There are no special connection requirements with the exceptions:

- Must not exceed 50VDC.
- Must not exceed 1A.

Note: On startup, the relay output briefly closes as part of the device initialization procedure. If output 1 is used and this behaviour is not desired, connect a 10K Ohm resistor between input 1 and ground. This will prevent the relay from closing.

MReX-5IO-DMR Dimensions

Top view



Side View

Note: Images are not to scale. Minor differences to the SMA connector may be possible depending on manufacturer variations and tolerances.

All dimensions are in millimetres (mm)

MReX-5IO-DMR Firmware Upgrade

In order to update the MReX-5IO-DMR firmware you will need:

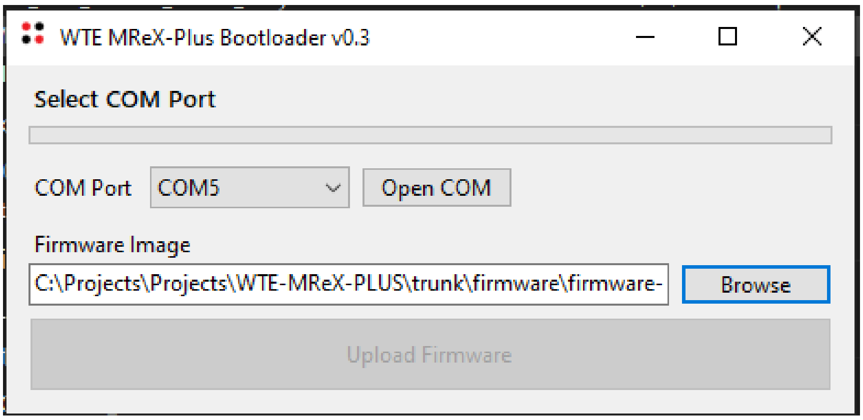
1. The WTE MReX-5IO-DMR-Plus Bootloader Tool provided if required from https://www.wte.co.nz/tools.html
2. Serial TTL cable.
3. An appropriate encrypted hex file supplied by WTE Limited.

Note: Attempting to load a hex file not intended for use with the MReX-5IO-DMR will render the MReX-5IO-DMR inoperable. Uploading firmware should only be performed if instructed to do so by WTE Limited or an authorised agent.

The firmware upgrade utility operates at high serial rate. Some legacy hardware serial COM ports do not work with this utility. Use a USB to serial adaptor cable if possible.

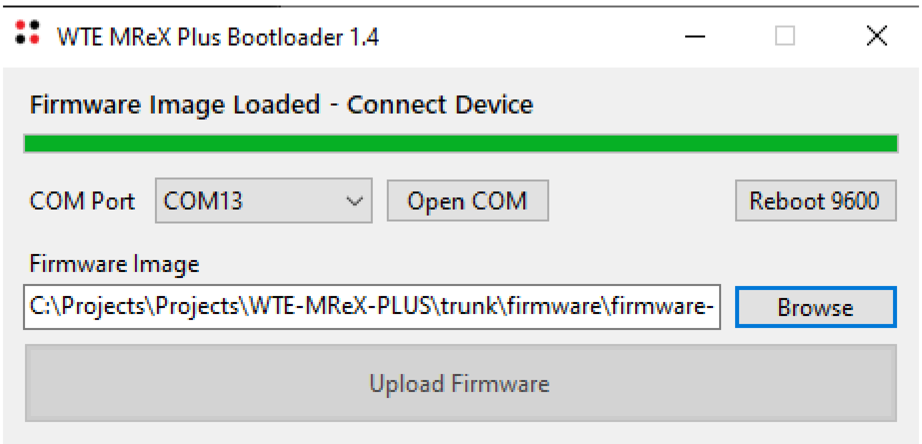
Firmware Upgrade Utility

This bootloader software has been customised by WTE to simplify the firmware replacement process for the MReX-5IO-DMR, This application automatically handles erasing and verifying of uploaded firmware. This utility does not perform any decryption function (decryption is carried out by the MReX-5IO-DMR itself).



Firmware Upgrade Process

1. Run the MReX-5IO-DMR-Bootloader – this is the WTE Firmware Update Tool as shown above.
2. MReX-5IO-DMR must be powered and connected to the RS232 port, or connected to the USB port, please refer to **Connecting to the MReX-5IO-DMR** section of this manual for more information.
3. Press the "Browse**"** button on the WTE Firmware Update Tool and select the appropriate MReX firmware file.
4. Select the correct COM port on the WTE Firmware Update Tool
5. Press "**Open COM**" button on the WTE Firmware Update Tool



6. Remove, and then apply power to the MReX-5IO-DMR, or alternatively, press the "Reboot 9600" button.
7. If the COM port is correct, and the unit is connected correctly, the "**Upload Firmware**" button will become green and clickable. If not clickable, press "**Close COM**" and return to step 5.
8. Press "**Upload Firmware**" on the WTE Firmware Update Tool to send the new firmware to the MReX-5IO-DMR.
9. A green progress bar will provide feedback on upload progress and completion.

The MReX-5IO-DMR is now ready and the WTE Firmware Update Tool can be closed.

Antenna

The modular approval for this device allows for a 50 ohm matched external antenna to be connected.

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 aerial specialist who will be able to advise and construct an aerial 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.

(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.

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.

No User-Serviceable Components. There are no user-serviceable components within the radio

RoHS and WEEE Compliance
MReX-5IO-DMR 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

MReX-5IO-DMR serial number can found on the unit, also serial number and model information are sent to serial on start-up.

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.

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 MReX-5IO-DMR can be damaged through improper handling and system integration. ESD handling precautions must be observed.

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.

Specification

TX Frequency Range:

- DMR-160/900: 137-174MHz, 860 - 870 MHz, 902-928MHz
- DMR-460/900: 421-480MHz, 860 - 870 MHz, 902-928MHz

RX Frequency Range:

- DMR-160/900: 137-174MHz, 421 – 480MHz, 860 - 870 MHz, 902-928MHz
- DMR-460/900: 421-480MHz, 421 – 480MHz, 860 - 870 MHz, 902-928MHz

Tx/Rx Frequency Accuracy:

- 0.5ppm.

Fixed Supply Voltage:

- 5-9V Internally fused at 250mA (not self resetting)

Battery Supply Voltage:

- 3V. Internally fused at 250mA (not self resetting)

Inputs:

- Five. Inputs accessible when used as a module. To operate tie to GND. Max input voltage is 12V. Inputs 1 and 2 are lost when configured to operate as outputs.

Outputs:

- Two relays. Max 1A at max voltage of 50V DC.

Message length:

- Input max configured message length 50 characters

Temperature Limits:

- -10 to + 55 degrees Celsius.

Max Tx Power:

- 20dBm (100mW) +/- 1dB

Max Rx Input Power:

- 13dBm (any level above this will destroy the receiver)

Receiver Sensitivity (+/- 1dB) @ 160MHz

- -130dBm (512 baud), -127 dBm (1200 baud), -119 dBm (DMR 9600 baud)

Max message length:

- Up to 5 messages with 150 characters can be queued for decoding or transmitting.

Antenna:
- SMA vertical antenna.

Transmit Current:
- Up to 95mA transmitting into matched 50 ohm antenna

Receive Current:
- Typical: 17mA + 20mA for each relay energised.

Firmware:
- Field upgradable.

Physical Dimensions (L x W x H):
- Module without SMA connector is 45mm X 21mm X 5mm

Serial Output:
- Serial 9600:8-N-1 baud (default). Other supported rates: 38400, 115200 and 256000.
- WTE protocol format.
- Any serial data when point to point serial mode used.

POCSAG Encode and Decode Support:
- POCSAG 512 either alpha or numeric including batched.
- POCSAG 1200 either alpha or numeric including batched.
- POCSAG 2400 either alpha or numeric including batched.
- Adjustable POCSAG preamble from 64 to 5000 bits (576 default).

Radio Link Security:
- AES 128-bit or AES 256-bit encryption.

DMR TX Support:
- ETSI TS 102 361-1, data
- Text Message Types:
    - Short message, unconfirmed and confirmed.
    - UDP compressed header, unconfirmed and confirmed.
    - Status header message, unconfirmed and confirmed.
- Max message length 250 characters.
- Tested DMR radios:
    - Hytera – PD565, PD665
    - Kirisun DP770, TM840H
    - Motorola SL4010e
    - Caltta PH690
    - Tait TP9300

DMR RX Support:

- Reception and decoding of Short message and compressed UDP header types.
- Reception of status messages.
- Decoded and bit corrected serial output using WTE protocol.
- Serial output of full DMR frame of all DMR non voice frames using DMR protocol.

Modulations Supported:
137-174MHz (MReX-5IO-DMR-160/900)

- 512 Baud, 12.5kHz Channel Space (2FSK)
- 1200 Baud, 12.5kHz Channel Space (2FSK)
- 4800 Baud, 12.5kHz Channel Space (2GFSK)
- 9600 Baud, 12.5kHz Channel Space (DMR - 4FSK RRC)
- 4800 Baud, 6.25kHz Channel Space (4GFSK)

421-480MHz (MReX-5IO-DMR-460/900)

- 512 Baud, 12.5kHz Channel Space (2FSK)
- 1200 Baud, 12.5kHz Channel Space (2FSK)
- 4800 Baud, 12.5kHz Channel Space (2GFSK)
- 9600 Baud, 12.5kHz Channel Space (DMR - 4FSK RRC)

860-870MHz

- 1200 Baud, 25kHz Channel Space (2GFSK)
- 4800 Baud, 25kHz Channel Space (2GFSK)
- 16K Baud, 50kHz Channel Space (2GFSK)
- 9600 Baud, 12.5kHz Channel Space (DMR - 4FSK RRC)

915-928MHz

- 1200 Baud, 25kHz Channel Space (2GFSK)
- 4800 Baud, 25kHz Channel Space (2GFSK)
- 16K Baud, 50kHz Channel Space (2GFSK)
- 64K Baud, 200kHz Channel Space (2GFSK)

902-915MHz

- 4800 Baud, 25kHz Channel Space (2GFSK, FHSS)
- 128K Baud, 500kHz Channel Space (2GFSK, FHSS)

Lab Tested Compliance Standards:

- EN 300 224-2
- EN 300 220
- EN 301 489,
- EN 62368
- EN 50385
- FCC part 15.247
- AS/NZ 4769