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Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China





HumDT™ Series
RF Transceiver Module
Data Guide

Wireless made simple®

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Do not use this or any Linx product to trigger an action directly from the data line or RSSI lines without a protocol or encoder/decoder to validate the data. Without validation, any signal from another unrelated transmitter in the environment received by the module could inadvertently trigger the action.

All RF products are susceptible to RF interference that can prevent communication. RF products without frequency agility or hopping implemented are more subject to interference. This module does not have a frequency hopping protocol built in.

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HumDT™ Series RF Transceiver Module Data Guide



Description

The HumDT™ Series transceiver is designed for the reliable wireless transfer of serial digital data. It consists of a highly optimized RF transceiver and integrated data and networking protocol. A frequency agile over-the-air protocol provides better link reliability than narrowband solutions while providing faster synchronization and data output than Frequency Hopping Spread Spectrum (FHSS) algorithms.

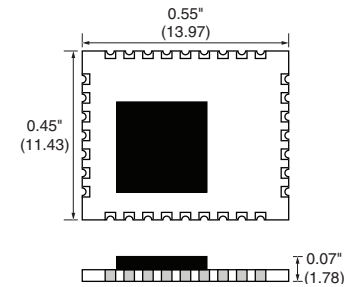


Figure 1: Package Dimensions

The frequency agile protocol sends the same data on up to 4 channels, providing the noise immunity benefits of FHSS without the overhead of a hopping protocol. A serial command selects the number of channels as well as which specific channels are used.

The module can achieve a line-of-sight range of up to 1,600m (1.0 mile). The final range may be less depending on the regulatory requirements in the country of operation and the antenna implementation.

The module's UART interface is used for module configuration and data transfer. 8 GPIOs can be used for analog and digital functions and are controlled through the UART. Housed in a compact reflow-compatible SMD package, the transceiver requires no external RF components except an antenna, which greatly simplifies integration and lowers assembly costs.

Features

- Frequency agile
- 8 analog and digital GPIOs
- Low power receive modes
- Simple UART interface
- AES-128 Encryption
- No external RF components required
- No production tuning required
- Tiny PLCC-32 footprint

Ordering Information

| Ordering Information | |
|----------------------|--|
| Part Number | Description |
| HUM-900-DT | 900MHz HumDT™ Series Transceiver |
| EVM-900-DT | 900MHz HumDT™ Series Carrier Board |
| MDEV-900-DT | 900MHz HumDT™ Series Master Development System |


Figure 2: Ordering Information

Absolute Maximum Ratings

| Absolute Maximum Ratings | | | | |
|--------------------------|------|----|----------------|-----|
| Supply Voltage V_{CC} | -0.3 | to | +3.9 | VDC |
| Any Input or Output Pin | -0.3 | to | $V_{CC} + 0.3$ | VDC |
| RF Input | | 0 | | dBm |
| Operating Temperature | -40 | to | +85 | °C |
| Storage Temperature | -40 | to | +85 | °C |

Exceeding any of the limits of this section may lead to permanent damage to the device. Furthermore, extended operation at these maximum ratings may reduce the life of this device.

Figure 3: Absolute Maximum Ratings

 **Warning:** This product incorporates numerous static-sensitive components. Always wear an ESD wrist strap and observe proper ESD handling procedures when working with this device. Failure to observe this precaution may result in module damage or failure.

Electrical Specifications

| HumDT™ Series Transceiver Specifications | | | | | | |
|--|------------|------|------|-------|-------|---------|
| Parameter | Symbol | Min. | Typ. | Max. | Units | Notes |
| Power Supply | | | | | | |
| Operating Voltage | V_{CC} | 2.0 | | 3.6 | VDC | |
| TX Supply Current | I_{CCTX} | | | | | |
| at +10dBm | | | 38 | 40 | mA | 1,2 |
| at 0dBm | | | 20.5 | 24 | mA | 1,2,3 |
| RX Supply Current | I_{CCRX} | | 22 | 28 | mA | 1,2,3,4 |
| Sleep Current | I_{SLP} | | 4.5 | 5 | mA | 1,2 |
| Power-Down Current | I_{PDN} | | 0.3 | 2 | μA | 1,2 |
| Idle Current | I_{IDL} | | 4.5 | 5 | mA | 1,2 |
| RF Section | | | | | | |
| Operating Frequency Band | F_C | 902 | | 928 | MHz | |
| Number of Channels | | | 4 | | | |
| Channel Spacing | | | 7 | | MHz | |
| Data Rate | | | | | | |
| RF Data Rate | | 26 | | 250 | kbps | |
| Serial Data Rate | | 1.2 | | 115.2 | kbps | |
| Receiver Section | | | | | | |
| Spurious Emissions | | | | -47 | dBm | |
| Receiver Sensitivity | | | | | | |
| @ min rate | | -98 | -101 | | dBm | 6 |
| @ max rate | | -89 | -92 | | dBm | 6 |
| RSSI Dynamic Range | | | 85 | | dB | |
| Transmitter Section | | | | | | |
| Output Power | P_O | +8.5 | +9.5 | | dBm | 7 |
| Harmonic Emissions | P_H | | -41 | | dBc | 7 |
| Output Power Control Range | | -30 | | 10 | dB | 7 |
| Antenna Port | | | | | | |
| RF Impedance | R_{IN} | | 50 | | Ω | 5 |
| Environmental | | | | | | |
| Operating Temp. Range | | -40 | | +85 | °C | 5 |
| Timing | | | | | | |
| Module Turn-On Time | | | | | | |
| Via V_{CC} | | | | 43 | ms | 11 |

HumDT™ Series Transceiver Specifications

| Parameter | Symbol | Min. | Typ. | Max. | Units | Notes |
|--------------------------------------|-----------|--------------------|------|--------------------|-------|-------|
| Via POWER_DOWN | | | | 47 | ms | 11 |
| Via Sleep | | | | 3 | ms | 11 |
| Serial Command Response | | | | | | |
| Status, Volatile R/W | | | 1.5 | 2.5 | ms | 8 |
| Analog Input Reading | | | 10 | 11 | ms | 8 |
| NV Update, Factory Reset | | | 24 | 27 | ms | 8 |
| Minimum Time between Command Packets | | 100 | | | ms | |
| Interface Section | | | | | | |
| Input | | | | | | |
| Logic Low | V_{IL} | | | $0.3 \cdot V_{CC}$ | VDC | |
| Logic High | V_{IH} | $0.7 \cdot V_{CC}$ | | | VDC | |
| Output | | | | | | |
| Logic Low, LED_0, LED_1 | V_{OLM} | | | $0.3 \cdot V_{CC}$ | VDC | 1,9 |
| Logic High, LED_0, LED_1 | V_{OHM} | $0.7 \cdot V_{CC}$ | | | VDC | 1,9 |
| Logic Low | V_{OL} | | | $0.3 \cdot V_{CC}$ | | 1,10 |
| Logic High | V_{OH} | $0.7 \cdot V_{CC}$ | | | | 1,10 |

1. Measured at $3.3V V_{CC}$
2. Measured at $25^{\circ}C$
3. MAX value represents extreme of HUM family; HumDT value is lower
4. Input power < $-60dBm$
5. Characterized but not tested
6. PER = 1%
7. Into a 50-ohm load
8. From end of command to start of response
9. 60mA source/sink
10. 6mA source/sink
11. HUM-DT in single-channel ED mode, time to accept joining network

Figure 4: Electrical Specifications

Typical Performance Graphs

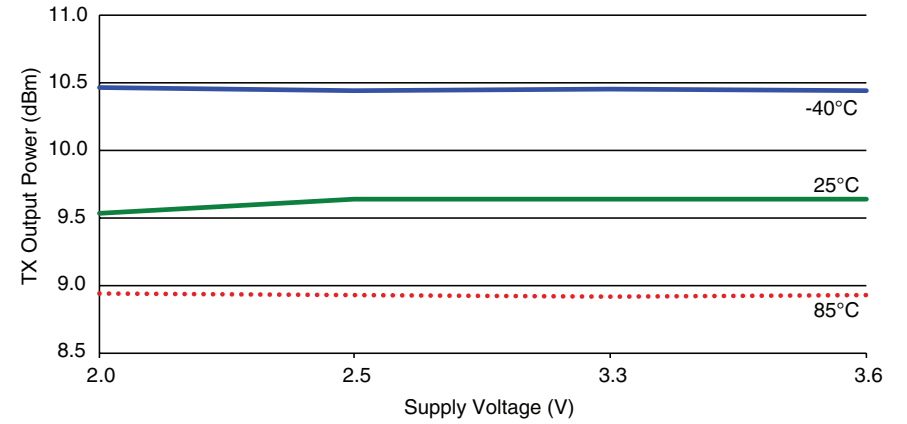


Figure 5: HumDT™ Series Transceiver Max Output Power vs. Supply Voltage - HUM-900-DT

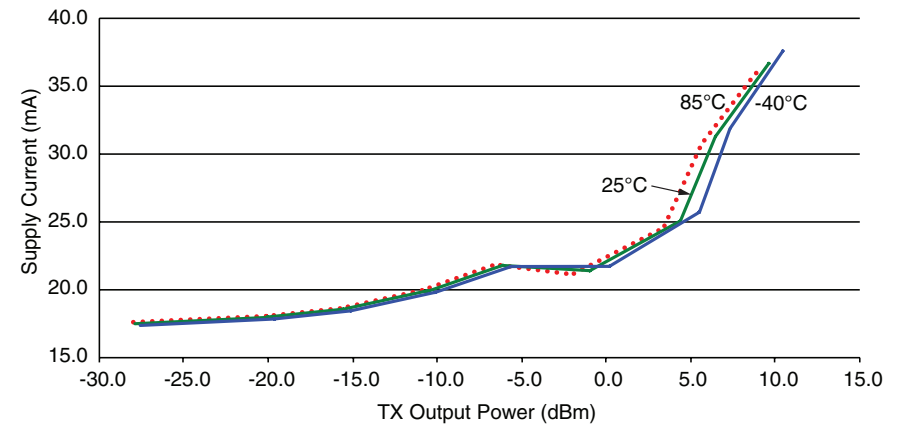


Figure 6: HumDT™ Series Transceiver Average Current vs. Transmitter Output Power at 2.5V - HUM-900-DT

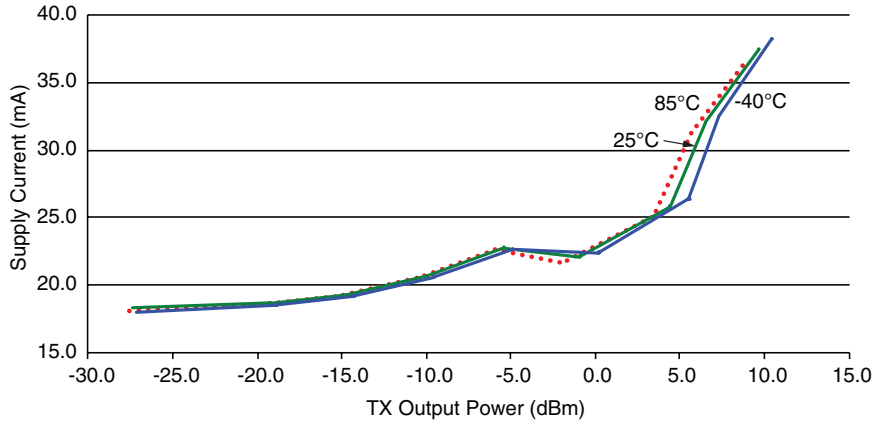


Figure 7: HumDT™ Series Transceiver Average TX Current vs. Transmitter Output Power at 3.3V - HUM-900-DT

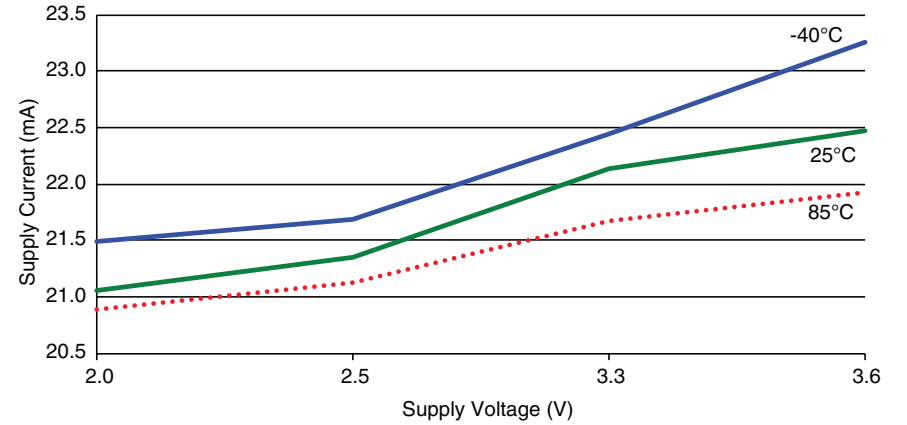


Figure 9: HumDT™ Series Transceiver TX Current vs. Supply Voltage at 0dBm - HUM-900-DT

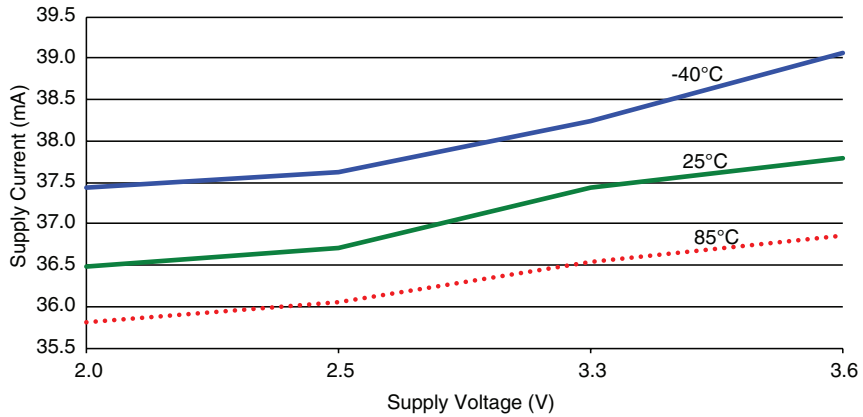


Figure 8: HumDT™ Series Transceiver TX Current vs. Supply Voltage at Max Power - HUM-900-DT

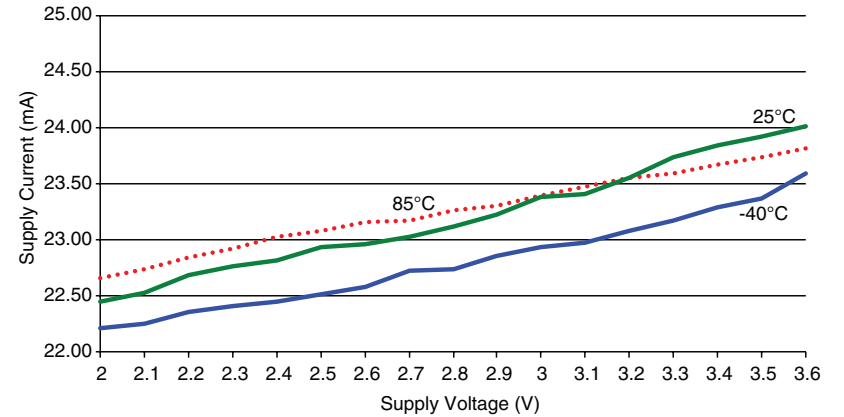


Figure 10: HumDT™ Series Transceiver RX Current Consumption vs. Supply Voltage - HUM-900-DT

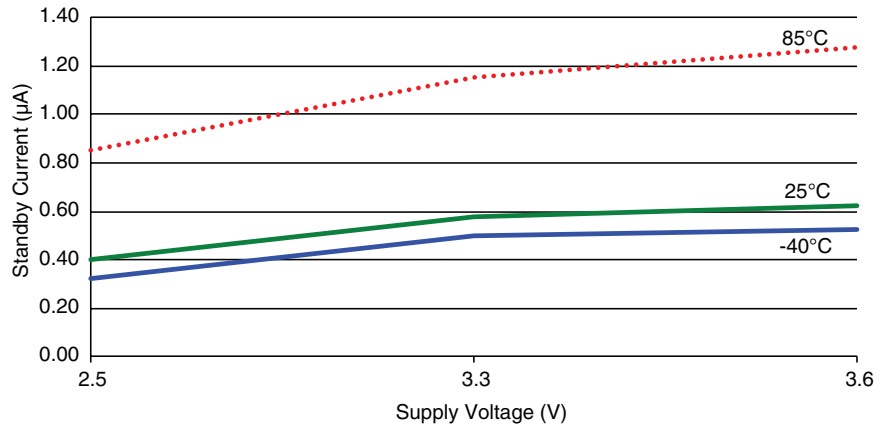


Figure 11: HumDT™ Series Transceiver Standby Current Consumption vs. Supply Voltage - HUM-900-DT

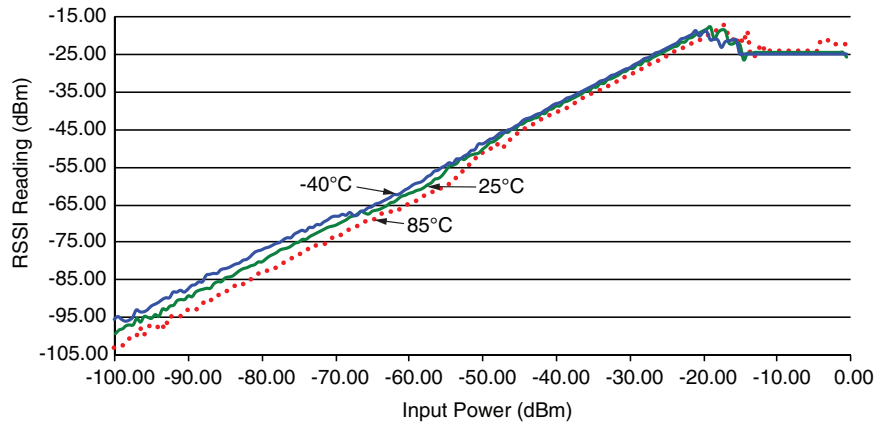


Figure 12: HumDT™ Series Transceiver RSSI Voltage vs. Input Power - HUM-900-DT

Pin Assignments

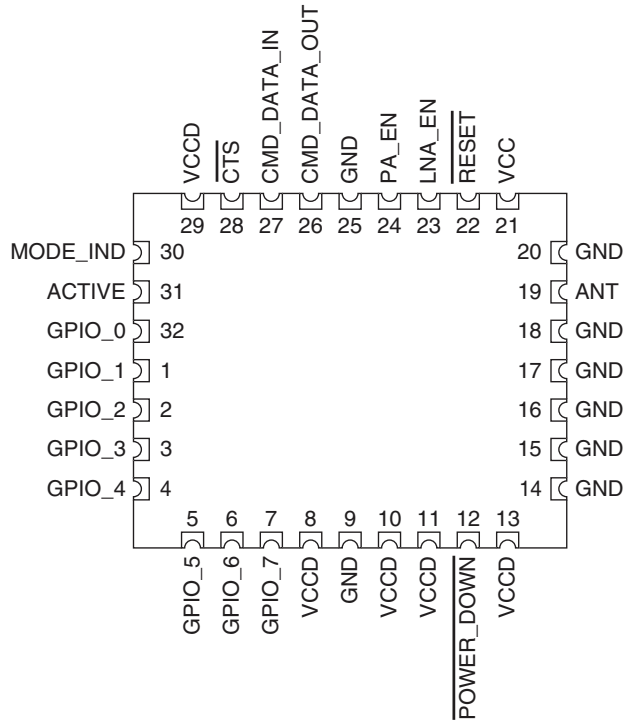


Figure 13: HumDT™ Series Transceiver Pin Assignments (Top View)

Pin Descriptions

| Pin Descriptions | | | |
|-------------------------|---------------|-----|--|
| Pin Number | Name | I/O | Description |
| 1, 2, 3, 4, 5, 6, 7, 32 | GPIO_0–GPIO_7 | I/O | General Purpose I/O Lines. Each line can be configured as either an analog input, a digital input or a digital output. The digital inputs can be configured to have either a 20kΩ pull up or pull down resistance or high impedance (no resistors). |
| 8, 10, 11, 13, 29 | VCCD | — | These lines are inputs that are pulled to supply internally. They can be left unconnected, but boards in noisy environments or with noisy components in the same product are recommended to pull these lines to V_{CC} . The potential exists for random noise to affect the line and cause unexpected operation. This risk is reduced in simple, battery powered applications, but should be considered in all designs. |

| Pin Descriptions | | | |
|-------------------------------|---------------------------------|-----|---|
| Pin Number | Name | I/O | Description |
| 9, 14, 15, 16, 17, 18, 20, 25 | GND | — | Ground |
| 12 | $\overline{\text{POWER_DOWN}}$ | I | Power Down. Pulling this line low places the module into a low-power state. The module is not functional in this state. Pull high for normal operation. Do not leave floating. |
| 19 | ANTENNA | — | 50-ohm RF Antenna Port |
| 21 | VCC | — | Supply Voltage |
| 22 | $\overline{\text{RESET}}$ | I | This line resets the module when pulled low. It should be pulled high for normal operation. This line has an internal 10k resistor to supply, so leave it unconnected if not used. |
| 23 | LNA_EN | O | Low Noise Amplifier Enable. This line is driven high when receiving. It is intended to activate an optional external LNA. |
| 24 | PA_EN | O | Power Amplifier Enable. This line is driven high when transmitting. It is intended to activate an optional external power amplifier. |
| 26 | CMD_DATA_OUT | O | Command Data Out. Output line for the serial interface commands |
| 27 | CMD_DATA_IN | I | Command Data In. Input line for the serial interface commands. |
| 28 | $\overline{\text{CTS}}$ | O | UART Clear To Send, active low. This line indicates to the host microcontroller when the module is ready to accept data. When $\overline{\text{CTS}}$ is high, the module is busy. When $\overline{\text{CTS}}$ is low, the module is ready for data. |
| 30 | MODE_IND | O | This output goes high when the module is sending or receiving data over the air. This line can directly drive an LED for visual indication of activity. |
| 31 | ACTIVE | O | This output goes high when the module is powered on and functional. This line can directly drive an LED for visual indication of activity. |

Figure 14: HumDT™ Series Transceiver Pin Descriptions

Theory of Operation

The HumDT™ Series transceiver is a low-cost, high-performance synthesized MSK transceiver. Figure 15 shows the module's block diagram.

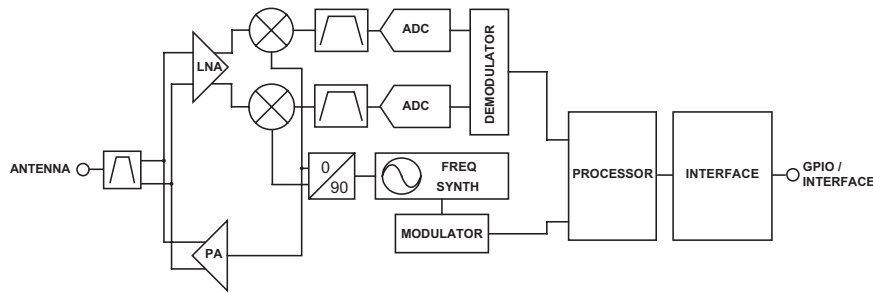


Figure 15: HumDT™ Series Transceiver RF Section Block Diagram

The HumDT™ Series transceiver operates in the 863 to 870MHz and 902 to 928MHz frequency bands. The transmitter output power is programmable. The range varies depending on the module's frequency band, antenna implementation and the local RF environment.

The RF carrier is generated directly by a frequency synthesizer that includes an on-chip VCO. The received RF signal is amplified by a low noise amplifier (LNA) and down-converted to I/Q quadrature signals. The I/Q signals are digitized by ADCs.

A low-power onboard communications processor performs the radio control and management functions including Automatic Gain Control (AGC), filtering, demodulation and packet synchronization. A control processor performs the higher level functions and controls the serial and hardware interfaces.

A crystal oscillator generates the reference frequency for the synthesizer and clocks for the ADCs and the processor.

Module Description

The HumDT™ Series module is a completely integrated RF transceiver and processor designed to transmit digital data across a wireless link. It has a built-in frequency agile over-the-air protocol that manages all of the transmission and reception functions. It takes data in on its UART and supplies the data out of a UART on the remote module.

The frequency agile protocol transmits the same data packet on 1 to 4 channels. The user can select how many channels are used and which of the four available channels are active. This method provides some of the noise immunity offered by frequency hopping systems, but without all of the overhead and latency required by the hopping algorithm.

The modules can be used to set up a star network with one module acting as the central hub or access point and up to 50 other modules as end nodes connected to the hub. The module supports one-hop routing so that the end nodes can communicate with each other through the access point. The network can also support up to four range extenders that can boost the physical size of the network.

Each module has 8 GPIOs that can be configured as digital inputs or outputs or as analog inputs. These are controlled through serial commands used by the module's Command Data Interface through a UART. These can act as a GPIO expander or as sensor voltage inputs.

A standard UART interface is used to configure the module for operation and for the data input and output. This is suitable for direct connection to UARTs on many microcontrollers, USB converters and RS-232 converters. A simple command set is used for configuration and data input.

Frequency Agility

In frequency agile mode, the module transmits the same data packet on up to four channels in turn, then loops around and sends the next data packet on each channel. This continues until all of the data has been sent. The number and selection of which channels are used are configured through serial commands using the module's Command Data Interface.

The receiver measures the RSSI of each channel, picks the quietest one and waits on that channel for transmitted data. It re-checks all of the channels about every 30 seconds and moves to a new channel if needed.

In normal operation, modules sit in receive mode listening for incoming packets. When data to be transmitted is input into the module's UART, the module automatically switches to the transmit mode and sends the data. All protocol functions like creating the data packet, changing channels and validating the received packet are handled automatically.

This method is considered narrowband operation and does not qualify for the higher transmitter output power of frequency hopping systems. However, the data throughput can be much faster since there is no hopping algorithm that needs to be maintained. This is especially true if only one or two channels are used.

The commands for configuring the channels are outlined in the Command Data Interface section. The available channels are shown in Figure 16.

| Channel Frequencies | |
|---------------------|-------------------------------|
| Channel Number | HUM-900-DT Frequency (MHz) |
| 0 | 904.5 |
| 1 | 911.5 |
| 2 | 918.5 |
| 3 | 925.5 |

Figure 16: HumDT™ Series Transceiver Frequency Agile RF Channel Frequencies

Networking

Each module can be configured as one of three device types; Access Point (AP), Range Extender (RE), and End Device (ED). These device types play a specific role in creating a star network.

The AP acts as the hub in a star network. It is an always-on device and only one AP is permitted per network. It receives all packets within its range and is capable of relaying messages from one ED to another.

The REs are always-on devices that extend the radio range on a network. They retransmit all received messages from devices in its network that are within range. This relaying of data extends the range of the network. Networks are limited to a maximum of four REs.

EDs are the simplest devices. They perform the actions in the network, such as remote control handhelds, sensors and actuators. The EDs may be battery powered and can be put into a low power mode to save current consumption.

There can be a maximum of 50 EDs in each network, with 1 AP and up to 4 REs.

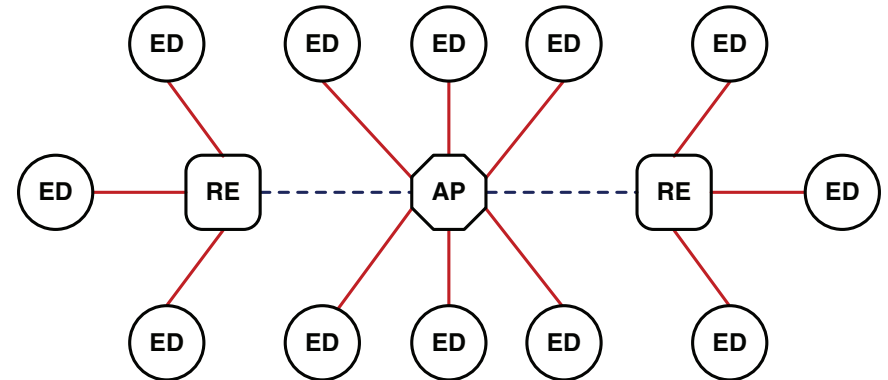


Figure 17: HumDT™ Series Transceiver Star Network

Each ED communicates with the AP either directly or through an RE. The AP can output the received data from the ED or forward the data on to another ED, depending on the addressing in the packet.

The AP sends out a beacon message about every 30 seconds to maintain the network. This is an automatic message and is not output by the module, though the MODE_IND line indicates the activity.

Initialization and Joining

The module runs through an initialization routine when it is powered up. It reads the operational configuration from its non-volatile memory and loads them into its volatile memory. The volatile memory is lost when power is removed, but it is faster to access so is better when the module is active. The module initializes all of the routines with the configuration settings and enters its device type, either AP, ED or RE.

Based on the device type setting, the module then begins the join and linking process. The join process is how an ED or RE gains access to an AP and joins a network. Once the module is joined, it sets up the link to the AP so that it can communicate its data.

All of this happens automatically when power is applied. If an AP and several EDs are brought online at the same time, the AP manages communication until all EDs are joined. No intervention is required by the user or an external microcontroller.

Once the initialization and join processes have been completed, the module outputs an initialization complete message on the CMD_DATA_OUT line. This is shown in Figure 56 in the Command Data Interface (CDI) Command Set section. This process occurs when the module is first powered on and when it wakes from sleep.

The CDI has commands for managing the modules associated with an AP. These include returning a count of associated modules, the full list of addresses of associated modules, and a command to delete a module from the list. Once an ED is deleted from the list no communications can occur until the module rejoins the network. This happens automatically when the power is cycled to the ED or the reset command is issued.

Addressing

There are two addresses used by the modules; the module address and the network ID. The module address is a 4 byte number that identifies the specific module in the network. This number is unique to the module and cannot be repeated within a network.

The network ID is a 4 byte number that is used to identify which network the module is in. This is shared by all modules within the network.

Modules that have different network IDs can have the same module address. No module should have the same module address and network ID. If this happens, the first module that contacts the AP is accepted into the network and the second is rejected and cannot communicate with the AP.

Each module is programmed with a unique 4 byte serial number at the factory. This can be used as the module address by reading it out through the CDI and writing it back as the local address. The serial number cannot be changed. This can ensure that every module in the system has a unique address rather than having to track addresses separately.

If two networks are operating in proximity, then it is possible for modules to hear transmissions from the other network. If the network ID in the received packet does not match the module's local network ID, then the packet is ignored and discarded.

Each module can also report out the modules it is linked to in the network. EDs only return the address of the AP. The AP outputs the addresses for all of the EDs that it has joined and linked to in the network. This is accomplished with a serial command through the module's Command Data Interface. This is a convenient way to quickly establish the entire network from the AP.

The REs do not have the intelligence to record all of the modules in its range. They respond with 0 associated modules.

GPIO Configuration

The module has 8 General Purpose Input / Output lines that can be configured and controlled through the Command Data Interface. They can be set in one of three ways.

- Digital Input - can be queried to see if the line is logical high or low.
- Digital Output - can be set to either logical high or low.
- Analog Input - connected to an internal Analog to Digital Converter (ADC). This provides a digital number that is proportional to the voltage on the line referenced to V_{CC} (0V to VCC range, 12 bits resolution).

Digital input lines have an internal pull-up to V_{CC} of approximately 20kOhm by default. The digital inputs can be configured to have either pull up or pull down resistors or be tri-state to fit different user hardware implementations.

Please see the Command Data Interface section for details on how to configure the GPIO settings.

Baud Rate

The module supports multiple serial baud rates on the UART for the Command Data Interface. The module uses the serial rate that is selected to automatically select one of its four RF baud bands. These baud bands determine the internal filter settings and the over-the-air data rate. Figure 18 shows the serial baud rate and the resulting baud band and RF baud rate.

| Baud Rate Configuration | | |
|-------------------------|--------------|---------------------|
| Serial Baud Rate (kbps) | RF Baud Band | RF Baud Rate (kbps) |
| 1.2 | 0 | 26 |
| 2.4 | 0 | 26 |
| 4.8 | 0 | 26 |
| 9.6 | 0 | 26 |
| 14.4 | 1 | 80 |
| 19.2 | 1 | 80 |
| 28.8 | 1 | 80 |
| 38.4 | 1 | 80 |
| 57.6 | 2 | 250 |
| 115.2 | 2 | 250 |
| reserved | 3 | 500 |

Figure 18: Baud Rate Configuration

Using the Low Power Features

The module supports several low-power features to save current in battery powered applications. Only EDs can use the low power states. APs and REs must be fully powered.

Taking the Power Down ($\overline{\text{POWER_DOWN}}$) line low places the module into the lowest power state. In this mode, the internal voltage regulator and all oscillators are turned off. All circuits powered from voltage regulator are also off. All GPIO lines retain the mode and output value set before entering power down. The module is not functional while in this mode and current consumption drops to about 0.3 μ A. Taking the line high wakes the module.

In Sleep, only the radio is powered down while all of the processor functions are still active. This has higher current consumption than power down, but leaves the processor able to perform functions, such as monitoring the GPIO lines. This state is controlled by a serial command.

In Idle, the receiver is disabled while processor is still running. The module switches to transmit mode when it has data to send. This state is controlled by a serial command.

External Amplifier Control

The HumDT™ Series transceiver has two output lines that are designed to control external amplifiers. The PA_EN line goes high when the module enters transmit mode. This can be used to activate an external power amplifier to boost the signal strength of the transmitter. The LNA_EN line goes high when the module enters receive mode. This can be used to activate an external low noise amplifier to boost the receiver sensitivity. These external amplifiers can significantly increase the range of the system at the expense of higher current consumption and system cost.

Encryption

The module implements AES encryption in ECB mode. The packet header information is sent in the clear and the payload data is encrypted.

Encryption algorithms are complex mathematical equations that use a number, called a key, to encrypt data before transmission. This is done so that unauthorized persons who may intercept the transmission cannot access the data. In order to decrypt the transmission, the receiver must use the same key that was used to encrypt it. The receiver performs the same calculations as the encoder and, if the key is the same, recovers the data.

The AES encryption algorithm is widely used, from basic wireless data links to Internet traffic to government communications. It is considered highly secure and reliable. The AES algorithm supports key lengths of 128, 192 and 256 bits. The HumDT™ module only supports 128 bits. The larger key lengths are more subject to government import and export regulations, though the user will need to confirm that 128 bits is allowable in their industry.

The strength of the encryption algorithm and the length of the key are only two factors in a secure system. The ultimate requirement is the secrecy of the key. The HumDT™ module only allows the key to be read out of the Access Point. It can be written into an End Device, but is otherwise inaccessible.

The AP should be kept in a secure location to prevent physical access by unauthorized persons. If the key is stored outside the system, such as in a database or list, then it should also be kept secure.

Restore Factory Defaults

The transceiver is reset to factory default with a serial command through the Command Data Interface. This command restores all of the configurations to factory default settings. These are shown in Figure 19.

| Factory Default Configurations | |
|--------------------------------|--|
| Parameter | Default Value |
| Device Type | ED |
| Module Address | 0x00-0x00-0x00-0x00 |
| Serial Baud Rate | 9.6kbps |
| Channel Mapping | Single Channel (911.5MHz) |
| TX Output Power | 0dBm |
| Network ID | 0x00-0x00-0x00-0x00 |
| All GPIOs | Digital Input with Pull-up |
| AES Key | 0x2B, 0x7E, 0x15, 0x16, 0x28, 0xAE, 0xD2, 0xA6, 0xAB, 0xF7, 0x15, 0x88, 0x09, 0xCF, 0x4F, 0x3C |

Figure 19: HumDT™ Factory Default Configurations

The module address is not changed to the factory default. This value is retained. This serial command requires knowing the current serial baud rate. If that is not known then all 10 supported rates should be tried to find out which is correct.

Command Data Interface

The DT Series transceiver has a serial Command Data Interface (CDI) that is used to configure and control the transceiver through software commands. This interface consists of a standard UART with a serial command set. The CMD_DATA_IN and CMD_DATA_OUT lines are the interface to the module's UART. The UART is configured for 1 start bit, 1 stop bit, 8 data bits, no parity and no flow control.

The general serial command format for the module is:

[Start Delimiter] [Command] [Parameters] [Data] [End Delimiter]

The Start Delimiter has a fixed value of 0x3C (the '<' ASCII character).

The Command codes are shown in Figure 20. The Command Data Interface Command Set section goes into the commands in detail.

The Data field is only available with the Send Data Packet and Send Broadcast Packet commands. This is the data that is transmitted over the air. The maximum number of data bytes in one data packet is 32 bytes.

The End Delimiter has a fixed value of 0x3E (the '>' ASCII character).

If a command sent to the module is successful, a response is returned. The general serial command response format is:

[Start Delimiter] [Response] [Parameters] [End Delimiter]

The Start Delimiter has a fixed value of 0x3C (the '<' ASCII character).

The Response Type code for each command is the same as the Command Type code. All the available Command Types are shown in Figure 20.

The Response Parameters for each type of response are detailed in the Command Data Interface Command Set section along with the corresponding command.

The End Delimiter has a fixed value of 0x3E (the '>' ASCII character).

All values are in hexadecimal format.

| CDI Command Codes | | | |
|--------------------|--------------------|--------------|--|
| Command Code (hex) | Parameters (bytes) | Data (bytes) | Command Type Definition |
| 21 | 6 | 0–32 | Send Data Packet |
| 22 | 0 | 0 | Read Non-volatile Configurations |
| 23 | 54 | 0 | Write Non-volatile Configurations |
| 24 | 2 | 0 | Read I/O Configurations |
| 26 | 2 | 0 | Read Analog Voltage Value |
| 27 | 2 | 0 | Read Digital IO Value |
| 28 | 3 | 0 | Write Digital Output Value |
| 29 | 0 | 0 | Read Channel Number |
| 2B | 0 | 0 | Read TX Power Level |
| 2C | 1 | 0 | Write TX Power Level |
| 2D | 0 | 0 | Read Radio State |
| 2E | 1 | 0 | Write Radio State |
| 2F | 0 | 0 | Read Ambient RSSI |
| 30 | 0 | 0 | Restore Factory Default Configurations |
| 31 | 0 | 0 | Read Device Name |
| 32 | 0 | 0 | Read Firmware Version |
| 33 | 0 | 0 | Read Module Serial Number |
| 37 | 0 | 0 | Read Frequency Agility Configurations |
| 38 | 1 | 0 | Write Frequency Agility Configurations |
| 39 | 1 | 0–32 | Send Broadcast Packet |
| 3A | 0 | 0 | Read Associated Modules |
| 3B | 4 | 0 | Delete Associated Module |
| 3C | 0 | 0 | Reset Module |
| 3D | 0 | 0 | Read Associated Module Count |
| 42 | 1 | 0 | CW Signal |
| 43 | 0 | 0 | Read AES Key |
| 44 | 16 | 0 | Write AES Key |
| 7A | 1 | 0 | Initialization Complete Message |

Figure 20: HumDT™ CDI Command Codes

The Command Data Interface Command Set

The following sections describe the commands and parameters.

Note: All values are shown in hexadecimal format unless otherwise stated.

The module has two forms of memory, volatile and non-volatile. Volatile memory is temporary and all values are lost when power is removed from the module. However, it is faster to access and the module typically uses the values in volatile memory during operation.

Non-volatile memory is retained when power is removed from the module. This is where default values are stored. When the module powers on, it pulls some values from non-volatile memory and loads them into volatile memory for use during normal operation.

There is one command to read (Command Code = 22) and one command to write (Command Code = 23) all of the configurations in non-volatile memory. The non-volatile memory has a life expectancy of about 1,000 writes, so using one command for all settings helps extend the life time.

Volatile settings have separate commands for each setting since it has a much larger life expectancy. This makes it easier to change just one configuration value.

Send Data Packet - Command Code = 21

This command instructs the module to transmit a data packet over the air.

| Send Data Packet Command and Response | | | | | | | | |
|---------------------------------------|-----|----------|----------|----------|----------|---------|------|-----|
| Command | | | | | | | | |
| Start | Cmd | Param 1 | Param 2 | Param 3 | Param 4 | Param 5 | Data | End |
| 3C | 21 | DestAdr3 | DestAdr2 | DestAdr1 | DestAdr0 | LEN | DATA | 3E |
| Response | | | | | | | | |
| Start | Rsp | Param1 | End | | | | | |
| 3C | 21 | Status | 3E | | | | | |

Figure 21: Send Data Packet Command and Response

The first four bytes consist of the destination address for the data packet with the DestAdr3 (Param 1 byte) being the Most Significant Byte (MSB). The Len byte (Param 5) is the total number of bytes in the Parameter and Data fields (5 bytes plus the number of data bytes).

The Data field contains 0 to 32 bytes of user defined data.

The response parameter indicates if the module successfully processed the command (0x00) or if there was an error (0x01). It only indicates that the data packet has been successfully transmitted by module. It does not indicate that the data was successfully received by the remote device.

When data is received by the module, the output format follows the same format with two exceptions. The source address (address of the transmitting module) replaces the destination address and the module adds one or two RSSI bytes to the end of the response.

The RSSI values depend on the number of hops the packet took. From AP to ED is one hop and only one RSSI byte is added. Transmissions from one ED to another ED must go through the AP, so there are two hops. RSSI1 is the first hop, RSSI2 is the second hop. There is no placeholder, so RSSI2 is either there or not.

The LEN byte includes the Parameter, Data and RSSI bytes.

| Received Data Packet Output | | | | | | | | | | |
|-----------------------------|-----|---------|---------|---------|---------|---------|------|-------|-------|-----|
| Start | Cmd | Param 1 | Param 2 | Param 3 | Param 4 | Param 5 | Data | RSSI1 | RSSI2 | End |
| 3C | 20 | SrcAdr3 | SrcAdr2 | SrcAdr1 | SrcAdr0 | LEN | DATA | RSSI1 | RSSI2 | 3E |

Figure 22: Received Data Packet CDI Output

The RSSI value is returned in 2's complement hex format. The RSSI value in dBm can be calculated based on the formula shown below.

$$\text{RSSI (dBm)} = \text{RSSI_value (in the response)} - 256$$

Read Non-volatile Configurations - Command Code = 22

This command reads all of the configurations that are stored in the module's non-volatile memory.

| Read Non-volatile Configurations Command and Response | | | | | |
|---|----------|---------|-----|----------|-----|
| Command | | | | | |
| Start | Command | End | | | |
| 3C | 22 | 3E | | | |
| Response | | | | | |
| Start | Response | Param 1 | ... | Param 55 | End |
| 3C | 22 | DType | ... | Status | 3E |

Figure 23: Read Non-volatile Configurations Command and Response

The response contains 55 bytes of configuration parameters. The full list of parameters are shown in Figure 24 followed by descriptions of each one.

Note that this command reads out the configurations stored in non-volatile memory. Any configurations that have been changed in volatile memory are not read by this command.

Parameter 1 is the device type. This indicates whether the module is acting as an Access Point (31), Range Extender (32) or End Device (33).

Parameters 2 through 4 are the module's local address that uniquely identifies it within the network. No other module in the same network can have the same address.

Parameter 6 is the UART serial baud rate. The codes for this are shown in Figure 25.

Parameter 7 configures the channel mapping for Frequency Agile mode. This byte contains two parts. The high nibble defines the number of channels out of the 4 available channels that are used. The low nibble is a bitmap which defines which channel(s) are being used. In this nibble, bit 0 corresponds to channel 0, bit 1 to channel 1 and so forth.

For example, the factory default value is 0x12. The high nibble is 0x01, so one channel is being used. The low nibble is 0x2, which is binary 0b0010, so channel 1 is being used.

| Module Configuration Parameters | | | |
|---------------------------------|---------------------|---|-----------------|
| Param # | Definition | Description | Default Value |
| 1 | Device Type | AP (0x31); RE (0x32); ED (0x33) | 0x33 |
| 2 | Module Address [3] | Module Local Address (MSB) | 0x00 |
| 3 | Module Address [2] | Module Local Address (2nd bytes) | 0x00 |
| 4 | Module Address [1] | Module Local Address (3rd byte) | 0x00 |
| 5 | Module Address [0] | Module Local Address (LSB) | 0x00 |
| 6 | Baud Rate | Baud Rate Code (default 9.6 kbps) | 0x03 |
| 7 | Channel Mapping | Channel number and Channel Map | 0x12 |
| 8 | Reserved | N/A | 0x00 |
| 9 | TX Power Level | The TX output power level code | 0x05 |
| 10 | Network ID [3] | Network ID for the module (MSB) | 0x00 |
| 11 | Network ID [2] | Network ID for the module (2nd byte) | 0x00 |
| 12 | Network ID [1] | Network ID for the module (3rd byte) | 0x00 |
| 13 | Network ID [0] | Network ID for the module (LSB) | 0x00 |
| 14 | Port 0; A/D | A/D config for GPIO lines (Analog=1; Digital=0) | 0x00 |
| 15 | Port 0; I/O | I/O config for GPIO lines (Output=1; Input=0) | 0x00 |
| 16 | Reserved | N/A | 0x0B |
| 17 | Reserved | N/A | 0x00 |
| 18 | Reserved | N/A | 0x00 |
| 19 | Pull-up / Pull-down | PU / PD config for GPIO lines (PU=0; PD=1) | 0x00 |
| 20 | Tristate | Tristate config for GPIO lines (PUD=0; Tri=1) | 0x00 |
| 21 | AES Key [15] | MSB of AES key | 0x2B |
| 22 | AES Key [14] | 2nd byte of AES key | 0x7E |
| 23 | AES Key [13] | 3rd byte of AES key | 0x15 |
| 24 | AES Key [12] | 4th byte of AES key | 0x16 |
| 25 | AES Key [11] | 5th byte of AES key | 0x28 |
| 26 | AES Key [10] | 6th byte of AES key | 0xAE |
| 27 | AES Key [9] | 7th byte of AES key | 0xD2 |
| 28 | AES Key [8] | 8th byte of AES key | 0xA6 |
| 29 | AES Key [7] | 9th byte of AES key | 0xAB |
| 30 | AES Key [6] | 10th byte of AES key | 0xF7 |
| 31 | AES Key [5] | 11th byte of AES key | 0x15 |
| 32 | AES Key [4] | 12th byte of AES key | 0x88 |
| 33 | AES Key [3] | 13th byte of AES key | 0x09 |
| 34 | AES Key [2] | 14th byte of AES key | 0xCF |
| 35 | AES Key [1] | 15th byte of AES key | 0x4F |
| 36 | AES Key [0] | LSB of AES key | 0x3C |
| 37 | Reserved | N/A | 0x00 |
| 38 | Reserved | N/A | 0x00 |
| 39 | Reserved | N/A | 0x00 |
| 40 | Reserved | N/A | 0x00 |
| 41 | Reserved | N/A | 0x00 |
| 42 | Reserved | N/A | 0x00 |
| 43 | Reserved | N/A | 0x00 |
| 44 | Reserved | N/A | 0x00 |
| 45 | Reserved | N/A | 0x00 |
| 46 | Reserved | N/A | 0x00 |
| 47 | Reserved | N/A | 0x00 |
| 48 | Reserved | N/A | 0x00 |
| 49 | Reserved | N/A | 0x00 |
| 50 | Reserved | N/A | 0x00 |
| 51 | Reserved | N/A | 0x00 |
| 52 | Reserved | N/A | 0x00 |
| 53 | Reserved | N/A | 0x00 |
| 54 | Reserved | N/A | 0x00 |
| 55 | Status | Indicates if the command is successful (0) or not (1) | 0x00 (no error) |

Figure 24: Read Non-volatile Configurations Response Parameters

| Baud Rate Codes | |
|-------------------------|----------------|
| Serial Baud Rate (kbps) | Baud Rate Code |
| 1.2 | 0 |
| 2.4 | 1 |
| 4.8 | 2 |
| 9.6 | 3 |
| 14.4 | 4 |
| 19.2 | 5 |
| 28.8 | 6 |
| 38.4 | 7 |
| 57.6 | 8 |
| 115.2 | 9 |
| reserved | N/A |

Figure 25: Baud Rate Codes

As another example take the value 0x23. The high nibble is 2, so 2 channels are used. The low nibble is 3, which is a binary 0b0011, so channels 0 and 1 are used.

Parameter 9 controls the transmitter output power level. Figure 26 shows the power level codes and the approximate output power. The actual output power may differ slightly from part-to-part.

| Transmitter Output Power Codes | |
|--------------------------------|-------------------------------------|
| Power Level Code | HUM-900-DT TX Output Power (dBm) |
| 00 | -30 |
| 01 | -20 |
| 02 | -15 |
| 03 | -10 |
| 04 | -5 |
| 05 | 0 |
| 06 | 5 |
| 07 | 7 |
| 08 | 10 |

Figure 26: Transmitter Output Power Codes

Parameters 10 through 13 set the ID of the network that the module is to join. Other modules respond only if they have this same network ID.

Parameter 14 configures the GPIO lines to be either analog or digital. The byte is a bit map with each bit corresponding to a single line; bit 0 corresponds to GPIO_0 and bit 7 corresponds to GPIO_7. Setting a bit to 0 makes that GPIO line digital and setting it to 1 makes the line analog.

Parameter 15 configures the GPIO lines to be either inputs or outputs. The byte is a bit map with each bit corresponding to a single line; bit 0 corresponds to GPIO_0 and bit 7 corresponds to GPIO_7. Setting a bit to 0 makes that GPIO line an input and setting it to 1 makes the line an output. Note that analog lines can only be inputs.

Parameter 19 configures the GPIO lines to have either pull-up resistors to V_{CC} or pull-down resistors to ground. If this byte is set to 0 then all of the GPIO lines have pull-up resistors. Any non-zero value configures the GPIO lines to have pull-down resistors. Note that the tri-state configurations in Parameter 20 take precedence over the resistors. If a line is configured to be tri-state then the resistors are not used.

Parameter 20 configures the GPIO digital input lines to either use the pull-up and pull-down resistors or to be tri-state. The byte is a bit map with each bit corresponding to a single line; bit 0 corresponds to GPIO_0 and bit 7 corresponds to GPIO_7. Setting a bit to 0 makes that GPIO line use the pull-up / pull-down resistors as configured by Parameter 19. Setting it to 1 makes the line tri-state, which is essentially having no resistors.

Setting an input to tri-state deactivates the resistors. This reduces the overall current consumption by removing the current draw through the 20k Ω pulling resistors. However, input lines set as tri-state must be in a determined state (high or low). They cannot be left floating or unpredictable operation may occur.

Parameters 21 through 36 contain the 128-bit key for the AES encryption algorithm. This key must be the same as all other modules on the network.

Parameter 55 indicates if the read command was successful (00) or if there was an error (01).

Write Non-volatile Configurations - Command Code = 23

This command writes all of the configurations that are stored in the module's non-volatile memory.

| Write Non-volatile Configurations Command and Response | | | | | |
|--|----------|---------|-----|----------|-----|
| Command | | | | | |
| Start | Command | Param 1 | ... | Param 54 | End |
| 3C | 23 | DType | ... | Rsv | 3E |
| Response | | | | | |
| Start | Response | Param 1 | End | | |
| 3C | 23 | Status | 3E | | |

Figure 27: Write Non-volatile Configurations Command and Response

This command follows the Parameters shown in Figure 24 with the exception of Parameter 55. That byte is a read-only and is not included in the Write command.

Once written, the non-volatile configurations can be read out immediately. A power cycle is required for them to take effect.

The module uses the values in volatile memory during operation. The module loads the values from non-volatile to volatile memory when it initializes after power-up, so a power cycle is necessary for the module to use the new values.

Read I/O Configurations - Command Code = 24

This command reads the configurations of a specific GPIO line from volatile memory.

| Read I/O Configurations Command and Response | | | | | | | |
|--|----------|---------|---------|---------|---------|---------|-----|
| Command | | | | | | | |
| Start | Command | Param 1 | Param 2 | End | | | |
| 3C | 24 | 00 | GPIO | 3E | | | |
| Response | | | | | | | |
| Start | Response | Param 1 | Param 2 | Param 3 | Param 4 | Param 5 | End |
| 3C | 24 | 00 | GPIO | ADCfg | IOCfg | Status | 3E |

Figure 28: Read I/O Configurations Command and Response

Parameter 1 is set to 0x00. Parameter 2 is the GPIO number to be queried, where 0 corresponds to GPIO_0 and 7 is GPIO_7 and so forth.

The response returns four parameter bytes. Parameter 1 is set to 0x00 and Parameter 2 returns the GPIO number that is being read. Parameter 3 returns the Analog / Digital configuration (digital = 0, analog = 1) and Parameter 4 returns the Input / Output configuration (input = 0, output = 1).

Parameter 5 indicates if the read command was successful (00) or if there was an error (01).

Read Analog Voltage Value - Command Code = 26

This command reads the analog voltage on a specific GPIO line.

| Read Analog Voltage Value Command and Response | | | | | | | |
|--|----------|---------|---------|---------|---------|---------|-----|
| Command | | | | | | | |
| Start | Command | Param 1 | Param 2 | End | | | |
| 3C | 26 | 00 | GPIO | 3E | | | |
| Response | | | | | | | |
| Start | Response | Param 1 | Param 2 | Param 3 | Param 4 | Param 5 | End |
| 3C | 26 | 00 | GPIO | ADC1 | ADC2 | Status | 3E |

Figure 29: Read Analog Voltage Value Command and Response

Parameter 1 is set to 0x00. Parameter 2 is the GPIO number to be queried, where 0 corresponds to GPIO_0 and 7 is GPIO_7 and so forth.

The response returns four parameter bytes. Parameter 1 is set to 0x00 and Parameter 2 returns the GPIO number that is being read. Param 3 and Param 4 return the voltage value on the pin. The voltage on the pin is calculated using the formula below.

$$\text{Voltage (V)} = [(Param 3) * 16 + (Param 4)] / 2047 * V_{CC}$$

For example, if a Read ADC Value command returns the following response and V_{CC} is 3.0V,

0x3C 0x26 0x00 0x07 0x21 0x0E 0x00 0x3E

This means that the voltage on GPIO_7 can be calculated as

$$[(0x21) * 16 + (0x0E)] / 2047 * 3.0 = 0.794V$$

The GPIO line being read must be configured as an analog input before the ADC value can be read.

Parameter 5 indicates if the command was successful (00) or if there was an error (01).

Read Digital IO Value - Command Code = 27

This command reads the digital input value on a specific GPIO line.

| Read Digital Input Value Command and Response | | | | | | |
|---|----------|---------|---------|---------|---------|-----|
| Command | | | | | | |
| Start | Command | Param 1 | Param 2 | End | | |
| 3C | 27 | 00 | GPIO | 3E | | |
| Response | | | | | | |
| Start | Response | Param 1 | Param 2 | Param 3 | Param 4 | End |
| 3C | 27 | 00 | GPIO | DIVal | Status | 3E |

Figure 30: Read Digital Input Value Command and Response

This command returns four Parameter bytes. Parameter 1 is set to 0x00 and Parameter 2 returns the GPIO number that is being read.

Parameter 3 is the state of the GPIO line that is being read. If it is high, Parameter 3 is 0x01. If it is low, Parameter 3 is 0x00.

Parameter 4 indicates if the command was successful (00) or if there was an error (01).

The GPIO line being read must be configured as a digital input or output before the value can be read.

Write Digital Output Value - Command Code = 28

This command sets the digital output value on a specific GPIO line.

| Write Digital Outputs Command and Response | | | | | |
|--|----------|---------|---------|---------|-----|
| Command | | | | | |
| Start | Command | Param 1 | Param 2 | Param 3 | End |
| 3C | 28 | 00 | GPIO | DOVal | 3E |
| Response | | | | | |
| Start | Response | Param 1 | End | | |
| 3C | 28 | Status | 3E | | |

Figure 31: Write Digital Outputs Value Command and Response

Parameter 1 is set to 0x00 and Parameter 2 is the GPIO number that is being written. Parameter 3 sets the output state (High = 01; Low = 00). The configuration made in volatile memory overwrites the configuration read from the non-volatile memory until a power reset.

The GPIO to be written must be configured as a digital output before the value can be written.

The response parameter indicates if the command was successful (00) or if there was an error (01).

Read Channel Number - Command Code = 29

This command reads the module's current channel number.

| Read Channel Number Command and Response | | | | | |
|--|----------|---------|-----|--|--|
| Command | | | | | |
| Start | Command | End | | | |
| 3C | 29 | 3E | | | |
| Response | | | | | |
| Start | Response | Param 1 | End | | |
| 3C | 29 | Chan | 3E | | |

Figure 32: Read Channel Number Command and Response

The channel number in the response ranges from 00 to 03. This value is stored in non-volatile memory.

Read TX Power Level - Command Code = 2B

This command reads the current TX output power level from RAM.

| Read TX Power Level Command and Response | | | | | |
|--|----------|---------|-----|--|--|
| Command | | | | | |
| Start | Command | End | | | |
| 3C | 2B | 3E | | | |
| Response | | | | | |
| Start | Response | Param 1 | End | | |
| 3C | 2B | TXPower | 3E | | |

Figure 33: Read TX Power Level Command and Response

The TX output power levels are shown in Figure 26. This command reads the TX output power level setting stored in volatile memory, which may be different from that stored in non-volatile memory.

Write TX Power Level - Command Code = 2C

This command sets the TX output power level in volatile memory.

| Write TX Power Level Command and Response | | | | | |
|---|----------|---------|-----|--|--|
| Command | | | | | |
| Start | Command | Param 1 | End | | |
| 3C | 2C | TXPower | 3E | | |
| Response | | | | | |
| Start | Response | Param 1 | End | | |
| 3C | 2C | Status | 3E | | |

Figure 34: Write TX Power Level Command and Response

The TX output power levels are shown in Figure 26. This command writes the TX output power level stored in volatile memory, which may be different from what is in non-volatile memory. This change is lost on a power cycle.

The response parameter indicates if the command was successful (00) or if there was an error (01).

Read Radio State - Command Code = 2D

This command reads the current radio state.

| Read Radio State Command and Response | | | |
|---------------------------------------|----------|---------|-----|
| Command | | | |
| Start | Command | End | |
| 3C | 2D | 3E | |
| Response | | | |
| Start | Response | Param 1 | End |
| 3C | 2D | RState | 3E |

Figure 35: Read Radio State Command and Response

The response returns the Radio State Code for the radio's current working state. The module can be in one of the five states shown in Figure 36.

| Radio State Codes | | |
|-------------------|-------------|---|
| RState Code | Radio State | Description |
| 0x00 | Unknown | An error has happened |
| 0x01 | Sleep | The radio is in sleep mode (turned off). |
| 0x02 | Idle | The radio is turned on in an idle mode (neither TX nor RX) |
| 0x03 | RX On | The radio is in RX mode. |
| 0x04 | TX On | TX state is automatically entered when data is input to the module. |

Figure 36: Radio State Codes

The Unknown state indicates an error has happened.

The Sleep state is a low-power state where the radio is powered off, but some microcontroller blocks are running.

The Idle state is a state where the RX section of the radio is turned off. However, the module can still switch to the TX On state when it has something to send. The microcontroller is running.

The RX On mode is where the radio is in receive mode and the microcontroller is running.

The TX On state is where the radio is in transmit mode and the microcontroller is running.

Write Radio State - Command Code = 2E

This command sets the current Radio State.

| Write Radio State Command and Response | | | |
|--|----------|---------|-----|
| Command | | | |
| Start | Command | Param 1 | End |
| 3C | 2E | RState | 3E |
| Response | | | |
| Start | Response | Param 1 | End |
| 3C | 2E | Status | 3E |

Figure 37: Write Radio State Command and Response

This command places the module into one of the RState codes shown in Figure 38.

| Radio State Codes | | |
|-------------------|-------------|---|
| RState Code | Radio State | Description |
| 0x00 | Awake | Wakes up the module from Sleep or Power Down and brings it to RX On |
| 0x01 | Sleep | Puts the radio into sleep state (turned off) |
| 0x02 | Idle | Sets the radio to idle state (neither TX nor RX) |
| 0x03 | RX On | Turns on the receiver, also wakes from Sleep |
| 0x04 | PDN | Puts the module into Power Down state |

Figure 38: Radio State Codes

The module automatically enters the TX state when there is data to be transmitted by the radio. It cannot be manually controlled by issuing a serial command.

Only EDs can go into Sleep, power down and Idle. APs and REs must stay awake.

The response parameter indicates if the command was successful (00) or if there was an error (01).

Read Ambient RSSI - Command Code = 2F

This command reads the current RSSI value. This indicates how quiet the current ambient RF environment is.

| Read Ambient RSSI Command and Response | | | |
|--|----------|---------|-----|
| Command | | | |
| Start | Command | End | |
| 3C | 2F | 3E | |
| Response | | | |
| Start | Response | Param 1 | End |
| 3C | 2F | RSSI | 3E |

Figure 39: Read Ambient RSSI Command and Response

The RSSI value is returned in 2's complement hex format. The RSSI value in dBm can be calculated based on the formula shown below.

$$\text{RSSI (dBm)} = \text{RSSI_value (in the response)} - 256$$

This command only returns the ambient RSSI. The RSSI for a received packet is included with the packet data. The response is only valid when the radio state is set to RX On.

Restore Factory Default Configurations - Command Code = 30

This command restores all the configurations in the non-volatile memory back to the factory default values.

| Restore Factory Default Configurations Command and Response | | | |
|---|----------|---------|-----|
| Command | | | |
| Start | Command | End | |
| 3C | 30 | 3E | |
| Response | | | |
| Start | Response | Param 1 | End |
| 3C | 30 | Status | 3E |

Figure 40: Restore Factory Default Configurations Command and Response

Once this command is issued and all non-volatile settings have been restored, a power cycle restores all volatile settings to the factory defaults. The module now works as it was originally shipped. The one exception is that the module address is retained. This can be set to the default of 00 00 00 00 if desired.

The response parameter indicates if the command was successful (00) or if there was an error (01).

Read Device Name - Command Code = 31

This command returns the name of the module.

| Read Device Name Command and Response | | | | | |
|---------------------------------------|----------|---------|-----|----------|-----|
| Command | | | | | |
| Start | Command | End | | | |
| 3C | 31 | 3E | | | |
| Response | | | | | |
| Start | Response | Param 1 | ... | Param 11 | End |
| 3C | 31 | Name0 | ... | Name11 | 3E |

Figure 41: Read Device Name Command and Response

The Device Name is "HUM-900-DT". The bytes that are output correspond to the ASCII values associated with the characters. They are terminated by a 00 control character. For example, the response is:

3C 31 48 55 4D 2D 39 30 30 2D 44 54 00 3E

Read Firmware Version - Command Code = 32

This command reads out the module's firmware version.

| Read Firmware Version Command and Response | | | | | | |
|--|----------|---------|---------|---------|---------|-----|
| Command | | | | | | |
| Start | Command | End | | | | |
| 3C | 32 | 3E | | | | |
| Response | | | | | | |
| Start | Response | Param 1 | Param 2 | Param 3 | Param 4 | End |
| 3C | 32 | FW3 | FW2 | FW1 | FW0 | 3E |

Figure 42: Read Firmware Version Command and Response

FW3 is the MSB and FW0 is the LSB in the number.

Read Module Serial Number - Command Code = 33

This command reads out the module's serial number.

| Read Module Serial Number Command and Response | | | | | | |
|--|----------|---------|---------|---------|---------|-----|
| Command | | | | | | |
| Start | Command | End | | | | |
| 3C | 33 | 3E | | | | |
| Response | | | | | | |
| Start | Response | Param 1 | Param 2 | Param 3 | Param 4 | End |
| 3C | 33 | SN3 | SN2 | SN1 | SN0 | 3E |

Figure 43: Read Module Serial Number Command and Response

The serial number is set at the factory and cannot be changed. Every DT Series module manufactured by Linx has a unique serial number. This is different from the module address. SN3 is the MSB and SN0 is the LSB in the number.

Read Frequency Agility Configurations - Command Code = 37

This command reads out the module's Frequency Agility channel mapping value.

| Read Frequency Agility Configurations Command and Response | | | |
|--|----------|---------|-----|
| Command | | | |
| Start | Command | End | |
| 3C | 37 | 3E | |
| Response | | | |
| Start | Response | Param 1 | End |
| 3C | 37 | CMap | 3E |

Figure 44: Read Frequency Agility Configurations Command and Response

The channel map value is one byte long and contains two parts. The high nibble defines the number of channels out of the 4 available channels that are used. The low nibble is a bitmap which defines which channel(s) are being used. In this nibble, bit 0 corresponds to channel 0, bit 1 to channel 1 and so forth.

For example, the factory default value is 0x12. The high nibble is 0x01, so one channel is being used. The low nibble is 0x2, which is binary 0b0010, so channel 1 is being used.

The response parameter indicates if the command was successful (00) or if there was an error (01).

Write Frequency Agility Configurations - Command Code = 38

This command configures the module's Frequency Agility channel mapping value.

| Write Frequency Agility Configurations Command and Response | | | |
|---|----------|---------|-----|
| Command | | | |
| Start | Command | Param 1 | End |
| 3C | 38 | CMap | 3E |
| Response | | | |
| Start | Response | Param 1 | End |
| 3C | 38 | Status | 3E |

Figure 45: Read Frequency Agility Configurations Command and Response

The channel map value is one byte long and contains two parts. The high nibble defines the number of channels out of the 4 available channels that are used. The low nibble is a bitmap which defines which channel(s) are being used. In this nibble, bit 0 corresponds to channel 0, bit 1 to channel 1 and so forth.

For example, the factory default value is 0x12. The high nibble is 0x01, so one channel is being used. The low nibble is 0x2, which is binary 0b0010, so channel 1 is being used.

The response parameter indicates if the command was successful (00) or if there was an error (01).

Send Broadcast Packet - Command Code = 39

This command is used by an AP to send a broadcast message to all of its associated EDs at one time.

| Send Broadcast Packet Command and Response | | | | |
|--|----------|---------|---------|-----|
| Command | | | | |
| Start | Command | Param 1 | Param 2 | End |
| 3C | 39 | LEN | DATA | 3E |
| Response | | | | |
| Start | Response | Param 1 | End | |
| 3C | 39 | Status | 3E | |

Figure 46: Send Broadcast Packet Command and Response

The LEN byte is the number of bytes in the DATA field plus 1 for the LEN byte. DATA can be up to 32 bytes.

The broadcast message is sent by the AP and is output by all of the EDs connected to the AP. This allows a single transmission to update all modules instead of having to address separate messages to each one.

The response parameter indicates if the command was successful (00) or if there was an error (01).

The EDs output the broadcast message as shown in Figure 47.

| Received Broadcast Packet | | | | | |
|---------------------------|---------|---------|---------|---------|-----|
| Start | Command | Param 1 | Param 2 | Param 3 | End |
| 3C | 39 | LEN | DATA | RSSI | 3E |

Figure 47: Received Broadcast Packet

The LEN byte is the total number of parameter bytes, including the LEN byte, data bytes and RSSI byte.

The DATA field is up to 32 bytes of data.

The RSSI byte is the RSSI for the received broadcast message. It is returned in 2's complement hex format. The RSSI value in dBm is calculated the same as the other RSSI values.

$$\text{RSSI (dBm)} = \text{RSSI_value (in the response)} - 256$$

Read Associated Modules - Command Code = 3A

This command reads out all of the modules that are associated with the current module.

| Read Associates List Command and Response | | | | | | |
|---|----------|---------|---------|---------|---------|-----|
| Command | | | | | | |
| Start | Command | End | | | | |
| 3C | 3A | 3E | | | | |
| Response 1 | | | | | | |
| Start | Response | Param 1 | End | | | |
| 3C | 3A | NumMod | 3E | | | |
| Response 2 | | | | | | |
| Start | Response | Param 1 | Param 2 | Param 3 | Param 4 | End |
| 3C | 3A | SrcAdr3 | SrcAdr2 | SrcAdr1 | SrcAdr0 | 3E |
| ... | | | | | | |
| Response n | | | | | | |
| Start | Response | Param 1 | Param 2 | Param 3 | Param 4 | End |
| 3C | 3A | SrcAdr3 | SrcAdr2 | SrcAdr1 | SrcAdr0 | 3E |

Figure 48: Read Associates List Command and Response

If the current module is an ED or RE, then the only associated node is the AP. An AP can have up to 50 associated EDs in a single network. Due to the lack of intelligence in an RE, this command does not provide the RE information.

The first response contains the number of modules associated with the current module. The module then outputs one response for each associated module that contains that module's address.