Table of Contents

Introduction

The TT Series transceiver has a serial Command Data Interface (CDI) that offers the option to configure and control the transceiver through software instead of through hardware. This interface consists of a standard UART with a serial command set. This allows fewer connections in applications controlled by a micro as well as more control and advanced features than available through hardware pins alone.

Connecting the Command Data Interface

The CMD_DATA_IN and CMD_DATA_OUT lines are the interface to the module's UART (Figure 1). An automatic baud rate detection system allows the interface to run at a variable data rate from 9.6kbps to 57.6kbps. The CDI is available for use when the transceiver is not in Power Down mode. CMD_DATA_IN and CMD_DATA_OUT are suitable for direct connection to a microcontroller UART (Figure 2). They operate on logic level voltages of GND to V_{CC}.

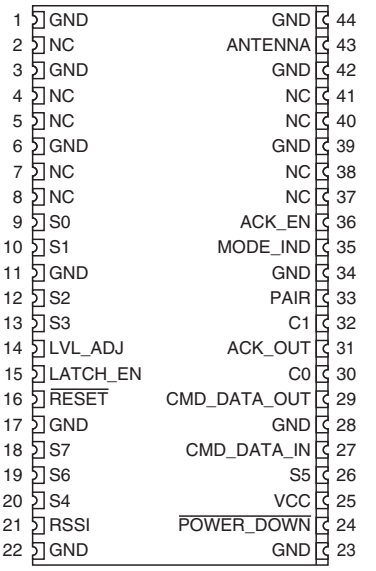

Figure 1: TT Series Transceiver Pinout (Top View)

TT Series Transceiver Pin Descriptions

Pin #	Name	Description
27	CMD_DATA_IN	Command Data In. This line is the input for command data to set up the module.
29	CMD_DATA_OUT	Command Data Out. This line outputs the command data responses when configuring the module.

Figure 2: TT Series Transceiver Pin Descriptions

The Command Data Interface Data Structure

All serial commands have the same prefix which is used to wake the module and set the serial data rate. The serial command format is:

[Prefix] [Payload]

Where the Prefix is (hexadecimal values):

[80] [55] [80+ Payload Length]

The payload length is in bytes, so if there are three bytes of payload then the last value is a hexadecimal 83. If there are four bytes, then the last value is a hexadecimal 84.

The payload varies with the serial command that is used and is described for each command in the Command Data Interface Command Set section.

Once the initial byte is sent, the command must be completed within 500ms. All partial packets are discarded after this time.

Bytes are sent LSB first with one start bit and one stop bit as in Figure 3.

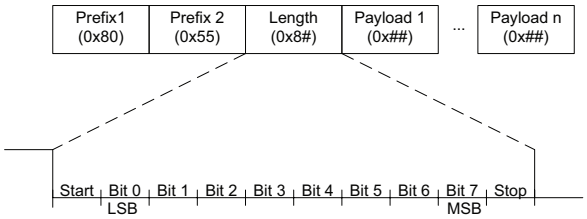

Figure 3: TT Series Transceiver CDI Data Structure

The Command Data Interface Command Set

The Command Data Interface has a set of commands that perform specific tasks. A set of parameters are used with the commands for module configuration and status reporting. These are shown in Figure 4. The values are shown in hexadecimal format unless otherwise stated.

The settings are stored in two types of memory inside the module. Volatile memory is quick to access, but it is lost when power is removed from the module. Non-volatile memory takes longer to access, but is retained when power is removed.

Many configuration settings are read from non-volatile memory on power up and saved in volatile memory since it is faster to read and write the volatile memory locations. There are commands to read and write both locations. The Read and Write commands are associated with volatile memory and the Read NV and Program are associated with the non-volatile memory. The two locations can be changed independently, so they may not match.

Figure 4 shows where each parameter is stored and the commands that are valid with each parameter.

Command Data Interface Operators			
Command	**CMD Code (hex)**	**Response Code (Hex)**	**Description**
Read	01	C1	Read the current value in volatile memory. If there is no volatile value, then the non-volatile value is returned.
Write	02	C0	Write a new value to volatile memory.
Read NV	03	C2	Read the value in non-volatile memory.
Program	04	C0	Program a new value to non-volatile memory.
Set Default Configuration	81	C0	Set all configuration items to their factory default values.
Erase All Addresses	82	C0	Erase all paired addresses from memory.
Transmit Control Data	83	C0	Transmit a control message.
Transmit ACK	84	C0	Transmit an acknowledgement for received data.
Transmit AWD	85	C0	Transmit an Acknowledge With Data (AWD) response with 2 bytes of custom data.

Parameter	**Location**	**CMD**	**ItemID (hex)**	**Description**
Device Name	N	R, N	01	NULL-terminated string of up to 16 characters that identifies the module.
Firmware Version	N	R, N	02	3 byte firmware version.
Serial Number	N	R, N	03	4 byte factory-set serial number.
Local Address	N	R, N, P	10	The module's 32-bit local address.
Status Line I/O Mask	N, V	R, N, W, P	11	Status lines direction (1 = Inputs, 0 = Outputs) , LSB = S0, used when enabled by Control Source
Latch Mask	N, V	R, N, W, P	12	Latching enable for output lines, LSB = S0, used when enabled by Control Source
TX Power Level	N, V	R, N, W, P	13	TX output power, signed nominal dBm, used when enabled by Control Source
Control Source	N, V	R, N, W, P	14	Configures the control options.
Message Select	N, V	R, N, W, P	15	Select message types to capture for serial readout
Paired Module Descriptor	N, V	R, N, P	18	Sets the index number, address and permissions mask of paired modules.
Receiver Duty Cycle	N, V	R, N, W, P	1A	Receiver duty cycle control
I/O Lines	V	R	20	Read the current state of the status and control lines.
RSSI	V	R	21	Read the RSSI of the last packet received and ambient level.
LADJ	V	R	22	Read the voltage on the LVL_ADJ line.
Module Status	V	R	23	Read the operating status of the module.
Captured Receive Packet	V	R	24	Read the last received packet.
Interrupt Mask	N, V	R, W, P	25	Sets the mask for events to generate a break on CMD_DATA_OUT.
Event Flags	V	R, W	26	Event flags that are used with the Interrupt Mask.

Figure 4: TT Series Transceiver Command Data Interface Operators

The Location column indicates where the data is stored; N = Non-volatile memory, V = Volatile memory

The CMD column indicates which commands are valid with the parameter; R = Read, W = Write, N = Read Non-volatile, P = Program

CDI Commands

Read

The Read command returns the value of the requested parameter from volatile memory. The volatile location is used in normal operation. If the parameter does not use a volatile location, then the associated non-volatile location is returned.

Command Format: [Prefix] [01] [ItemID] [Index]
01 = Read command
ItemID = the parameter to read
Index = optional byte that is used with the Paired Module Descriptor parameter

The Read command triggers a Read Active Data (RAD) response.

Reply Format: [Prefix] [C1] [ItemID] [Values]
C1 = RAD response
ItemID = the parameter that was read
Values = the parameter values being returned

Write

The Write command sets the parameter to the specified value in volatile memory. It remains in effect until the module is reset by cycling power. Volatile parameters are set to the corresponding non-volatile values on power-up. Unless otherwise specified, changes take effect as soon as a non-error response is sent.

Command Format: [Prefix] [02] [ItemID] [Values]
02 = Write Command
ItemID = the parameter to write
Values = One or more bytes containing new parameter values

The Write command triggers an Acknowledge (ACK) response.

Reply Format: [Prefix] [C0] [Error Code] [Command Payload]
C0 = ACK reply
Error Code = shown in Figure 5.
Command Payload = the command that was received by the module

Read NV

The Read NV command returns the value of the requested parameter that is in non-volatile memory. This command is useful for diagnostic purposes, but the Read command is recommended for normal interface since this returns the values currently being used by the module.

Command Format: [Prefix] [03] [ItemID] [Index]
03 = Read NV command
ItemID = the parameter to read
Index = optional byte that is used with the Paired Module Descriptor parameter

The ReadNV command triggers a Read Non-Volatile Data (RNVD) response.

Reply Format: [Prefix] [C2] [ItemID] [Values]
C2 = Read NV response
ItemID = the parameter that was read
Values = the parameter values being returned

Program

The Program command sets the parameter to the specified value in both volatile and non-volatile memory. It remains the default value on power-up until the non-volatile parameter is rewritten or the module is reset to factory defaults. Unless otherwise specified, changes to the parameters take effect as soon as a non-error response is sent.

> Note: Writing to non-volatile parameters takes about 5ms per byte.
> Each parameter byte has a minimum of 100,000 lifetime write cycles.

Command Format: [Prefix] [04] [ItemID] [Values]
04 = Program Command
ItemID = the parameter to program
Values = One or more bytes containing new parameter values

The Program command triggers an ACK response just like the Write command.

Reply Format: [Prefix] [C0] [Error Code] [Command Payload]
C0 = ACK reply
Error Code = shown in Figure 5.
Command Payload = the command that was received by the module

ACK Response Error Codes

Command	Code	Description
ERR_NONE	00	The command succeeded. No error occurred.
ERR_CMND	F1	The command or Read/ReadNV/Write/Program ItemID field is undefined
ERR_VALU	F2	The value field is out or range for specified command or Write/Program Item field
ERR_INTN	F3	Internal error
ERR_SNFG	F4	Item is locked or read-only and cannot be written (includes inhibit during Pairing process)

Figure 5: ACK Response Error Codes

Set Default Configuration

This command sets all configuration parameters to the factory default values.

Set Default Configuration

Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	81	AB	7E

Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	81	AB	7E

Figure 6: Set Default Configuration Command and Response

Erase All Addresses

This command erases all of the paired modules from memory.

Erase All Addresses

Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	82	AB	7D

Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	82	AB	7D

Figure 7: Erase All Addresses Command and Response

Transmit Control Data

This command initiates the transmission of a specified number of control packets with specified status line settings and two bytes of custom data.

Transmit Control Data

Command

Prefix	PKT LGTH	CMD	ItemID	V1	V2	V3	V4
80 55	86	83	Flags	Duration	Status	CData1	CData2

Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3	V4	V5	V6
80 55	88	C0	00	83	Flags	Duration	Status	CData1	CData2

Figure 8: Transmit Control Data Command and Response

Multiple transmissions increase the probability that the RU will receive the data.

Flags, bit 0 = Wait
0 – Transmit on the next slot
1 – Wait until the module completes the previous transmission
Duration – The number of packets to transmit
Status = Status line settings to transmit; bit b0 is line S0, b7 is line S7
CData1, CData2 = Custom data value to transmit with the packet

If a transmit operation is in process when a new transmit command is issued, the Wait bit (FLAGS.0) determines whether the new data transmits immediately or waits until the previous packet count is complete. In both cases the transmit hop timing continues without interruption. The Wait bit has no effect if the transmitter is not active.

When the transmit packet counter expires without new control data the IU reverts to hardware-based transmission, which starts shutdown timing if none of the status line inputs are high.

A previously initiated transmission can be terminated early by sending a Transmit Control Data command with Wait = 0 and Duration = 0. This initiates the shutdown timing.

If the module is transmitting from status line activation when this command is sent, the previous transmission data is immediately replaced with data from this command. Hardware-based transmission control resumes when the Transmit Command Data command or command series times out.

The TX Packet Sent event flag is set when all packets of have been transmitted. The interrupt mask can be used to generate a break when the flag is set.

Transmit ACK

This command initiates transmission of acknowledgement for the control message currently being received. It must be initiated before the control message transmission terminates.

Transmit ACK

Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	84	Qual	NPkts

Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	84	Qual	NPkts

Figure 9: Transmit ACK Command and Response

Qual = ACK Qualifier

0 = transmit an ACK as a response to control packets in the current RU session matching the packet output by reading Captured Receive Packet. ACK transmission is cancelled by a change of received data or the end of the current RU session.

1 = transmit an ACK for any packet during the current RU session. ACK transmission is cancelled by the end of the current RU session.

NPkts = Number of Packets – maximum number of acknowledge packets to transmit, 0 = continuous for the current session.

For both qualifier modes, a received control packet from the current RU session must have been read serially by using the Read command for the Captured Receive Packet parameter. The ACK transmission is terminated after NPkts packets have been transmitted or the IU stops sending control packets.

For Qual = 0, the ACK is cancelled if the received control data (Status or Custom Data field) is different from the data read by Captured Receive Packet. This mode assures that an ACK is transmitted only for the exact data which has been read from the RU. This qualifier can result in no ACKs being sent if the incoming control data changes before the first opportunity to transmit an ACK.

For Qual = 1, the ACK is not cancelled by control data changes. This mode is appropriate if status line changes during a transmission should not interrupt ACK transmission.

An ACK packet is transmitted to the IU immediately after receiving the next transmission if the qualifier condition is true. If the qualifier condition is false, the ACK transmission is cancelled. If NPkts = 0, the acknowledge message is transmitted for each incoming message of the RU session as long as the qualifier is true.

If an AWD response is active or pending when a Transmit ACK message is received, the AWD transmission request is cancelled and the Transmit ACK becomes effective.

The TX Packet Sent event flag is set when all packets of have been transmitted. The interrupt mask can be used to generate a break when the flag is set.

Transmit AWD

This command initiates transmission of an Acknowledge With Data (AWD) response to the current control messages being received. The response includes two bytes of custom data which can be read from the IU.

Transmit AWD

Command

Prefix	PKT LGTH	CMD	ItemID	V1	V2	V3
80 55	85	85	Qual	NPkts	CData1	CData2

Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3	V4	V5
80 55	87	C0	00	85	Qual	NPkts	CData1	CData2

Figure 10: Transmit AWD Command and Response

Qual = AWD Qualifier

- 0 = transmit an AWD as a response to control packets in the current RU session matching the packet output by reading Captured Receive Packet. AWD transmission is cancelled by a change of received data or the end of the current RU session.
- 1 = transmit an AWD for any packet during the current RU session. AWD transmission is cancelled by the end of the current RU session.
- 2 = transmit AWD for the next RU session. The AWD transmission is cancelled by the end of the RU session in which the AWD response was transmitted.

NPkts = Number of Packets – maximum number of acknowledge packets to transmit, 0 = continuous for current session.
CData1, 2 = Two bytes of custom data included with the ACK transmission.
For qualifier modes 0 and 1, a received control packet from the current RU session must have been read serially by using the Read command for Captured Receive Packet. The AWD transmission is terminated after NPkts packets have been transmitted or the IU stops sending control packets.

For Qual = 0, the AWD is cancelled if the received control data (Status or Custom Data field) is different from the data read by Captured Receive Packet. This mode assures that an AWD is transmitted only for the exact data which has been read from the RU. This qualifier can result in no AWD being sent if the

incoming control data changes before the first opportunity to transmit an AWD. For Qual = 1, the AWD is not cancelled by control data changes. This mode is appropriate if status data changes during transmission should not interrupt AWD transmission.

For Qual = 2, the AWD is transmitted in response to the current RU session or, if no RU session is active, the next RU session. Unlike qualifiers 0 and 1, the response is sent for an RU session with any valid IU and any control data from the IU. The transmission is terminated by the end of the responding RU session. The pending request to transmit for the next RU session is cancelled by resetting the module through Power Down or a power cycle.

An AWD packet is transmitted to the IU immediately after receiving the next transmission if the specified qualifier condition is true. If the qualifier condition is false, the AWD transmission is cancelled. If NPkts = 0, the acknowledge message is transmitted for each incoming message of the RU session as long as the qualifier is true.

If an Acknowledge response is active when a Transmit AWD message is received, the Acknowledge transmission is cancelled and the Transmit AWD becomes effective, instead.

The TX Packet Sent event flag is set when all packets of have been transmitted. The interrupt mask can be used to generate a break when the flag is set.

CDI Parameters

Device Name - ItemID = 01

This ASCII value starts with “TT-xxx” to indicate a TT-Series Transceiver where “xxx” is a frequency designator (900 = 900MHz). The characters “TT-xxx” may be followed by additional characters indicating factory model or configuration codes. The variable-length name is terminated with a null byte (00).

Device Name

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	01

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2	V3	V4	V5	V6	V7
80 55	89	C1	01	54	54	2D	39	30	30	00

Figure 11: Device Name Command and Response

Firmware Version - ItemID = 02

These three bytes contain the major, minor and incremental fields of the firmware version number.

Firmware Version

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	02

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2	V3
80 55	84	C1	02	FWH	FWL	FWI

Figure 12: Firmware Version Command and Response

Each byte is a hexadecimal value: 12 03 01 indicates version 18.3.1.
FWH = major version number
FWL = minor version number
FWI = incremental version number

Serial Number - ItemID = 03

This parameter is the factory-set 32-bit serial number for the module.

Serial Number

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	03

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2	V3	V4
80 55	86	C1	03	SER1	SER2	SER3	SER4

Figure 13: Serial Number Command and Response

SER1 is the MSB and SER4 is the LSB of the serial number. This number is factory set and cannot be changed.

Local Address - ItemID = 10

This four-byte value is the local address for the module, which is transmitted with every control message. It is preset to a unique value at the factory, but can be changed. An address of 0xFFFFFFFF designates “no address” and is not allowed.

Local Address

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	10

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2	V3	V4
80 55	86	C1	10	ADR1	ADR2	ADR3	ADR4

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1	V2	V3	V4
80 55	86	04	10	ADR1	ADR2	ADR3	ADR4

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3	V4	V5	V6
80 55	88	C0	00	04	10	ADR1	ADR2	ADR3	ADR4

Figure 14: Local Address Command and Response

Status Line I/O Mask - ItemID = 11

This byte sets the input / output direction for the eight status lines. This item is enabled when Control Source byte CWord.3 = 1. It has no effect when CWord.3 = 0. This parameter value is independent of the C0 and C1 lines.

A 1 bit configures the corresponding status line as an input, 0 for output. The least significant bit configures line S0. The factory default is FF, making all lines inputs. Status lines that change from input to output are initially driven low.

Status Line I/O Mask

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	11

Read Response

Prefix	PKT LGTH	Code	ItemID	V1
80 55	83	C1	11	SMask

Write Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	02	11	SMask

Write Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	02	11	SMask

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	04	11	SMask

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	04	11	SMask

Figure 15: Status Line I/O Mask Command and Response

Latch Mask - ItemID = 12

This byte selects latching mode for the status line outputs. This item is enabled when Control Source byte CWord.4 = 1. When CWord.4 = 0, the latched or momentary configuration is set by the LATCH_EN line.

When Control Source byte CWord.4 = 1, the status line outputs with a corresponding 1 bit in the mask operate in latching mode. A 0 bit configures them for momentary operation. The least significant bit configures line S0. The factory default is 00, making all lines momentary.

Latch Mask

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	12

Read Response

Prefix	PKT LGTH	Code	ItemID	V1
80 55	83	C1	12	LMask

Write Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	02	12	LMask

Write Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	02	12	LMask

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	04	12	LMask

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	04	12	LMask

Figure 16: Latch Mask Command and Response

TX Power Level - ItemID = 13

This signed byte sets the module's RF output power in dBm.

TX Power Level

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	13

Read Response

Prefix	PKT LGTH	Code	ItemID	V1
80 55	83	C1	13	TXPower

Write Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	02	13	TXPower

Write Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	02	13	TXPower

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	04	13	TXPower

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	04	13	TXPower

Figure 17: TX Power Level Command and Response

This is enabled when Control Source byte CWORD.0 = 1. It is set and read independently of the LVL_ADJ input. The valid range is –20 to +12 in signed twos compliment (e.g. –4 is set as FC). A value larger than the maximum module value results in the maximum output value. This value is approximate and doesn't reflect the antenna connection or efficiency. The factory default is 0. Changes take effect on the start of the next IU session.

Control Source - ItemID = 14

This item contains two fields: CWord and CData.

Control Source

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	14

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2	V3
80 55	85	C1	14	CWord	CData1	CData2

Write Command

Prefix	PKT LGTH	CMD	ItemID	V1	V2	V3
80 55	85	02	14	CWord	CData1	CData2

Write Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3	V4	V5
80 55	87	C0	00	02	14	CWord	CData1	CData2

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1	V2	V3
80 55	85	04	14	CWord	CData1	CData2

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3	V4	V5
80 55	87	C0	00	04	14	CWord	CData1	CData2

Figure 18: Control Source Command and Response

CWord has control bits that determine which aspects of operation are controlled by control lines, and which are controlled by internal configuration. Figure 19 shows the definition of the CWord bits.

CData is a two-byte value for the custom data field that is transmitted with each Control Data message initiated by a status input line. The default value is 0. Different values for CData can be sent by the Transmit Control Data serial command. Changes to the power level source take effect on the start of the next IU session. Other control changes take effect immediately.

CWord Definition	
CWord Bit	**Description**
0	TX RF Power Level Source 0 = TX output power is set by the voltage on LVL_ADJ (default) 1 = TX output power is set by the TX Power Level Serial Command
1	Enable Status Lines 0 = Hardware lines disabled, transmit only on serial command 1 = Hardware lines enabled, transmit when active (default)
2	Enable Receiver 0 = Receiver Off 1 = Receiver Active (default)
3	Status Line Direction Control 0 = Direction Set by C0 and C1 (default) 1 = Direction Set by Status Line I/O Mask
4	Output Latch Control 0 = All output latched if LATCH_EN is high, unlatched if low (default) 1 = Set by Latch Mask
5–7	Reserved, set to 0

Figure 19: CWord Byte Definition

Message Select - ItemID = 15

This byte selects which received packet types are captured for readout with Captured Receive Packet.

Message Select

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	15

Read Response

Prefix	PKT LGTH	Code	ItemID	V1
80 55	83	C1	15	MSel

Write Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	02	15	MSel

Write Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	02	15	MSel

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	04	15	MSel

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	04	15	MSel

Figure 20: Message Select Command and Response

Message Select Definition	
MSel Value	**Description**
0	None (default)
1	New control message from a paired source
2	New received Acknowledge or Acknowledge with Data message during IU TX operation
3	Types 1 and 2
4	New valid control message (from any address)
5	New valid control, Acknowledge, or AWD message (from any address)
6	Any new message with TT-compatible modulation, sync, length code, and CRC

Figure 21: Message Select Definition

A message is captured for readout with Captured Receive Packet if it matches the selected type, any previously captured message has been read, and

1. It is the first message captured, or
2. It is different from the previously captured message, or
3. It is from a newer control session than the previously captured message

Once captured, it remains available for readout until the module is reset.

Setting the Interrupt Mask bit 0 (IMask.0) to a 1 enables an interrupt event when a new message of the selected type is captured. This tells an external processor that a new message is available to be read. Please see the Interrupt Mask section for more information.

The interrupt event is useful when reading the packets directly rather than using the status line outputs to drive circuitry. An example is if a system needs more than 40 paired devices, then setting Message Select to 6 causes the module to accept any TT-compatible packet. When the Notify Event occurs, the Captured Receive Packet item can be used to pass the message to an external device with more memory to handle the address verification. The custom data bytes can also be used for further verification of the system or additional control.

Paired Module Descriptor - ItemID = 18

Reading or Programming this item reads or sets the descriptor for a single item in the Paired Module List. The descriptor contains the paired unit's address and Permissions Mask

Paired Module Descriptor Fields		
Field	**Range**	**Description**
NX	1 – 40 (decimal)	The index of the Paired Module List row to be accessed
ADDRESS	00000000 – FFFFFFFF	The address of a paired module. FFFFFFFF indicates an empty row
PERMISSIONS	00 – FF	The Permission Mask of the paired module

Figure 22: Paired Module Descriptor Fields

Writing a Paired Module Descriptor

NX is the index of the row in the Paired Module List to be written. The following data is written into that location in the table, replacing the existing values. The address must be unique in the list. An ERR_VALU error response is returned if the address matches the address in any row other than NX. The order of the rows in the list does not affect the module's operation.

Reading a Paired Module Descriptor

When a read operation is performed, the RNVD response returns the data from row NX in the Paired Module List.

Paired Module Descriptor

Read Command

Prefix	PKT LGTH	CMD	ItemID	Index
80 55	83	01	18	NX

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2	V3	V4	V5	V6
80 55	88	C1	18	NX	ADR1	ADR2	ADR3	ADR4	PER

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1	V2	V3	V4	V5	V6
80 55	88	04	18	NX	ADR1	ADR2	ADR3	ADR4	PER

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3	V4	V5	V6	V7	V8
80 55	8A	C0	00	04	18	NX	ADR1	ADR2	ADR3	ADR4	PER

Figure 23: Paired Module Descriptor Command and Response

A 1 bit in the Permission Mask indicates that the paired module with the corresponding address is allowed to change the corresponding status line output. A 0 bit means that the paired module cannot change the status line output.

The least significant bit configures line S0. Bits in the permission mask corresponding to status inputs have no effect. The pair process sets this to FF by default, allowing the paired unit to control all lines.

Receiver Duty Cycle - ItemID = 1A

This item configures the RU receiver to be turned on periodically to lower the average DC power. The factory-reset default value for DCycle is 0, which disables duty cycling, giving the fastest response time.

Receiver Duty Cycle

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	1A

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2
80 55	84	C1	1A	DCycle	KeepOn

Write Command

Prefix	PKT LGTH	CMD	ItemID	V1	V2
80 55	84	02	1A	DCycle	KeepOn

Write Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3	V4
80 55	86	C0	00	02	1A	DCycle	KeepOn

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1	V2
80 55	84	04	1A	DCycle	KeepOn

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3	V4
80 55	86	C0	00	04	1A	DCycle	KeepOn

Figure 24: Receiver Duty Cycle Command and Response

Receiver Duty Cycle Fields

Field	Range	Description
DCycle	0 (default, constant receive) 1 - 255	The duty cycle interval between receiver turn-on points, seconds.
KeepOn	0 - 255	The keep on period, seconds (default = 0)

Figure 25: Receiver Duty Cycle Fields

When a non-zero duty cycle period is set, the RU turns on the receiver every duty cycle period. If a valid control packet is received, the RU keeps the receiver turned on while packets are being received. This is shown in Figure 26.

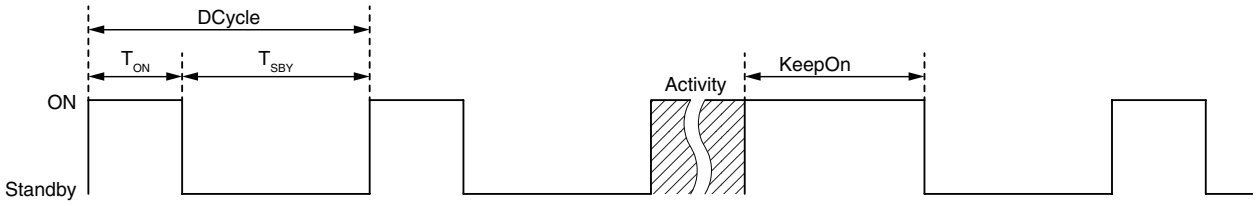

Figure 26: Receiver Duty Cycle

If RU activity occurs, the receiver stays on for at least KeepOn seconds after the last valid packet is received or data has been transmitted, allowing a quick response to successive controls or response transmissions. After KeepOn

seconds have elapsed with no valid activity, the receiver is turned off and the module resumes the duty cycle operation by going into a low power mode for DCycle seconds. KeepOn has no effect if DCycle = 0.

Receiver duty cycling is inactive during the Pair operation and transmission. Setting Control Source CWord bit 2 = 0 (receiver off) overrides receiver duty cycling. When the receiver is cycled off, the module responds immediately to a status line input going high.

The receiver average current consumption is given by the following:

$$I_{AVG} = \frac{(T_{ON} \times I_{RX}) + (T_{SBY} \times I_{SBY})}{DCycle}$$

Where
I_{AVG} = average current when duty cycling active (mA)
I_{RX} = receiver on current (mA)
I_{SBY} = receiver standby current (mA)
T_{ON} = receiver monitor duration (seconds)
T_{SBY} = duration in standby mode (seconds) = DCycle - T_{ON}

T_{ON} = 0.326s and is a fixed value. Approximate values with Vcc = 3.3V are:

I_{RX} = 18.7mA
I_{sby} = 0.151mA.

IO Lines - ItemID = 20

This parameter is the state of status lines and control lines.

IO Lines

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	20

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2
80 55	84	C1	20	Status	Control

Figure 27: IO Lines Command and Response

Status = Status lines, S0 - S7. S0 is the LSB.
Control = Control and output lines. The bits in this field represent the current logic state of the control input lines and the ACK_OUT and MODE_IND output lines. The bit definitions are in Figure 28.

Control Bit Definitions

Bit	Description
0	LATCH_EN
1	C0
2	C1
3	PAIR
4	ACK_EN
5	ACK_OUT
6	MODE_IND
7	Unused

Figure 28: Control Bit Definitions

RSSI - ItemID = 21

This read-only parameter is the signal strength of the last accepted packet and the current ambient level. The ambient power is read once per second when waiting for a control packet. Both values are initialized on reset to 80. Accurate results are limited to approximately –112dBm to –36dBm.

RSSI

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	21

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2
80 55	84	C1	21	LRSSI	CRSSI

Figure 29: RSSI Command and Response

LRSSI = RF power of the last accepted packet in dBm. This is a signed value.

CRSSI = Current ambient RF power on the current channel in dBm. This is a signed value.

LADJ - ItemID = 22

This read-only parameter is the voltage on the LADJ line. A separate voltage measurement is taken each time this item is read.

LADJ

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	22

Read Response

Prefix	PKT LGTH	Code	ItemID	V1
80 55	83	C1	22	LADJV

Figure 30: LADJ Command and Response

The formula to calculate the voltage on the LADJ line is:

V_{LADJ} = (LADJV / 256) * V_{CC}

Module Status - ItemID = 23

This item describes the current operating status of the module.

Module Status

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	23

Read Response

Prefix	PKT LGTH	Code	ItemID	V1	V2	V3	V4
80 55	86	C1	23	SFlag	TXP	SLM	LAM

Figure 31: Module Status Command and Response

Module Status Fields

Field	Bit	Description	
SFlag	0 – 2	Value	Operating Mode
		0	Idle
		1	Receiver Ready
		2	RU Cycle (receiving)
		3	IU Cycle (transmitting)
		4	Pairing process
		5 – 7	Reserved
	3	Reserved	
	4	ACK received during last IU transmission	
	5	AWD received during last IU transmission	
	6	0	
	7	Module interrupt flag (see Interrupt Mask)	
TXP	Currently selected transmit power level in dBm (signed byte)		
SLM	Current Status Line I/O Mask (set by the C0 and C1 lines or the Status Line I/O Mask, as determined by CWord.3)		
LAM	Current Latch Mask (set by the LATCH_EN line or the Latch Mask, as determined by CWord.4)		

Figure 32: Module Status Fields

SFlag.4 – This flag is reset when the module is reset and at the beginning of an IU session. It is set when an Acknowledge message is received in response to a control message during an IU session, otherwise it is unchanged.

SFlag.5 – This flag is reset when the module is reset and at the beginning of an IU session. It is set when an Acknowledge with Data message is received in response to a control message during an IU session, otherwise it is unchanged.

SFlag.7 – This flag is set when an Event Flags bit = 1 with a corresponding Interrupt Mask bit = 1.

Captured Receive Packet - ItemID = 24

This read-only item contains the last unread received control packet which was selected by the Message Select parameter and captured for serial output. The default selection type is off (no messages are captured).

Captured Receive Packet

Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	24

Response

Prefix	PKT LGTH	Code	ItemID	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
80 55	8C	C1	24	Class	RSSI	Type	ADR1	ADR2	ADR3	ADR4	Status	CData1	CData2

Figure 33: Captured Receive Packet Command and Response

Captured Receive Packet Fields

Field	Description	
Class	Bit	Description
	0	If set, the message is from a paired device
	1	If set, the RU session is active
RSSI	RSSI, the signal strength in dBm	
Type	Value	Packet Type
	1 or 2	Control (1) or terminating control (2) packet
	4	Acknowledge packet
	5	Acknowledge With Data packet
	6	Pair packet
ADRx	Four byte address of the transmitting unit	
Status	Status line settings of the transmitting unit	
CData1, 2	Two bytes of custom data transmitted with the command message	

Figure 34: Captured Receive Packet Fields

Reading this item has no effect on hardware-based operation and response.

Once a message is captured, no further messages are captured until this item is read by a serial command. Reading this item with no message is available returns a Read response with no data in the Value fields.

A break can be enabled on message capture by setting the Interrupt Mask bit 0 to 1.

Reading the Captured Receive Packet clears the received message buffer, so that no message is available through the serial interface until another selected packet is received.

As an example, the module gives the following response:

80 55 8C C1 24 03 C0 01 12 34 56 78 05 10 20

Class = 03 so the IU which sent the message is paired with the connected module and the session is currently active.

RSSI = C0, so the RSSI is –64dBm.

Type = 01, so the message is a control packet

ADRx = 12345678, which is the IU address.

Status = 05, so IU status lines S0 and S2 are high.

CData1, 2 = 10 and 20, which are the custom data values sent by the IU.

This item is useful when reading the packets directly rather than using the status line outputs to drive circuitry. An example is if a system needs more than 40 paired devices, then setting Message Select to 6 causes the module to accept any TT-compatible packet. When the Notify Event occurs, the Captured Receive Packet item can be used to pass the message to an external device with more memory to handle the address verification. The custom data bytes can also be used for further verification of the system or additional control.

Interrupt Mask - ItemID = 25

This item contains control bits that enable a break condition on CD_OUT (logic low for 2ms which can be interepeted as an interrupt to an external controller) when a selected event occurs. See interrupts and event notification for more details.

Interrupt Mask

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	25

Read Response

Prefix	PKT LGTH	Code	ItemID	V1
80 55	83	C1	25	IMask

Write Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	02	25	IMask

Write Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	02	25	IMask

Program Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	04	25	IMask

Program Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	04	25	IMask

Figure 35: Interrupt Mask Command and Response

The definitions for the Interrupt Mask bits are show in Figure 36. By default, no interrupts are set.

Interrupt Mask Definitions

Bit	Description
0	Selected message ready
1	Status input line change
2	Control input change
3	Operating mode change (module status)
4	TX packets sent
5 – 7	Not used, set to 0

Figure 36: Interrupt Mask Definitions

Event Flags - ItemID = 26

This item contains flags showing events which have occurred since the bit was cleared. These bits are set independently of the Interrupt Mask bits.

Event Flags

Read Command

Prefix	PKT LGTH	CMD	ItemID
80 55	82	01	26

Read Response

Prefix	PKT LGTH	Code	ItemID	V1
80 55	83	C1	26	EVFLG

Write Command

Prefix	PKT LGTH	CMD	ItemID	V1
80 55	83	02	26	EVFLG

Write Response

Prefix	PKT LGTH	Code	Error	V1	V2	V3
80 55	85	C0	00	02	26	EVFLG

Figure 37: Event Flags Command and Response

Bits are only set when module detects the corresponding change, regardless of the Interrupt Mask settings. If interrupts are not used, it is not necessary to clear the Event Flags.

Any bit in the EVFLG byte that is a 1 that has a corresponding bit in the IMask byte that is also a 1 indicates an unprocessed interrupt event.

Events are cleared by either reading the associated ItemID or writing a 0 to the bits to be cleared. Writing a 1 leaves the status unchanged.

Event flag 4 is set when all packets from a single transmit command have been sent. This aids in transmitting multiple packets with different data. This flag is cleared by sending a transmit command (CMD = 83, 84 or 85) rather than reading an ID.

Event Flag Definitions

Bit	Description	Resetting ItemID
0	Selected message ready	24 (Captured Receive Packet)
1	Status input line change	20 (IO Lines)
2	Control input change	20 (IO Lines)
3	Operating mode change	23 (Module Status)
4	TX packets sent	Write command 83, 84 or 85 (transmit commands)
5 – 7	Not used, set to 0	

Figure 38: Event Flag Definitions

Interrupts and Event Notifications

One of the advanced features offered by the module's serial interface is the ability to notify an external processor when an event has occurred. A Notify Event is an approximately 2ms pulse on the CD_OUT line. This condition is normally detected as a break condition or a null byte with a frame error by an external controller. The transceiver delays sending the Notify Event until any currently active message on CD_IN is finished and a reply is sent, plus an additional delay of at least 1.5ms.

The Interrupt Mask configuration parameter defines the interrupt conditions that generate a Notify Event. The external controller may read the Event Flags parameter to determine the type of condition, and read the appropriate parameters to get further details.

All interrupting conditions must be reset before the Notify Event can be generated again. Multiple interrupt conditions may be set. A Notify Event occurs when the first condition is met and does not occur again until after all interrupting event flags are cleared, even if subsequent interrupt conditions are met. If multiple events occur before the flags are cleared, the appropriate bits are set in the Event Flags parameter, but a Notify Event is not be generated.

The events may be cleared by writing a 0 to the associated event flag bits directly or by reading the associated parameter ItemIDs. Reading the resetting ItemID automatically clears the event flag. Clearing all the event flags resets the Module Interrupt Flag, enabling future Notify Events. The Module Interrupt Flag is set when any of the interrupt flags are set.

The state of the Module Interrupt Flag can be read with the Module Status parameter. This flag should be read to ensure that all events have been serviced. If the Module Interrupt Flag is set after clearing events, a new event has occurred and must also be cleared before another Notify Event can be generated.

By default the Interrupt Mask is set to 0, which disables Notify Events.

Please see the Interrupt Mask and Event Flag parameter descriptions for more information.

> Note: If the Interrupt Mask is non-zero, then floating inputs may cause a series of control line or status line change interrupts. Ensure that all inputs are set to supply or ground and are not floating.

Examples

The CDI can be used for many purposes.

Production Programming

The modules can be configured in production through the CDI rather than needing to manually set the hardware lines.

- Use the Status Line I/O Mask parameter to configure the status lines as either inputs or outputs.
- Use the Latch Mask parameter to set each status line as either latched or momentary.
- Use the Control Source parameter to set the hardware or software control of the inputs.

Dynamically Change Transmitter Output Power

The transmitter output power can be reduced to lower current consumption in instances where signal conditions are good and the full power level is not needed. An external microcontroller can compare the RSSI to a threshold and lower the power when the RSSI is above the threshold. Multiple thresholds can be set to correspond to multiple output power levels.

- Use the RSSI parameter to get the signal strength of the last received packet.
- Use the TX Power Level parameter to adjust the transmitter output power.

Add or Remove Specific Devices

In cases where a module in a system becomes lost or damaged and needs to be replaced, the new module can be programmed with the same address and paired devices as the old unit. This prevents the need for reprogramming all of the other devices in the system.

If a system is planned out, then all devices can be programmed rather than have to manually pair each device in the system with every other device.

The Permissions Mask is also set for each paired device, setting whether or not a specific paired device is authorized to control specific outputs.

- Use the Paired Unit Descriptor command to load addresses and Permissions Masks into the module.

Power Savings

When set as an IU only (all status lines are inputs) the module automatically goes into a low power state until a status line is activated or a command is received on the CMD_DATA_IN line. When configured as an RU (at least one status line is an output and no inputs are activated) the module defaults to receive mode looking for a command message. To conserve power, the receiver can be turned off indefinitely or duty cycling may be enabled. The expense is a longer response time to a command since no packets are received while the receiver is off.

- To turn off the receiver, use the Control Source parameter to set CWord bit 2 to a 0. Set the bit to a 1 to reactivate the receiver.

- Use the Receiver Duty Cycle parameter to set the duty cycle interval.

Output Received Messages

The control messages received by the module can be output by the CDI for further analysis by an external device. This can include logging the address of the IU for recording access attempts and monitoring the status line settings in the received packet instead of monitoring eight hardware lines. All valid messages can be output so that an external device with more memory can perform the address validation. This can expand the system beyond the 40 units that can be paired with each module.

- Use the Message Select parameter to set the type of messages to capture.

- Use the Interrupt Mask parameter to trigger an interrupt when the selected message is received.

- Use the Captured Receive Packet command to read the received packet.

Send Custom Data

Up to two bytes of custom data can be sent with each transmission and acknowledgement. This can include sensor data, battery voltage or additional command or verification data.

- Set Control Source CData1 and CData2 values to specify the custom data sent when an input status line initiates a transmission.

- Use the Transmit Control Data command to directly transmit status and custom data.

- Use the Transmit AWD command to send a custom response with data.

- Use the Message Select parameter to set the type of message to capture.

- Use the Interrupt Mask parameter to trigger an interrupt when the selected message is received.

- Use the Captured Receive Packet ItemID to read the received packet.

Trigger a Transmission

The CDI can be used to initiate transmission of control messages rather than using the hardware status lines.

- Use the Transmit Control Data command to trigger transmission of control messages.

Control Acknowledgements

The CDI can be used to control the acknowledgements transmitted in response to valid control messages rather than using the hardware ACK_EN line.

- Use the Transmit ACK command to initiate the transmission of acknowledge messages in response to qualified control messages.

- Use the Transmit AWD command to initiate the transmission of acknowledge messages in response to qualified control messages that include two bytes of custom data.

Set Interrupts

The module supports interrupts that trigger a pulse on the CMD_DATA_OUT line. This pulse is interpreted as a break condition by a connected microcontroller. Interrupts can be enabled for several types of events.

- Use the Interrupt Mask parameter to set the events that trigger an interrupt.

- Use the Event Flags parameter to view which event or events triggered the interrupt.

- Use the Module Status parameter to view the master Module Interrupt Flag (SFlag bit 7).

Read the Received Signal Strength

The module records the signal strength of each packet as it is received as well as the ambient RF level. This can be used to assess the link quality as well as the current RF environment.

- Use the RSSI parameter to read out the RSSI of the last valid packet and the current ambient level.

159 Ort Lane, Merlin, OR 97532
Phone: +1 541 471 6256
Fax: +1 541 471 6251
www.linxtechnologies.com