Linx TECHNOLOGIES

# TT Series
# Remote Control and Sensor Transceiver
# Data Guide

Wireless made simple®

**Warning:** Linx radio frequency ("RF") products may be used to control machinery or devices remotely, including machinery or devices that can cause death, bodily injuries, and/or property damage if improperly or inadvertently triggered, particularly in industrial settings or other applications implicating life-safety concerns. No Linx Technologies product is intended for use in any application without redundancies where the safety of life or property is at risk.

The customers and users of devices and machinery controlled with RF products must understand and must use all appropriate safety procedures in connection with the devices, including without limitation, using appropriate safety procedures to prevent inadvertent triggering by the user of the device and using appropriate security codes to prevent triggering of the remote controlled machine or device by users of other remote controllers.

**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 have a frequency hopping protocol built in, but the developer should still be aware of the risk of interference.

**Do not use any Linx product over the limits in this data guide.** Excessive voltage or extended operation at the maximum voltage could cause product failure. Exceeding the reflow temperature profile could cause product failure which is not immediately evident.

**Do not make any physical or electrical modifications to any Linx product.** This will void the warranty and regulatory and UL certifications and may cause product failure which is not immediately evident.

## Ordering Information

| Ordering Information | |
|---|---|
| **Part Number** | **Description** |
| TRM-900-TT | 900MHz TT Series Remote Control and Sensor Transceiver |
| TRM-900-TT-A | 900MHz Amplified TT Series Remote Control and Sensor Transceiver |
| EVM-900-TT | 900MHz TT Series Evaluation Module |
| EVM-900-TT-A | 900MHz Amplified TT Series Evaluation Module |
| EVAL-900-TT | TT Series Basic Evaluation Kit |
| EVAL-900-TT-A | Amplified TT Series Basic Evaluation Kit |
| MDEV-900-TT | TT Series Master Development System |
| MDEV-900-TT-A | Amplified TT Series Master Development System |
| Transceivers are supplied in tubes of 18 pcs. | |

Figure 2: Ordering Information

## Electrical Specifications

| TT Series Transceiver Specifications | | | | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Symbol** | **Min.** | **Typ.** | **Max.** | **Units** | **Notes** |
| Power Supply | | | | | | |
| Operating Voltage | $V_{CC}$ | 2.5 | | 5.5 | VDC | |
| Peak TX Supply Current | $I_{TX}$ | | | | | |
| TT @ +12.5dBm | | | 33.9 | 38.1 | mA | 1,2 |
| TT @ 0dBm | | | 15.2 | 18.9 | mA | 1,2 |
| TT-A @ +23.5dBm | | | TBD | | mA | 1,2 |
| TT-A @ 0dBm | | | TBD | | mA | 1,2 |
| Average TX Supply Current | | | | | | |
| TT @ +12.5dBm | | | 21.3 | | mA | 1,2 |
| TT-A @ +12.5dBm | | | TBD | | mA | 1,2 |
| RX Supply Current | $I_{RX}$ | | 18.8 | 23 | mA | 1,2 |
| Standby Current | $I_{SBY}$ | | 200 | | µA | 1,2 |
| Power-Down Current | $I_{PDN}$ | | | 0.1 | µA | 1,2 |

| TT Series Transceiver Specifications | | | | | | |
|---|---|---|---|---|---|---|
| Parameter | Symbol | Min. | Typ. | Max. | Units | Notes |
| Input | | | | | | |
| Logic Low | $V_{IL}$ | | | 0.8 | VDC | 9 |
| Logic Low | $V_{IL}$ | | | $V_{CC}$*0.15 | VDC | 10 |
| Logic High | $V_{IH}$ | 2 | | 5.5 | | 9 |
| Logic High | $V_{IH}$ | $V_{CC}$*0.25+0.8 | | 4.5 | VDC | 10 |
| Output | | | | | | |
| Logic Low | $V_{OL}$ | | | 0.6 | VDC | 11 |
| Logic High | $V_{OH}$ | $V_{CC}$–0.7 | | $V_{CC}$ | VDC | 12 |
| Certifications | | | | | | |
| Modular Certifications | FCC, Industry Canada | | | | | |

1. Measured at 3.3V $V_{CC}$
2. Measured at 25ºC
3. Guaranteed by design
4. Characterized but not tested
5. PER = 5%
6. Into a 50-ohm load
7. No RF interference
8. Response time is from end of command to start of response
9. $4.5 \leq V_{CC} \leq 5.5$
10. $V_{CC} \leq 4.5$
11. $I \leq 8mA$ @ $V_{CC} \geq 5V$; $I \leq 6mA$ @ $V_{CC} \geq 3.3V$; $I \leq 0.8mA$ @ $V_{CC} \geq 2.5V$
12. $I \leq 3.5mA$ @ $V_{CC} \geq 5V$; $I \leq 3mA$ @ $V_{CC} \geq 3.3V$; $I \leq 1mA$ @ $V_{CC} \geq 2.5V$
13. Maximum 80ms if $V_{CC} < 2.6V$

Figure 3: Electrical Specifications

## Absolute Maximum Ratings

| Absolute Maximum Ratings | | | | |
|---|---|---|---|---|
| Supply Voltage $V_{cc}$ | –0.3 | to | +5.5 | VDC |
| Any Input or Output Pin | –0.3 | to | $V_{CC}$ + 0.3 | VDC |
| RF Input | | 0 | | dBm |
| Operating Temperature | –40 | to | +85 | ºC |
| Storage Temperature | –55 | to | +125 | ºC |

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 4: Absolute Maximum Ratings

## TRM-xxx-TT Typical Performance Graphs

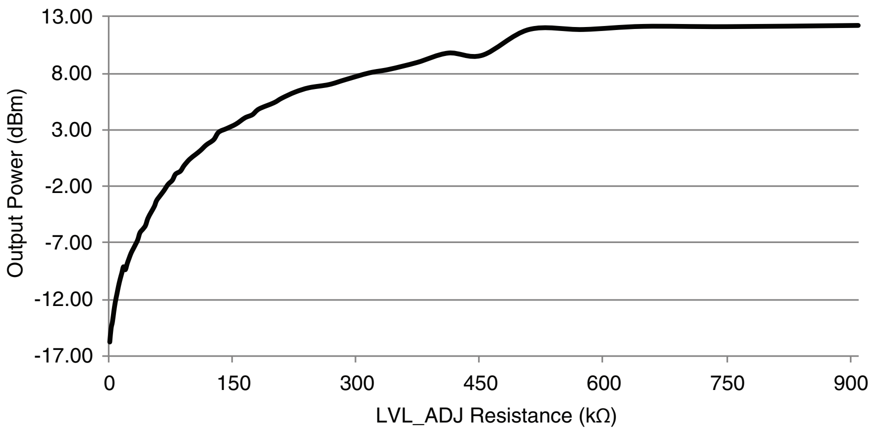


Figure 6: TT Series Transceiver Output Power vs. LVL_ADJ Resistance

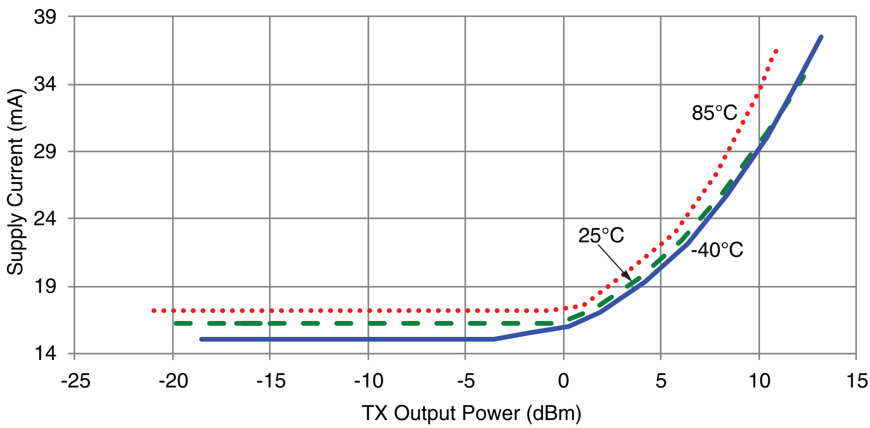


Figure 7: TT Series Transceiver Peak Current Consumption vs. Transmitter Output Power at 3.3V

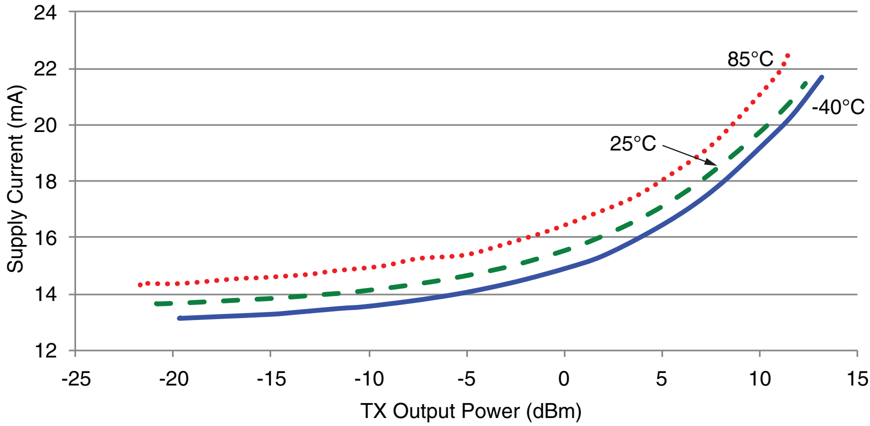


Figure 10: TT Series Transceiver Average Current Consumption vs. Transmitter Output Power at 5.5V

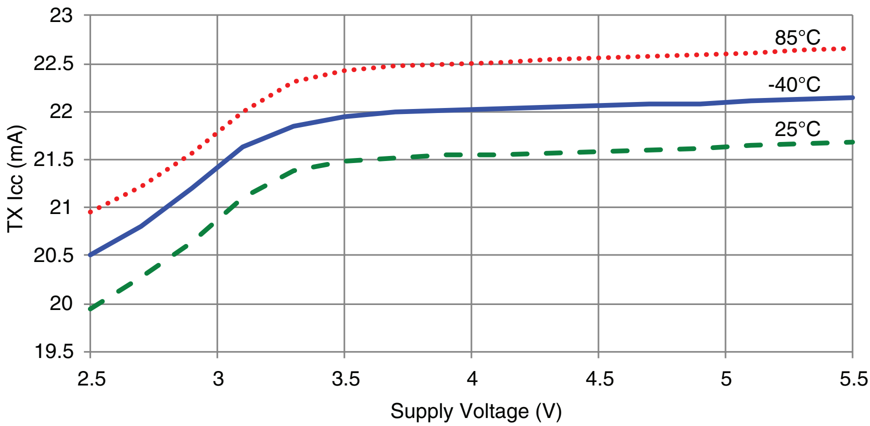


Figure 11: TT Series Transceiver TX Current Consumption vs. Supply Voltage at Max Power

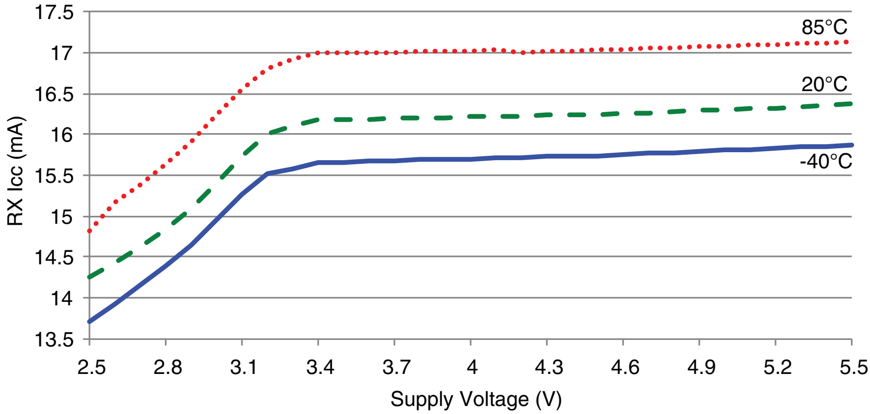


Figure 14: TT Series Transceiver RX Current Consumption vs. Supply Voltage

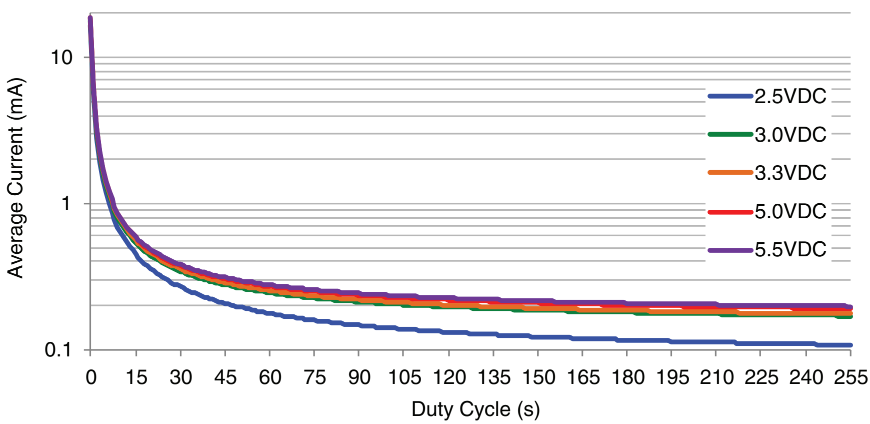


Figure 15: TT Series Transceiver Average RX Current Consumption vs. Duty Cycle

## Pin Assignments

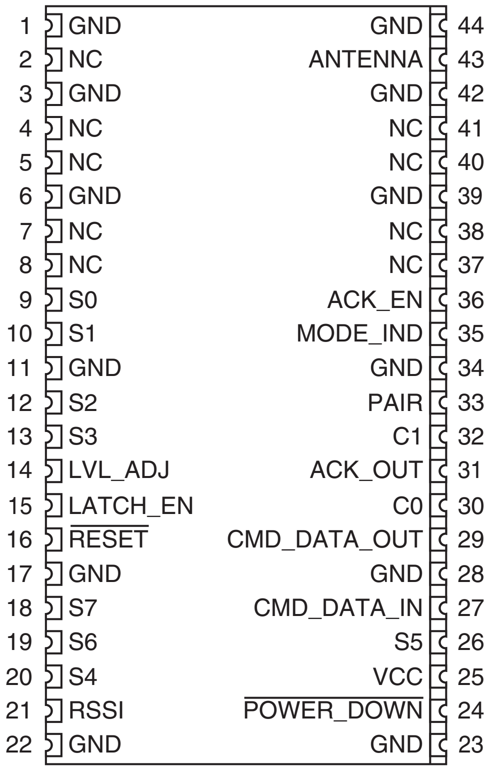


Figure 18: TT Series Transceiver Pin Assignments (Top View)

## Pin Descriptions

| Pin Descriptions | | | |
|---|---|---|---|
| **Pin Number** | **Name** | **I/O** | **Description** |
| 1, 3, 6, 11, 17, 22, 23, 28, 34, 39, 42, 44 | GND | — | Ground |
| 2, 4, 5, 7, 8, 37, 38, 40, 41 | NC | — | No Electrical Connection. Do not connect any traces to these lines. |
| 9, 10, 12, 13, 18, 19, 20, 26 | S0 - S7 | I/O | Status Lines. Each line can be configured as either an input to register button or contact closures or as an output to control application circuitry. |
| 14 | LVL_ADJ [1] | I | Level Adjust. This line sets the transmitter output power level. Pull high or leave open for the highest power; connect to GND through a resistor to lower the power. |

## Theory of Operation

The TT Series transceiver is a low-cost, high-performance synthesized FSK transceiver. Its exceptional sensitivity results in outstanding range performance. Figure 20 shows a block diagram for the module.

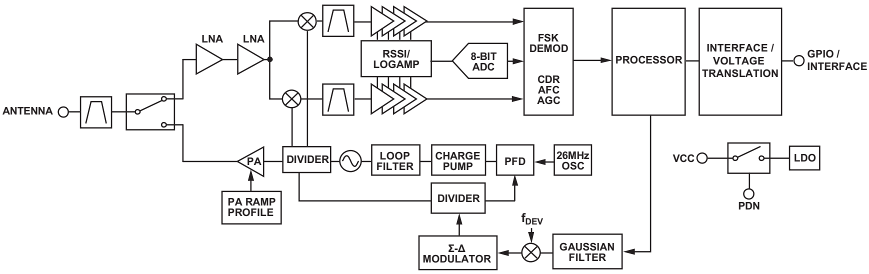


Figure 20: TT Series Transceiver RF Section Block Diagram

The TT Series transceiver is designed for operation in the 902 to 928MHz frequency band. The RF synthesizer contains a VCO and a low-noise fractional-N PLL. The VCO operates at twice the fundamental frequency to reduce spurious emissions. The receive and transmit synthesizers are integrated, enabling them to be automatically configured to achieve optimum phase noise, modulation quality and settling time.

The transmitter output power is programmable from –15.5dBm to +12.5dBm with automatic PA ramping to meet transient spurious specifications. The ramping and frequency deviation are optimized to deliver the highest performance over a wide range of data rates.

The receiver incorporates highly efficient low-noise amplifiers that provide up to –112dBm sensitivity. Advanced interference blocking makes the transceiver extremely robust when in the presence of interference.

A low-power onboard communications processor performs the radio control and management functions. A control processor performs the higher level functions and controls the serial and hardware interfaces. This block also includes voltage translation to allow the internal circuits to operate at a low voltage to conserve power while enabling the interface to operate over the full external voltage. This prevents hardware damage and communication errors due to voltage level differences.

While operation is recommended from 3.3V to 5.0V, the transceiver can operate down to 2.5V.

## Basic Hardware Operation

The following steps describe how to use the TT Series module with hardware only. Basic application circuits that correspond to these steps are shown in Figure 21.

1. Set the C0 and C1 lines opposite on both sides.

2. Press the PAIR button on both sides. The MODE_IND LED begins flashing slowly to indicate that the module is searching for another module.

3. Once the pairing is complete, the MODE_IND LED flashes quickly to indicate that the pairing was successful.

4. The modules are now paired and ready for normal use.

5. Pressing a status line button on one module (the IU) activates the corresponding status line output on the second module (the RU).

6. Taking the ACK_EN line high on the RU causes the module to send an acknowledgement to the IU. The ACK_OUT line on the IU goes high to indicate that the acknowledgement has been received. Tying the line to $V_{CC}$ causes the module to send an acknowledgement as soon as a command message is received.

This is suitable for basic remote control or command systems. No programming is necessary for basic hardware operation. The following sections describe the functions in more detail and the Typical Applications section shows additional example schematics for using the modules.

Sensor applications can replace the buttons with triggered outputs from sensors. A comparator circuit can be used to trigger a line when a sensor reading crosses a threshold, providing a warning or indication to a user.

The Command Data Interface section describes the more advanced features that are available with the serial interface.

## Transceiver Operation

The transceiver has two modes of operation: Initiating Unit (IU) that transmits control messages and Responding Unit (RU) that receives control messages. If all of the status lines are set as inputs, then the module is set as an IU only. The module stays in a low power sleep mode until a status line goes high, starting the Transmit Operation.

If all of the status lines are set as outputs, then the module is set as an RU only. It stays in Receive Operation looking for a valid transmission from a paired IU.

A module with both input and output status lines can operate as an IU and an RU. The module idles in Receive Operation until either a valid transmission is received or a status line input goes high, initiating the Transmit operation.

When an input goes high, the transceiver captures the logic state of each of the status lines. The line states are placed into a packet along with the local 32-bit address. The IU transmits the packets as it hops among 25 RF channels.

An RU receives the packet and checks its Paired Module List to see if the IU has been paired with the module and is authorized to control it. If the IU's address is not in the table, then the RU ignores the transmission. If the address is in the table, then the RU calculates the channel hopping pattern from the IU's address and sets its status line outputs according to the received packet. It then hops along with the IU and updates the states of its outputs with every packet. Its outputs can be connected to external circuitry that activates when the lines go high.

The RU can also send an acknowledgement back to the IU. Using the serial interface the RU can include up to two bytes of custom data with the acknowledgement, such as sensor data or battery voltage levels. Using the hardware control, if ACK_EN is high when a valid control packet is received, the module sends back a simple acknowledgement (ACK). It sends an Acknowledge with Data (AWD) response when custom data is programmed into the module using a serial command.

## The Pair Process

The Pair process enables two transceivers to communicate with each other. Each transceiver has a local 32-bit address that is transmitted with every packet. If the address in the received packet is not in the RU's Paired Module List, then the transceiver does not respond. Adding devices to the authorized list is accomplished through the Pair process or by a serial command. Each module can be paired with up to 40 other modules.

The Pair process is initiated by taking the PAIR line high on both units to be associated. Activation can either be a momentary pulse (less than two seconds) or a sustained high input, which can be used to extend the search and successful pairing display. With a momentary activation, the search is terminated after 30 seconds. If Pairing is started with a sustained high input, the search continues as long as the PAIR input is high.

When Pair is activated, the module displays the Pair Search sequence on the MODE_IND line (Figure 22) and goes into a search mode where it looks for another module that is also in search mode. It alternates between transmit and receive, enabling one unit to find the other and respond.

Once bidirectional communication is established, the two units store each other's addresses in their Paired Module List with full Permissions Mask and display the Pair Found sequence on their MODE_IND lines. The Pair Found sequence is displayed for at least 3 seconds. If the PAIR input is held high from the beginning of Pairing, the Pair Found display is shown for as long as PAIR is high.

When Pairing is initiated, the module pairs with the first unit it finds that is also in Pair Search. If multiple systems are being Paired in the same area, such as in a production environment, then steps should be taken to ensure that the correct units are paired with each other.

The Pair process can be canceled by taking PAIR high a second time.

If the address table is full when the PAIR line is raised, the Pair Error sequence is displayed on the MODE_IND line for 10 seconds and neither of the Pairing units will store an address. In this case, the module should either be reset to clear the address table or the serial interface can be used to remove addresses.

If a paired unit is already in the Paired Module List, then no additional entry is added though the existing entry's Permissions Mask may be modified.

## Mode Indicator

The Mode Indicator line (MODE_IND) provides feedback about the current state of the module. This line switches at different rates depending on the module's current operation. When an LED is connected to this line it blinks, providing a visual indication to the user. Figure 22 gives the definitions of the MODE_IND timings.

| MODE_IND Timing | |
|---|---|
| **Module Status** | **Display** |
| Transmit Mode | Solid ON when transmitting packets. |
| Receive Mode | Solid ON when receiving packets. |
| Pair Search | ON for 100ms, OFF for 900ms while searching for another unit during the Pair process |
| Pair Found | ON for 400ms, OFF for 100ms when the transceiver has been Paired with another transceiver. This is displayed for at least 3 seconds. |
| Pair Error | ON for 100ms, OFF for 100ms when the address table is full and another unit cannot be added. |
| Remote Pair Error | ON for 100ms, OFF for 100ms, ON for 100ms OFF for 300ms when the remote unit's address table is full and a Pair cannot be completed. |
| Pair Canceled | ON for 100ms, OFF for 200ms, ON for 100ms when the Pair process is canceled. |
| Reset Acknowledgement | ON for 600ms, OFF for 100ms, ON for 200ms, OFF for 100ms, ON for 200ms and OFF for 100ms when the reset sequence is recognized. |
| Extended Pair Completed | Solid ON when the pairing operation is completed and waiting for the PAIR line to go low. |

Figure 22: MODE_IND Timing

## Reset to Factory Default

The transceiver is reset to factory default by taking the Pair line high briefly 4 times, then holding Pair high for more than 3 seconds. Each brief interval must be high 0.1 to 2 seconds and low 0.1 to 2 seconds. (1 second nominal high / low cycle). The sequence helps prevent accidental resets. Once the sequence is recognized the MODE_IND line blinks the Reset Acknowledgement defined in Figure 22 until the PAIR line goes low. After the input goes low, the configuration is initialized. Factory reset also clears the Paired Module table but does not change the local address.

If the PAIR input timing doesn't match the reset sequence timing, the module reverts to normal operation without a reset or pairing.

## Using the Low Power Features

The Power Down ($\overline{\text{POWER\_DOWN}}$) line can be used to completely power down the transceiver module without the need for an external switch. This line allows easy control of the transceiver power state from external components, such as a microcontroller. The module is not functional while in power down mode.

> **Warning:** Pulling any of the module inputs high while in Power Down can partially activate the module, increasing current consumption and potentially placing it into an indeterminate state that could lead to unpredictable operation. Pull all inputs low before pulling $\overline{\text{POWER\_DOWN}}$ low to prevent this issue. Lines that may be hardwired (for example, the ACK_EN line) can be connected to the $\overline{\text{POWER\_DOWN}}$ line so that they are lowered when $\overline{\text{POWER\_DOWN}}$ is lowered.

## Using the LVL_ADJ Line

The Level Adjust (LVL_ADJ) line allows the transceiver's output power to be easily adjusted for range control or lower power consumption. This is done by placing a resistor to ground on LVL_ADJ to form a voltage divider with an internal 100kΩ resistor. When the transceiver powers up, the voltage on this line is measured and the output power level is set accordingly. When LVL_ADJ is connected to $V_{CC}$ or floating, the output power and current consumption are the highest. When connected to ground, the output power and current are the lowest. The power is digitally controlled in 58 steps providing approximately 0.5dB per step. See the Typical Performance Graphs section (Figure 6) for a graph of the output power vs. LVL_ADJ resistance.

> **Warning:** The LVL_ADJ line uses a resistor divider to create a voltage that determines the output power. Any additional current sourcing or sinking can change this voltage and result in a different power level. The power level should be checked to confirm that it is set as expected.

Even in designs where attenuation is not anticipated, it is a good idea to place resistor pads connected to LVL_ADJ and ground so that it can be used if needed. Figure 23 shows the 1% tolerance resistor value that is needed to set each power level and gives the approximate output power for each level. The output power levels are approximate and may vary part-to-part.

## Receiver Duty Cycle

The module can be configured to automatically power on and off while in receive mode. Instead of being powered on all the time looking for transmissions from an IU, the receiver can wake up, look for data and go back to sleep for a configurable amount of time. If it wakes up and receives valid data, then it stays on and goes back to sleep when the data stops. This significantly reduces the amount of current consumed by the receiver. It also increases the time from activating the IU to getting a response from the RU.

The duty cycle is controlled by the Duty Cycle serial command through the Command Data Interface. DCycle sets the number of seconds between receiver turn on points as shown in Figure 24.

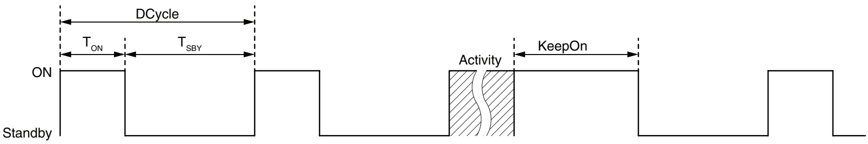


Figure 24: Receiver Duty Cycle

The module's average current consumption can be calculated with the following equation.

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

Figure 25: Receiver Duty Cycle Average Current Consumption Equation

$T_{ON}$ is fixed at about 0.326 seconds and $T_{SBY}$ = DCycle - $T_{ON}$. The receiver current ($I_{RX}$) and standby current ($I_{SBY}$) vary with supply voltage, but some typical values are in Figure 26.

**TT Series Typical Current Consumption**

| $V_{CC}$ (VDC) | 2.5 | 3.0 | 3.3 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 |
|---|---|---|---|---|---|---|---|---|
| $I_{RX}$ (mA) | 16.5 | 17.8 | 18.7 | 18.8 | 18.8 | 18.9 | 18.9 | 18.9 |
| $I_{SBY}$ (mA) | 0.0862 | 0.1471 | 0.1509 | 0.1525 | 0.1569 | 0.1616 | 0.1669 | 0.1737 |

Figure 26: TT Series Transceiver Typical Current Consumption

Figure 15 shows a graph of the average current consumption vs. duty cycle for several supply voltages. This graph shows that the average current

## The Command Data Interface

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 for fewer connections in applications controlled by a microcontroller as well as for more control and advanced features than can be offered through hardware pins alone.

The serial port uses the CMD_DATA_IN and CMD_DATA_OUT lines as a UART. An automatic baud rate detection system allows the interface to run at a variable data rate from 9.6kbps to 57.6kbps.

The Command Data Interface has two sets of operators. One is a set of commands that performs specific tasks and the other is a set of parameters that are for module configuration and status reporting. These are shown in Figure 28.

TT Series Transceiver Command Data Interface Reference Guide has full details on each command. Some key features available with the serial interface are:

- Configure the module through software instead of setting the hardware lines.
- Change the output power, providing the ability to lower power consumption when signal levels are good and extend battery life.
- Individually set which status lines are inputs and outputs.
- Individually set status line outputs to operate as momentary or latched.
- Add or remove specific paired devices.
- Individually set Permission Masks that prevent certain paired devices from activating certain status line outputs.
- Change the module's local address for production or tracking purposes or to replace a lost or broken product.
- Put the module into a low power state to conserve battery power.

| Command Data Interface Commands and Parameters | |
|---|---|
| **Command** | **Description** |
| Read | Read the current value in volatile memory. If there is no volatile value, then the non-volatile value is returned. |
| Write | Write a new value to volatile memory. |
| Read NV | Read the value in non-volatile memory. |
| Program | Program a new value to non-volatile memory. |
| Set Default Configuration | Set all configuration items to their factory default values. |
| Erase All Addresses | Erase all paired addresses from memory. |
| Transmit Control Data | Transmit a control message. |
| Transmit ACK | Transmit an acknowledgement for received data. |
| Transmit AWD | Transmit an Acknowledge With Data (AWD) response with two bytes of custom data. |
| **Parameter** | **Description** |
| Device Name | NULL-terminated string of up to 16 characters that identifies the module. Read only. |
| Firmware Version | 3 byte firmware version. Read only. |
| Serial Number | 4 byte factory-set serial number. Read only. |
| Local Address | The module's 32-bit local address. |
| Status Line I/O Mask | Status lines direction (1 = Inputs, 0 = Outputs), LSB = S0, used when enabled by Control Source |
| Latch Mask | Latching enable for output lines, LSB = S0, used when enabled by Control Source |
| TX Power Level | TX output power, signed nominal dBm, used when enabled by Control Source |
| Control Source | Configures the control options. |
| Message Select | Select message types to capture for serial readout. |
| Paired Module Descriptor | Sets the index number, address and permissions mask of paired modules. |
| Duty Cycle | Receiver duty cycle control |
| I/O Lines | Read the current state of the status and control lines. |
| RSSI | Read the RSSI of the last packet received and ambient level. Read only. |
| LADJ | Read the voltage on the LVL_ADJ line. Read only. |
| Module Status | Read the operating status of the module. |
| Captured Receive Packet | Read the last received packet. Read only. |
| Interrupt Mask | Sets the mask for events to generate a break on CMD_DATA_OUT. |
| Event Flags | Event flags that are used with the Interrupt Mask. |

Figure 28: TT Series Transceiver Command Data Interface Commands and Parameters

## Usage Guidelines for FCC Compliance

The TT Series module is provided with an FCC and Industry Canada Modular Certification. This certification shows that the module meets the requirements of FCC Part 15 and Industry Canada license-exempt RSS standards for an intentional radiator. The integrator does not need to conduct any further testing under these rules provided that the following guidelines are met:

- An approved antenna must be directly coupled to the module's U.FL connector through an approved coaxial extension cable.
- Alternate antennas can be used, but may require the integrator to perform certification testing.
- The module must not be modified in any way. Coupling of external circuitry must not bypass the provided connectors.
- End product must be externally labeled with "Contains FCC ID: OJMTRM900TTA / IC: 5840A-TRM900TTA".
- The end product's user's manual must contain an FCC statement equivalent to that listed on page 33 of this data guide.
- The antenna used for this transceiver must not be co-located or operating in conjunction with any other antenna or transmitter.
- The integrator must not provide any information to the end-user on how to install or remove the module from the end-product.

> Note: The integrator is required to perform unintentional radiator testing on the final product per FCC sections 15.107 and 15.109 and IC RSS-GEN.

Any changes or modifications not expressly approved by Linx Technologies could void the user's authority to operate the equipment.

## Additional Testing Requirements

The modules have been tested for compliance as an intentional radiator, but the integrator is required to perform unintentional radiator testing on the final product per FCC sections 15.107 and 15.109 and Industry Canada license-exempt RSS standards. Additional product-specific testing might be required. Please contact the FCC or Industry Canada regarding regulatory requirements for the application. Ultimately is it the integrator's responsibility to show that their product complies with the regulations applicable to their product.

## Product Labeling

The end product must be labeled to meet the FCC and IC product label requirements. It must have the below or similar text:

Contains FCC ID: OJMTRM900TTA / IC: 5840A-TRM900TTA

The label must be permanently affixed to the product and readily visible to the user. “Permanently affixed” means that the label is etched, engraved, stamped, silkscreened, indelibly printed, or otherwise permanently marked on a permanently attached part of the equipment or on a nameplate of metal, plastic, or other material fastened to the equipment by welding, riveting, or a permanent adhesive. The label must be designed to last the expected lifetime of the equipment in the environment in which the equipment may be operated and must not be readily detachable.

## FCC RF Exposure Statement

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

## Antenna Selection

Under FCC and Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by the FCC and Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

The TRM-900-TT radio transmitter has been approved by the FCC and Industry Canada to operate with the antenna types listed in Figure 30 with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Conformément à la réglementation d’Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d’un type et d’un gain maximal (ou inférieur) approuvé pour l’émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l’intention des autres utilisateurs, il faut choisir le type d’antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l’intensité nécessaire à l’établissement d’une communication satisfaisante.

## Typical Applications

Figure 31 and Figure 32 show circuits using the TT Series transceiver.

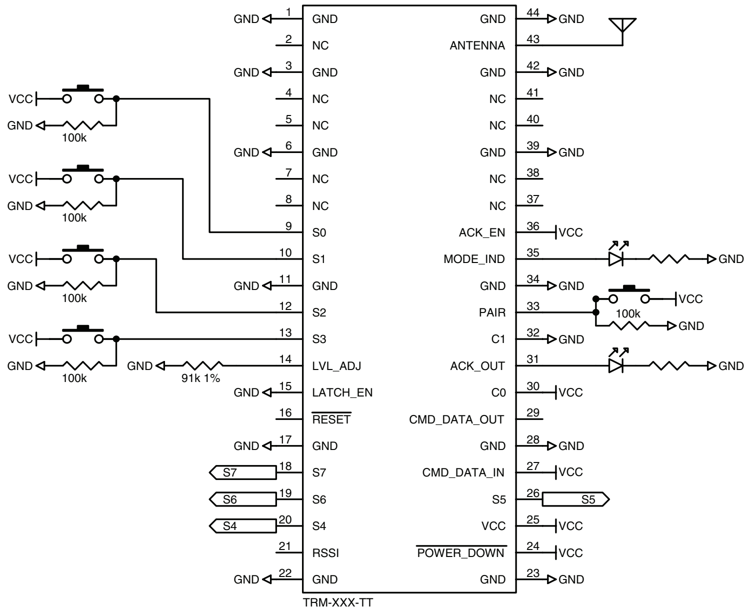


Figure 31: TT Series Transceiver Basic Application Circuit

In this example, C0 is high and C1 is low, so S0–S3 are inputs and S4–S7 are outputs. The inputs are connected to buttons that pull the lines high and weak pull-down resistors to keep the lines from floating when the buttons are not pressed. The outputs would be connected to external application circuitry.

LATCH_EN is low, so the outputs are momentary.

The Command Data Interface is not used in this design, so CMD_DATA_IN is tied high and CMD_DATA_OUT is not connected.

ACK_OUT and MODE_IND are connected to LEDs to provide visual indication to the user.

PAIR is connected to a button and pull-down resistor to initiate the Pair Process when the button is pressed.

ACK_EN is tied high so the module sends acknowledgements as soon as it receives a control message.

## Antenna Considerations

Figure 33: Linx Antennas

The choice of antennas is a critical and often overlooked design consideration. The range, performance and legality of an RF link are critically dependent upon the antenna. While adequate antenna performance can often be obtained by trial and error methods, antenna design and matching is a complex task. Professionally designed antennas such as those from Linx (Figure 33) help ensure maximum performance and FCC and other regulatory compliance.

Linx transmitter modules typically have an output power that is higher than the legal limits. This allows the designer to use an inefficient antenna such as a loop trace or helical to meet size, cost or cosmetic requirements and still achieve full legal output power for maximum range. If an efficient antenna is used, then some attenuation of the output power will likely be needed. This can easily be accomplished by using the LVL_ADJ line.

It is usually best to utilize a basic quarter-wave whip until your prototype product is operating satisfactorily. Other antennas can then be evaluated based on the cost, size and cosmetic requirements of the product. Additional details are in Application Note AN-00500.

The transceiver includes a U.FL connector as well as a line for the antenna connection. This offers the designer a great deal of flexibility in antenna selection and location within the end product. Linx offers cable assemblies with a U.FL connector on one end and several types of standard and FCC-compliant reverse-polarity connectors on the other end. Alternatively, the designer may wish to use the pin and route the antenna to a PCB mount connector or even a printed loop trace antenna. This gives the designer the greatest ability to optimize performance and cost within the design.

> Note: Either the connector or the line can be used for the antenna, but not both at the same time.

## Interference Considerations

The RF spectrum is crowded and the potential for conflict with unwanted sources of RF is very real. While all RF products are at risk from interference, its effects can be minimized by better understanding its characteristics.

Interference may come from internal or external sources. The first step is to eliminate interference from noise sources on the board. This means paying careful attention to layout, grounding, filtering and bypassing in order to eliminate all radiated and conducted interference paths. For many products, this is straightforward; however, products containing components such as switching power supplies, motors, crystals and other potential sources of noise must be approached with care. Comparing your own design with a Linx evaluation board can help to determine if and at what level design-specific interference is present.

External interference can manifest itself in a variety of ways. Low-level interference produces noise and hashing on the output and reduces the link's overall range.

High-level interference is caused by nearby products sharing the same frequency or from near-band high-power devices. It can even come from your own products if more than one transmitter is active in the same area. It is important to remember that only one transmitter at a time can occupy a frequency, regardless of the coding of the transmitted signal. This type of interference is less common than those mentioned previously, but in severe cases it can prevent all useful function of the affected device.

Although technically not interference, multipath is also a factor to be understood. Multipath is a term used to refer to the signal cancellation effects that occur when RF waves arrive at the receiver in different phase relationships. This effect is a particularly significant factor in interior environments where objects provide many different signal reflection paths. Multipath cancellation results in lowered signal levels at the receiver and shorter useful distances for the link.

Do not route PCB traces directly under the module. There should not be any copper or traces under the module on the same layer as the module, just bare PCB. The underside of the module has traces and vias that could short or couple to traces on the product's circuit board.

The Pad Layout section shows a typical PCB footprint for the module. A ground plane (as large and uninterrupted as possible) should be placed on a lower layer of your PC board opposite the module. This plane is essential for creating a low impedance return for ground and consistent stripline performance.

Use care in routing the RF trace between the module and the antenna or connector. Keep the trace as short as possible. Do not pass it under the module or any other component. Do not route the antenna trace on multiple PCB layers as vias add inductance. Vias are acceptable for tying together ground layers and component grounds and should be used in multiples.

Each of the module's ground pins should have short traces tying immediately to the ground plane through a via.

Bypass caps should be low ESR ceramic types and located directly adjacent to the pin they are serving.

A 50-ohm coax should be used for connection to an external antenna. A 50-ohm transmission line, such as a microstrip, stripline or coplanar waveguide should be used for routing RF on the PCB. The Microstrip Details section provides additional information.

In some instances, a designer may wish to encapsulate or "pot" the product. There are a wide variety of potting compounds with varying dielectric properties. Since such compounds can considerably impact RF performance and the ability to rework or service the product, it is the responsibility of the designer to evaluate and qualify the impact and suitability of such materials.

## Production Guidelines

The module is housed in a hybrid SMD package that supports hand and automated assembly techniques. Since the modules contain discrete components internally, the assembly procedures are critical to ensuring the reliable function of the modules. The following procedures should be reviewed with and practiced by all assembly personnel.

## Hand Assembly

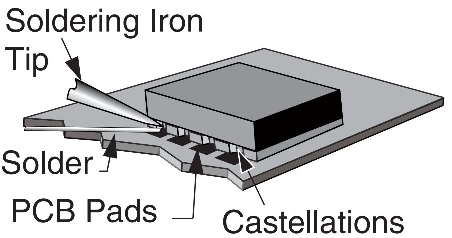

Figure 38: Soldering Technique

Pads located on the bottom of the module are the primary mounting surface (Figure 38). Since these pads are inaccessible during mounting, castellations that run up the side of the module have been provided to facilitate solder wicking to the module's underside. This allows for very quick hand soldering for prototyping and small volume production. If the recommended pad guidelines have been followed, the pads will protrude slightly past the edge of the module. Use a fine soldering tip to heat the board pad and the castellation, then introduce solder to the pad at the module's edge. The solder will wick underneath the module, providing reliable attachment. Tack one module corner first and then work around the device, taking care not to exceed the times in Figure 39.

**Warning:** Pay attention to the absolute maximum solder times.

| **Absolute Maximum Solder Times** |
|---|
| Hand Solder Temperature: +427ºC for 10 seconds for lead-free alloys |
| Reflow Oven: +255ºC max (see Figure 40) |

Figure 39: Absolute Maximum Solder Times

## Automated Assembly

For high-volume assembly, the modules are generally auto-placed. The modules have been designed to maintain compatibility with reflow processing techniques; however, due to their hybrid nature, certain aspects of the assembly process are far more critical than for other component types. Following are brief discussions of the three primary areas where caution must be observed.

## General Antenna Rules

The following general rules should help in maximizing antenna performance.

1. Proximity to objects such as a user's hand, body or metal objects will cause an antenna to detune. For this reason, the antenna shaft and tip should be positioned as far away from such objects as possible.

2. Optimum performance is obtained from a ¼- or ½-wave straight whip mounted at a right angle to the ground plane (Figure 41). In many cases, this isn't desirable for practical or ergonomic reasons, thus, an alternative antenna style such as a helical, loop or patch may be utilized and the corresponding sacrifice in performance accepted.

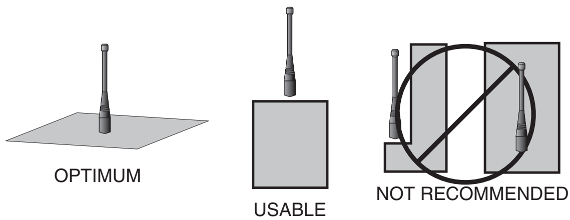


Figure 41: Ground Plane Orientation

3. If an internal antenna is to be used, keep it away from other metal components, particularly large items like transformers, batteries, PCB tracks and ground planes. In many cases, the space around the antenna is as important as the antenna itself. Objects in close proximity to the antenna can cause direct detuning, while those farther away will alter the antenna's symmetry.

4. In many antenna designs, particularly ¼-wave whips, the ground plane acts as a counterpoise, forming, in essence, a ½-wave dipole (Figure 42). For this reason, adequate ground plane area is essential. The ground plane can be a metal case or ground-fill areas on a circuit board. Ideally, it should have a surface area less than or equal to the overall length of the ¼-wave radiating element. This is often not practical due to size and configuration constraints. In these instances, a designer must make the best use of the area available to create as much ground

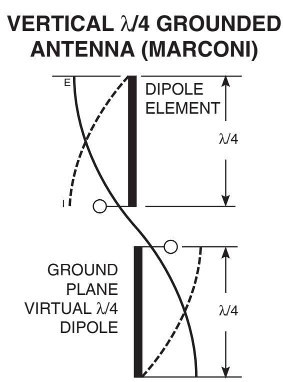


Figure 42: Dipole Antenna

## Common Antenna Styles

There are hundreds of antenna styles and variations that can be employed with Linx RF modules. Following is a brief discussion of the styles most commonly utilized. Additional antenna information can be found in Linx Application Notes AN-00100, AN-00140, AN-00500 and AN-00501. Linx antennas and connectors offer outstanding performance at a low price.

### Whip Style

A whip style antenna (Figure 44) provides outstanding overall performance and stability. A low-cost whip can be easily fabricated from a wire or rod, but most designers opt for the consistent performance and cosmetic appeal of a professionally-made model. To meet this need, Linx offers a wide variety of straight and reduced height whip style antennas in permanent and connectorized mounting styles.

Figure 44: Whip Style Antennas

The wavelength of the operational frequency determines an antenna's overall length. Since a full wavelength is often quite long, a partial ½- or ¼-wave antenna is normally employed. Its size and natural radiation resistance make it well matched to Linx modules. The proper length for a straight ¼-wave can be easily determined using the formula in Figure 45. It is also possible to reduce the overall height of the antenna by using a helical winding. This reduces the antenna's bandwidth but is a great way to minimize the antenna's physical size for compact applications. This also means that the physical appearance is not always an indicator of the antenna's frequency.

$$L = \frac{234}{F_{MHz}}$$

Figure 45:
L = length in feet of quarter-wave length
F = operating frequency in megahertz

### Specialty Styles

Linx offers a wide variety of specialized antenna styles (Figure 46). Many of these styles utilize helical elements to reduce the overall antenna size while maintaining reasonable performance. A helical antenna's bandwidth is often quite narrow and the antenna can detune in proximity to other objects, so care must be exercised in layout and placement.

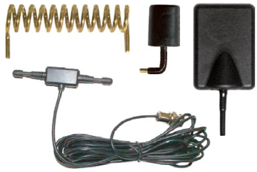

Figure 46: Specialty Style Antennas

## Regulatory Considerations

Note: Linx RF modules are designed as component devices that require external components to function. The purchaser understands that additional approvals may be required prior to the sale or operation of the device, and agrees to utilize the component in keeping with all laws governing its use in the country of operation.

When working with RF, a clear distinction must be made between what is technically possible and what is legally acceptable in the country where operation is intended. Many manufacturers have avoided incorporating RF into their products as a result of uncertainty and even fear of the approval and certification process. Here at Linx, our desire is not only to expedite the design process, but also to assist you in achieving a clear idea of what is involved in obtaining the necessary approvals to legally market a completed product.

For information about regulatory approval, read AN-00142 on the Linx website or call Linx. Linx designs products with worldwide regulatory approval in mind.

In the United States, the approval process is actually quite straightforward. The regulations governing RF devices and the enforcement of them are the responsibility of the Federal Communications Commission (FCC). The regulations are contained in Title 47 of the United States Code of Federal Regulations (CFR). Title 47 is made up of numerous volumes; however, all regulations applicable to this module are contained in Volume 0-19. It is strongly recommended that a copy be obtained from the FCC's website, the Government Printing Office in Washington or from your local government bookstore. Excerpts of applicable sections are included with Linx evaluation kits or may be obtained from the Linx Technologies website, www.linxtechnologies.com. In brief, these rules require that any device that intentionally radiates RF energy be approved, that is, tested for compliance and issued a unique identification number. This is a relatively painless process. Final compliance testing is performed by one of the many independent testing laboratories across the country. Many labs can also provide other certifications that the product may require at the same time, such as UL, CLASS A / B, etc. Once the completed product has passed, an ID number is issued that is to be clearly placed on each product manufactured.

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