# Miniature Smart RF Transceiver

## Features

- Intelligent Wire replacement SMARTRADIO
- form factor:  16mm x 18mm
- 2Km range
- Transmit Power +13dBm
- High sensitivity -116dBm (@ 2.4kbps)
- Max data rate @ 500Kbps
- Simple UART and SPI interface
- Best in Class cost performance
- Available as 433/868/915MHz
- 1.8V  – 3.6V Operating Voltage
- Low power consumption
  - 0.5nA Standby
  - 10mA Rx
  - 18mA Tx @ 10dBm
- 64 byte Buffer (FIFO)
- Integrated battery voltage sensor
- Based on Silicon Labs' Si4455 chipset
- No configuration necessary
- No external components
- Fast and effective Plug and Play RF Comms



## Applications

- Home automation
- Sensor / mesh RF networks
- Telemetry
- Keyless entry
- Health monitors
- RF Data comms

## Applications

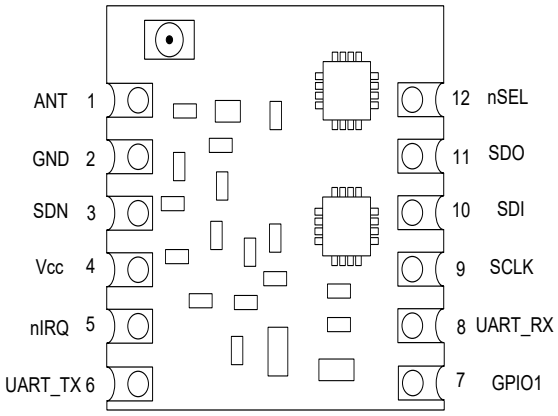
The ZETAPLUS Smart Module is a plug and play Radio Communications module with simple SPI and UART (LV RS232) interface.

With only a few connections to  power, comms and antenna, the user can quickly start sending and receiving data. No other external components are required.

With a highly tuned on-board RF matching network ZETAPLUS outperforms other modules achieving range far in excess of its competitors for the given power output/power consumption.

Additional features, include a 64-byte TX/RX FIFOs, preamble detection, sync word detector, and CRC are all automatically handled, reducing current consumption and allow for the use of lower-cost system MCUs.  The ZETAPLUS also gives access to the integrated auxiliary 11-bit ADC used for the internal battery voltage detector making low battery detect very simple to implement on your design.

## Pin Description

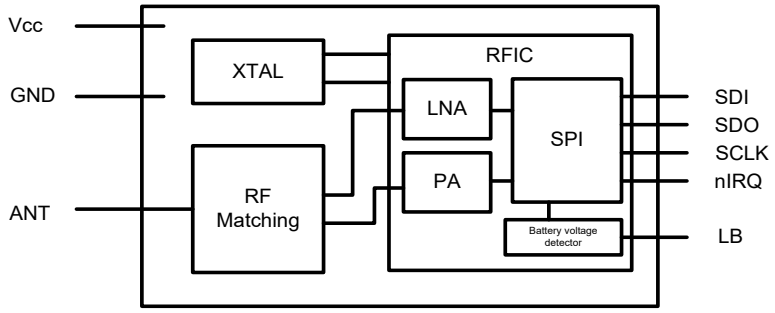



| PIN | Definition | Type | Function |
|---|---|---|---|
| 1 | Antenna Pin | In/Out | Antenna pin connection.<br>Keep short and match to 50phms for best performance |
| 2 | GND | In | Ground connection |
| 3 | Shutdown | Active high | The shutdown state is the lowest current consumption state of the device and is entered by driving SDN high. In this state, all register contents are lost and there is no SPI access. Drive low to exit |
| 4 | Vcc | In | Power connection |
| 5 | Interrupt | Output | Active Low<br>Interrupt Status Output – Read interrupt status for event details<br>E.g. The FIFO on the ZETAPLUS module contains data |
| 6 | UART_TX | Out | RS232 Transmit pin |
| 7 | GPIO1 | In / Out | General Purpose I/O can be configured by Si4455 to provide additional function |
| 8 | UART_RX | In | RS232 Receive Pin |
| 9 | Serial clock | In | Serial Clock Input (0 – VDD V): Provides serial data clock for 4-line serial data bus |
| 10 | Serial data In | In | Serial Data Input (0 – VDD V): Serial data stream input for 4-line serial data bus |
| 11 | Serial data Out | Out | Serial Data Output (0 – VDD V) |
| 12 | Serial interface select | In | Serial Interface Select Input (0 – VDD V): Provides select/enable function for 4-line serial data bus. |

## Ordering information

| Part Number | Description |
|---|---|
| ZETAPLUS-433-SO | FM transceiver module, 433MHz (marked Red Dot) SMT |
| ZETAPLUS-433-D | FM transceiver module, 433MHz (marked Red Dot) DIP |
| ZETAPLUS-868-SO | FM transceiver module, 868MHz (marked Blue Dot) SMT |
| ZETAPLUS-868-D | FM transceiver module, 868MHz (marked Blue Dot) DIP |
| ZETAPLUS-915-SO | FM transceiver module 915MHz (marked Yellow Dot) SMT |
| ZETAPLUS-915-D | FM transceiver module 915MHz (marked Yellow Dot) DIP |

## Block Diagram



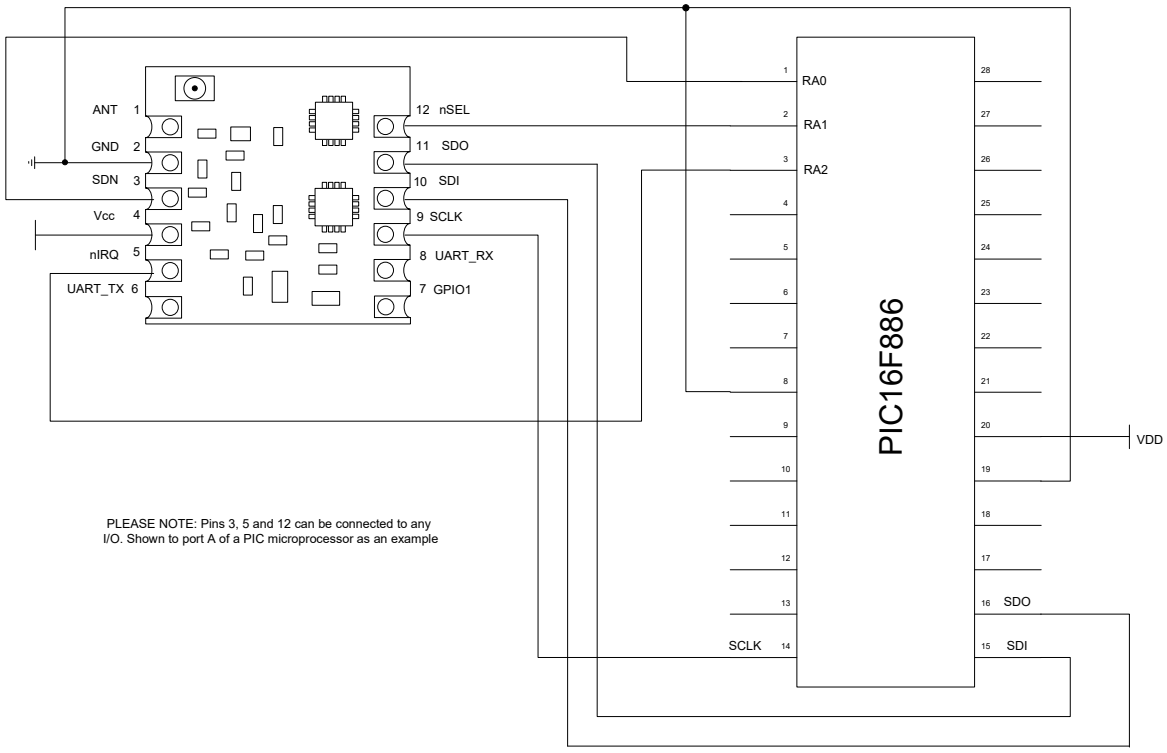

## Application notes

Communication with ZETAPLUS module can be via SPI interface or UART (LVTTL). For transmission using SPI load the correct decimal byte values into the SPI TX register. When a byte is received using SPI the nIRQ line will be pulled low, this shows that data will be ready to be read from the SPI register.

Using the UART (LVTTL) load the correct decimal byte values into the UART TX register, this will be sent to the ZETAPLUS via it's RX pin. When data is received by a ZETAPLUS the module will output the data through the TX pin of the module to the RX pin of the controlling device (microprocessor) where this can be read.

## SPI Command Set and Interface

## Application schematic- ZETAPLUS and PIC16F886




## Mode selection:

| Command for MODE select: ATM 1-3 | | |
|---|---|---|
| Command | Name | Description |
| 1 | RX | The command enters RX mode using whichever settings were last configured using the #R command below. |
| 2 | Ready | Ready is a low power wake state which can be used for fast entry to RX or switching between TX and RX. Time to RX or TX from READY <1ms |
| 3 | Sleep | Low power sleep mode with register retention. |

| Command | A | T | M | 1 |
|---|---|---|---|---|
| Decimal byte value | 65 | 84 | 77 | 1 |

Example: Place the codec in receive mode
Note: alternative possible example of mode select for some terminal programs: ATM#001.

## Receive mode:

| Command for RECEIVER select: ATR CHANNEL, PACKET LENGTH | | |
|---|---|---|
| Command | Name | Description |
| 0-15 | CHANNEL | Set in 250KHz increments starting at (FREQ dependent):<br>At 433MHz: 0=433.92<br>At 868MHz: 0=869.50<br>At 915MHz: 0=915 |
| 1-65 | PACKET LENGTH | Length of data packet to be sent in 8 bit bytes |

Example: Enter receiver mode on channel 2 with a packet length of 10 (8 bit) bytes.

| ommand | A | T | R | 2 | 10 |
|---|---|---|---|---|---|
| Decimal byte value | 65 | 84 | 82 | 2 | 10 |

## Transmit mode

| Command for Transmit Mode: ATS CHANNEL, PACKET LENGTH, DATA | | |
|---|---|---|
| Command | Name | Description |
| 0-15 | Channel | Set in 250KHz increments starting at (FREQ dependent):<br>At 433MHz: 0=433.92<br>At 868MHz: 0=869.50<br>At 915MHz: 0=915 |
| 1-64 | Packet length | The length of the data packet to follow. In 8 bit bytes. |
| | Data | Your data to be transmitted. |

| Command | A | T | S | 2 | 13 | DATA |
|---|---|---|---|---|---|---|
| Decimal byte value | 65 | 84 | 83 | 2 | 13 | Your 13 bytes |

## Sync bytes / addressing

| Configure module sync bytes: Command: ATA SYNC1, SYNC2, SYNC3, SYNC4 | | |
|---|---|---|
| Command | Name | Description |
| 1-4 | SYNC1-4 | Sent sync bytes 1-4.<br>The sync bytes appear directly after the pre-amble in data packet and can be used as a form of addressing to discriminate between required and spurious data. Set these bytes and the module will then only pass on data which contains the correct sync bytes configuration. Set all to AA if not required.<br>NOTE: Reverse order bytes: ie 2D = D4, D4 =2B |

Example: Set the sync bytes to 12 34 56 78

| Command | A | T | A | 12 | 34 | 56 | 78 |
|---|---|---|---|---|---|---|---|
| Decimal byte value | 65 | 84 | 65 | 12 | 34 | 56 | 78 |

## RF Baud Rate

| Configure the RF baud rate: Command: ATB 0-19<br>Note SDN must be toggled high/low for setting to take affect and can take up to 15ms to complete. | | |
|---|---|---|
| Command | Name | Description |
| 1-19 | Baud rate | GFSK RF baud rates in kbps<br>1=4.8 kbps<br>2=9.6 kbps<br>3=38.4 kbps<br>4=128.0 kbps<br>5=256.0 kbps<br>6=500.0 kbps |

Example: Set the RF baud rate to 500kbps GFSK:

| Command | A | T | B | 6 |
|---|---|---|---|---|
| Decimal byte value | 65 | 84 | 66 | 6 |

## RF Output Power

| Configure the RF power output: Command: ATP 1-127 | | |
|---|---|---|
| Command | Name | Description |
| 1-127 | Power output | Power output in increments from 1-127 |

Example: Set the power outputs to 32:

| Command | A | T | P | 15 |
|---|---|---|---|---|
| ASCII | 65 | 84 | 80 | 32 |

## NOTE

*"SI4455 o/p power as defined in the datasheet:-*
*The PA circuitry in the chip contains an output device whose size may be adjusted by enabling/disabling different numbers of device fingers. Selection of a higher value results in an increase in TX output power.*
*The relationship between output power and the number of enabled device fingers is not necessarily linear, and is dependent upon the PA mode of operation (e.g., Class-E or Switched Current), the duty cycle of the drive signal to the output circuit, the VDD supply voltage, and the output match. As a result, there is no simple formula to relate the setting of the PA_PWR_LVL property to an absolute value of output power in dBm.*
*The adjustment resolution of the TX output power is very fine (step size < 0.1 dB) when operating near the maximum power setting, but becomes coarser as the output power level is reduced."*

## Communication with the ZETAPLUS via SPI interface.

Maximum SPI data rate: 1.4Mhz

Data is sent over the SPI bus on the ZETAPLUS codec in standard SPI format using the correct command set. A 50ms timeout exists to avoid lock-up if not all requested data bytes are sent - in this scenario the packet would be aborted and no data sent.

When in receive mode and an RF packet is received the U_IRQ pin will go low indicating SPI data is ready to be read.

The following two pages show example timing diagrams for the SPI bus communication.

## Selecting preferred communication method.

Only one communication method can be used at a time and priority is set by the last access method.

For example if you enable receive mode via SPI it will revert to SPI communication from there on unless you access the device via UART it will then revert to UART communication only from then on.




Above is the first byte of SPI data following U_IRQ going low after an RF packet has been received.

Sequence:-

1. IRQ goes low indicating a packet has been received.
2. Read byte over SPI bus.
3. If IRQ remains low then more data is still available to read. Goto 2.

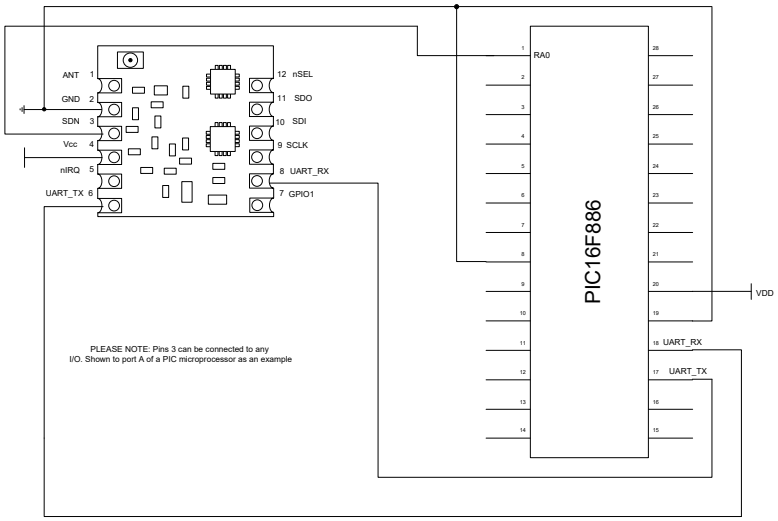
The first two bytes read should be #R followed by the packet length & RSSI value then the packet data.




Above is the complete SPI & IRQ Timing diagram for #R<RSSI> <Packet > plus 12 byte data packet

## UART Application

## Application schematic- ZETAPLUS and PIC16F886




## UART command set

**UART configuration:**
Baud rate: 19200, Data bits: 8, Parity: none, Stop bits: 1

Note all UART I/O are at Low level and must not exceed 5V.

**UART in**
Data is sent to the RX pin on the ZETAPLUS n standard UART format using the correct command set. A 50ms timeout exists to avoid lock-up if not all requested data bytes are sent - in this scenario the packet would be aborted and no data sent.

**UART out**
Data is output from the TX pin on the ZETAPLUS.

When in receive mode and an RF packet is received the data packet is automatically send over the UART.

### Firmware Version

| Use this command to check which firmware version of the ZETAPLUS-PLUS you are using. | | |
|---|---|---|
| Command | Name | Description |
| N/A | Firmware Version | Example reply:<br><br># V 1 . 0 0<br>EXAMPLE 35 86 31 46 30 30 |

Example: Check firmware version

| Command | A | T | V |
|---|---|---|---|
| Decimal byte value | 65 | 84 | 86 |

## Retrieve Configuration and

| Use this command to check the current settings of the device | | |
|---|---|---|
| Command | Name | Description |
| N/A | Configuration and settings | Example reply:<br><br>#? FOLLOWED BY 8 BYTE AS BELOW<br>OPERATING MODE (MODE:- 1= RX 2=READY)<br>RF BAUD RATE (1-19 AS PER DS)<br>RF POWER OP (1-127)<br>SYNC BYTE 1<br>SYNC BYTE 2<br>SYNC BYTE 3<br>SYNC BYTE 4<br>CHANNEL NUMBER (0-15 AS PER DS)<br><br>EXAMPLE 35 63 1 1 127 45 210 0 0 0 |

Example: Retrieve settings

| Command | A | T | ? |
|---|---|---|---|
| Decimal byte value | 65 | 84 | 63 |

## RSSI

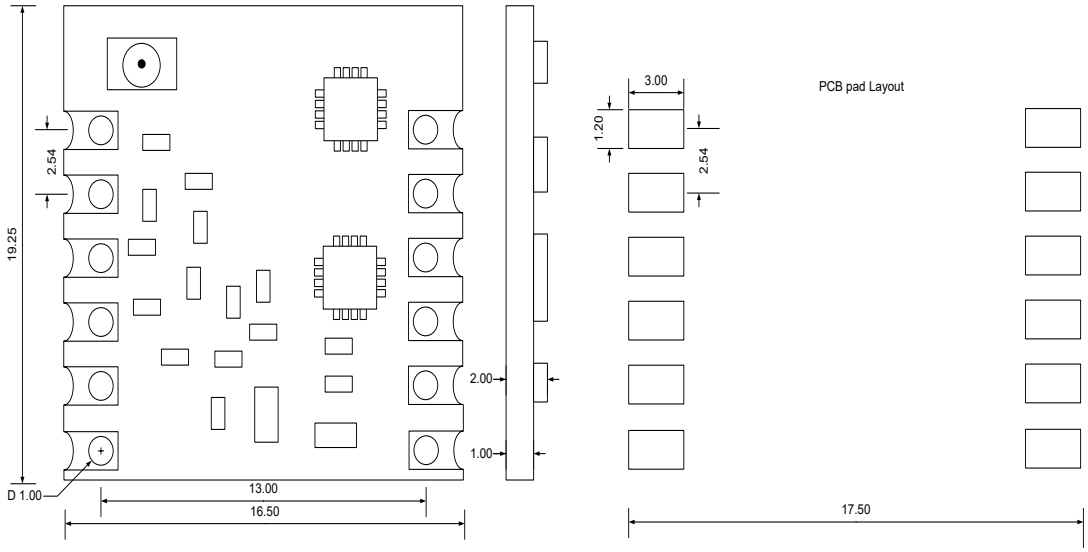
| Use this command to retrieve the RSSI value | | |
|---|---|---|
| Command | Name | Description |
| N/A | RSSI | Example reply:<br><br>#Q FOLLOWED BY ONE BYTE RSSI VALUE (0-255)<br><br>EXAMPLE 35 81 56 |

Example: Retrieve settings

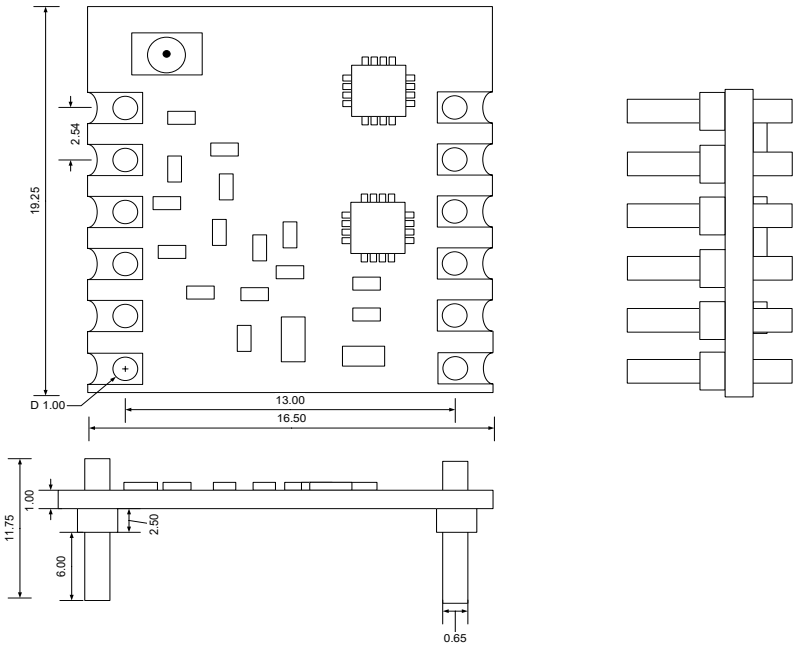
| Command | A | T | ? |
|---|---|---|---|
| Decimal byte value | 65 | 84 | 63 |

## Mechanical dimensions

### Surface Mount Package




### P-DIP Package



# 1. Electrical Specifications

## Recommended operating conditions

| Parameter | Symbol | Test condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Ambient Temperature | $T_A$ | | -40 | 25 | 85 | °C |
| Supply Voltage | $V_{DD}$ | | 1.8 | | 3.6 | V |
| I/O Drive Voltage | $V_{GPIO}$ | | 1.8 | | 3.6 | V |

## DC characteristics

| Parameter | Symbol | Test condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Supply voltage range | $V_{DD}$ | | 1.8 | 3.3 | 3.6 | V |
| Power saving modes | $I_{Shutdown}$ | RC oscillator, main digital regulator, and low power digital regulator OFF. | – | 30 | – | nA |
| | $I_{Standby}$ | Register values maintained. | – | 50 | – | nA |
| | $I_{Ready}$ | Crystal oscillator and main digital regulator ON, all other blocks OFF. | – | 2 | – | mA |
| | ISPI Active | SPI active state | | 1.35 | | mA |
| TUNE mode current | $I_{Tune_RX}$ | RX tune | – | 6.5 | – | mA |
| | $I_{Tune_TX}$ | TX tune | – | 6.9 | – | mA |
| RX mode current | $I_{RX}$ | | – | 10 | – | mA |
| TX mode current | $I_{TX}$ | +10 dBm output power, 868 MHz | – | 18 | – | mA |
| | | +13 dBm output power, 868 MHz | – | 30 | – | mA |

## Synthesiser AC electrical characteristics

| Parameter | Symbol | Test condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Synthesizer frequency Range | $F_{SYN}$ | | 860 | – | 869 | MHz |
| Synthesizer frequency Resolution | $F_{RES\ 868}$ | 850–870 MHz | – | 114.4 | – | Hz |

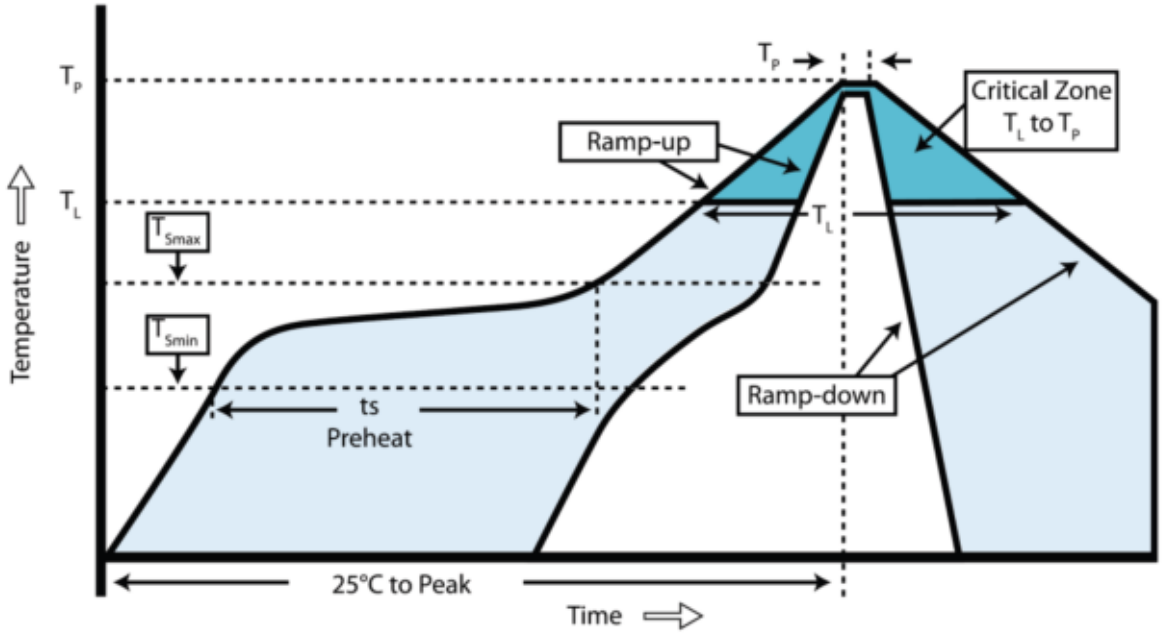
Transmitter AC electrical characteristics

| Parameter | Symbol | Test condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| TX frequency range | $F_{TX}$ | | 850 | – | 870 | MHz |
| (G)FSK data rate | $DR_{FSK}$ | | 1.0 | – | 500 | kbps |
| OOK data rate | $DR_{OOK}$ | | 0.5 | – | 120 | kbps |
| Modulation deviation range | $Df_{960}$ | 850–870 MHz | – | – | 500 | kHz |
| Modulation deviation resolution | $FRES_{960}$ | 850-870 MHz | – | 114.4 | – | Hz |
| Output power range | $P_{TX}$ | | -40 | – | +13 | dBm |
| TX RF output steps | DP | Using switched current match within 6 dB of max power | – | 0.1 | – | dB |
| TX RF output level variation vs. temperature | $DP_{RF_TEMP}$ | -40 to +85 °C | – | 1 | – | dB |
| TX RF output level Variation vs. frequency | $DP_{RF_FREQ}$ | Measured across 850-870 MHz | – | 0.5 | – | dB |
| Transmit modulation filtering | B*T | Gaussian filtering bandwidth time product | – | 0.5 | – | |
| Spurious emissions | $P_{OB\ TX1}$ | $P_{OUT}$ = +13 dBm, Frequencies < 1 GHz | – | -54 | – | dBm |
| | $P_{OB\ TX2}$ | 1–12.75 GHz, excluding harmonics | – | -42 | – | dBm |
| Harmonics | $P2_{HARM}$ | Using reference design TX matching network and filter with max output power. Harmonics reduce linearly with output power. | – | -42 | – | dBm |
| | $P3_{HARM}$ | | – | -42 | – | dBm |

Receiver AC electrical characteristics

| Parameter | Symbol | Test condition | Min | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| RX frequency range | $F_{RX}$ | | 850 | — | 870 | MHz |
| RX sensitivity | $P_{RX_2}$ | (BER < 0.1%) (2.4 kbps, GFSK, BT = 0.5, DF = ±30 kHz, 114 kHz Rx BW) | — | −116 | — | dBm |
| | $P_{RX_40}$ | (BER < 0.1%) (40 kbps, GFSK, BT = 0.5, DF = ±25 kHz, 114 kHz Rx BW) | — | −108 | — | dBm |
| | $P_{RX_128}$ | (BER < 0.1%) (128 kbps, GFSK, BT = 0.5, DF = ±70 kHz, 305 kHz Rx BW) | — | −103 | — | dBm |
| | $P_{RX_OOK}$ | (BER < 0.1%, 1 kbps, 185 kHz Rx BW, OOK, PN15 data) | — | −113 | — | dBm |
| | | (BER < 0.1%, 40 kbps, 185 kHz Rx BW, OOK, PN15 data) | — | −102 | — | dBm |
| RX channel bandwidth | BW | | 40 | — | 850 | kHz |
| BER variation vs power Level[2] | $P_{RX_RES}$ | Up to +5 dBm Input Level | — | 0 | 0.1 | ppm |
| RSSI resolution | $RES_{RSSI}$ | | — | ±0.5 | — | dB |
| ±1-Ch offset selectivity | $C/I_{1\,CH}$ | Desired Ref Signal 3 dB above sensitivity, BER < 0.1%. Interferer is CW and desired modulated with 1.2 kbps, DF = 5.2 kHz, GFSK with BT= 0.5, RX BW = 58 kHz channel spacing = 100 kHz | — | −56 | — | dB |
| ±2-Ch offset selectivity | $C/I_{2\,CH}$ | | — | −59 | — | dB |
| Blocking 200 kHz–1 MHz | $200K_{BLOCK}$ | Desired ref signal 3 dB above sensitivity, BER < 0.1%. Interferer is CW and desired modulated with 1.2 kbps DF = 5.2 kHz GFSK with BT = 0.5, RX BW = 58 kHz | — | −58 | — | dB |
| Blocking 1 MHz offset | $1M_{BLOCK}$ | | — | −61 | — | dB |
| Blocking 8 MHz offset | $8M_{BLOCK}$ | | — | −79 | — | dB |
| Image rejection | $Im_{REJ}$ | Rejection at the image frequency IF = 468 kHz | — | −35 | — | dB |
| Spurious emissions | $P_{OB_RX1}$ | Measured at RX pins | — | −54 | — | dBm |

## ZETAPLUS module re-flow guide




ZETAPLUS MODULE is a 2 layer PCB, re-flow is based on IPC/JEDEC JSTD020C July 2004

| Profile feature | Value (lead free) |
|---|---|
| Ramp up rate | 3°C /s |
| Pre-heat temperature<br>- Temperature Min ($T_{Smin}$)<br>- Temperature Max ($T_{smax}$)<br>- Pre-heat time | <br>150°C<br>200°C<br>60-100s |
| Peak temperature ($T_P$) | 240°C |
| Time at $T_P$ | 10-20sec |
| Ramp down rate | 6°C/s |
| Time from 25°C to peak | 8 mins max. |

# ZETAPLUS Smart RF Transceiver

## Range Test

Two Transceiver boards were built using simple prototyping board and a host PIC microcontroller . One board was programmed as a transmitter to send a beacon signal at 1 second interval. The other board was programmed as receiver which acknowledged the received signal back to the transmitter thus creating a ping-pong test set.

A simple piece of wire was used as antenna for both boards

Prototyping board and wire as antenna is not ideal, but many real applications are often a compromise!



Our Range Testing was conducted from Ditchling Beacon providing an open Line of Sight Test.

1. The Transmitter was placed Receiver was mounted on the back of a pick up truck and the receiver was carried by hand ~5ft from the ground .
2. As the receiver travelled away from the transmitter Line of sight was occasionally lost when we went in the shadow of a hill, at this time the RF signal was intermittent, A Reliable signal in Line of sight was observed to 2.4K range, thereafter we couldn't go any further as the pathway stopped.. At this range in L.O.S the signal was 100% reliable.





Test conditions

- $T_A$ = +18 °C
- $V_{DD}$= +3.3 Vdc
- Dry, Broken Sunshine, Relative Humidity 45%

Result:

The test achieve a maximum range of 2.4km after this point the terrain dropped away and a line of sight was completely lost, it is possible that the module may have achieved a longer range.

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