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WTX3D/RX3D

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Frequency Programmable FM UHF Transmitter/Receiver

The WTX3D and RX3D data radio modules are PLL synthesiser-based frequency programmable miniature PCB mounting UHF radio transmitter and receiver pair which enable the simple implementation of a wireless data link at up to 64 kbps at distances up to 75 metres in-building and 300 metres open ground.
Unlike legacy crystal-controlled TX/RX modules, the frequency programmable feature enables WTX3D/RX3D to be offered in number of custom frequencies within a given SAW filter band without requiring long lead time or MOQ.

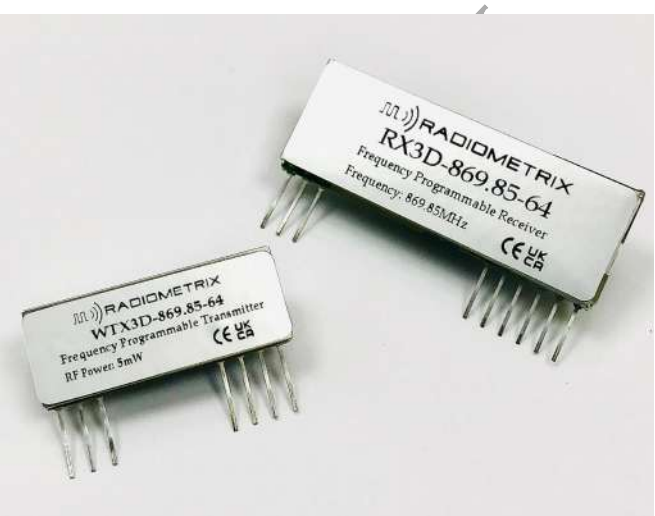

Fig 3: WTX3D-869.85-64 & RXD-868.85-65

Features

- Conforms to European ETSI EN 301 489-3 and EN 300 220-2 (ERP @ 5mW and @ 25mW)
- North American version conforms to FCC part 15.249
- Data rates: up to 10kbps or 64kbps
- SAW front end filter and full screening
- 869.85MHz and 868.30 MHz (EU) or 914.50MHz (North America) as standard

Technical Summary

Transmitter - WTX3D

- Crystal-locked PLL, FM modulated at up to 64 Kbps
- Supply: 2.9V - 16V @ 18mA TX (5mW), 39mA TX (25mW)
- +7dBm on WTX3D, +14dBm on WTX3DH
- Improved frequency accuracy

Receiver - RX3D

- SAW front end filter gives >55dB image rejection
- Supply: 2.9V - 16V @ 15mA
- Receiver Sensitivity: -111dBm for 12dB SINAD @64kbps,
  -113dBm for 12dB SINAD @10kbps
- Received Signal Strength Indicator (RSSI)
- Analogue and digital baseband outputs

Applications

- Industrial or Commercial Telemetry and Telecommand
- Wireless Queue Management System
- Wheel Balancing
- Sports Scoreboard Display
- Security and fire alarms
- Wireless Battery Monitor.

***Evaluation platforms**: Universal Evaluation Kit, NBEK + SIL carrier*

WTX3D transmitter

Functional overview

The WTX3D transmitter consists of a frequency modulated crystal locked PLL feeding a LC match and RF filter. An Enable pin controls operation. The transmitter achieves full RF output typically within 2ms of this line being pulled low. Modulation is applied at the TXD input and may be either a serial digital stream toggling between 0V and 3V (digital drive) or a high level of ac coupled analogue waveform up to 1.7V peak-to-peak (linear drive). Modulation shaping is performed internally by a 2nd order lowpass filter, which minimises spectral spreading.

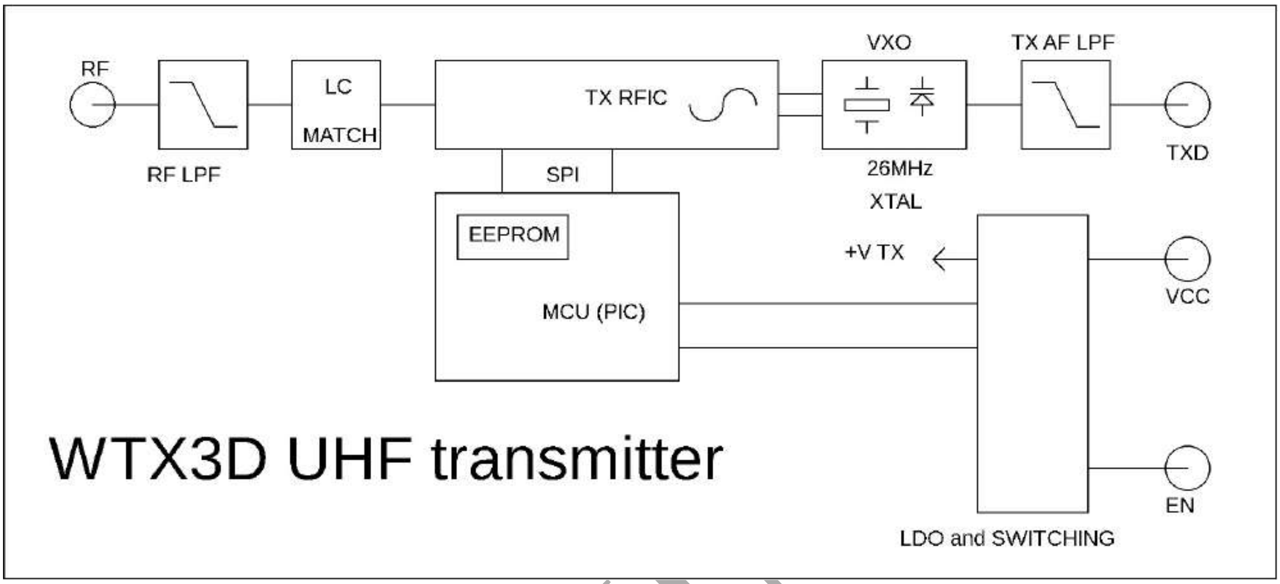

Fig. 2: WTX3D block diagram

Pin description:

RF GND *(pins 1 & 3)*
*R*F ground, internally connected to the module screen and pin 6 (0V). These pins should be directly connected to the RF return path - e.g. coax braid, main PCB ground plane etc.

RF OUT *(pin 2)*
50Ω RF output to the antenna. Internally DC-isolated. See antenna section of apps notes for details of suitable antennas.

En *(pin 4)*
Tx enable. <0.15V shuts down module (current <1µA). >1.7V enables the transmitter. Impedance ~1MΩ. Observe slew rate requirements (see apps notes).

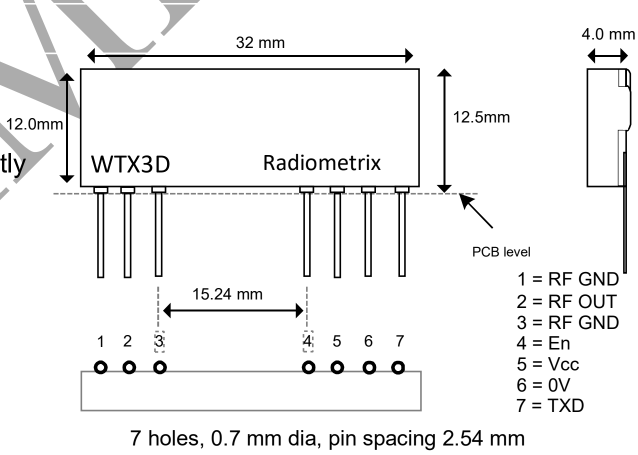

Fig 3: WTX3D Dimension and Pinout

Vcc *(pin 5)*
DC +ve supply pin. +2.9 to +16.0 volts. The supply should be clean, <20mVpp ripple.

0V *(pin 6)*
DC supply ground. Internally connected to pins 1 & 3 and module screen.

TXD *(pin 7)*
This DC-coupled transmitter modulation input will accept either serial digital data or high level linear signals. Drive signal must be limited to 0V min, 3V max. See page 6 for suggested drive methods. Input impedance >50kΩ.

RX3D receiver

Functional overview

The RX3D receiver is a single conversion FM superhet with an IF of 10.7MHz. A SAW bandpass filter in the receiver front-end provides image rejection and suppression of other unwanted out-of-band signals. Like the transmitter, the receiver is controlled by its own active low RX select line. A post-detection lowpass filter establishes the signal bandwidth and ensures clean operation of the subsequent adaptive data slicer. The slicer is optimised for balanced data such as bi-phase code. A received signal strength (RSSI) output with 60dB of range is provided.

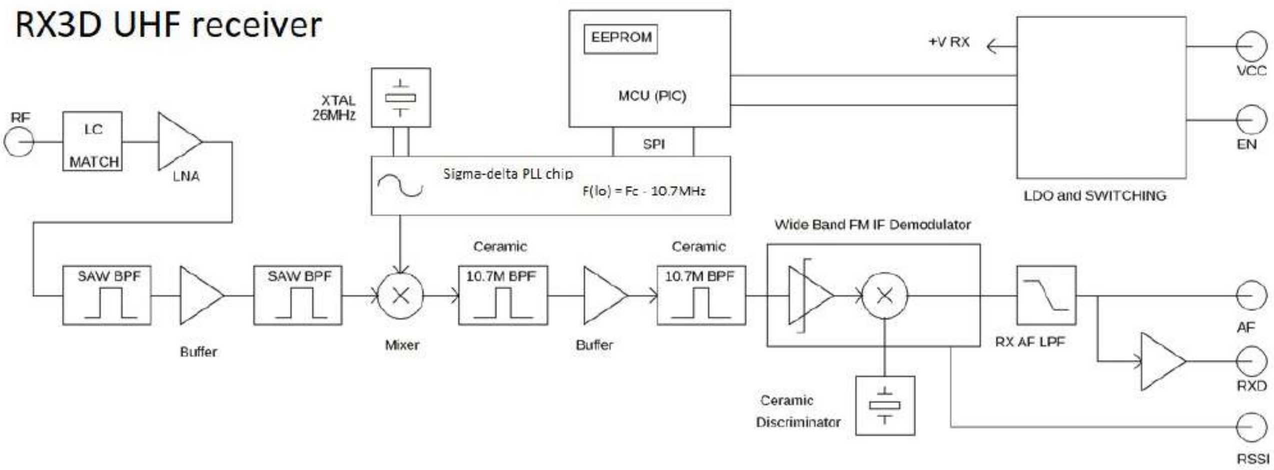

Fig. 4: Block diagram

Pin description

Antenna *pin 1*

50Ω RF connection to the antenna, DC-isolated.

RF GND *pins 2 & 3*

RF ground pins, internally connected to the module screen and to pin 6 (0V). These pins should be connected directly to the RF return path (e.g. coax braid, main PCB ground plane etc).

EN (Enable pin version) *pin 4*

Active high RX enable pin

<0.5V shuts down module (current <3uA). >2V enables

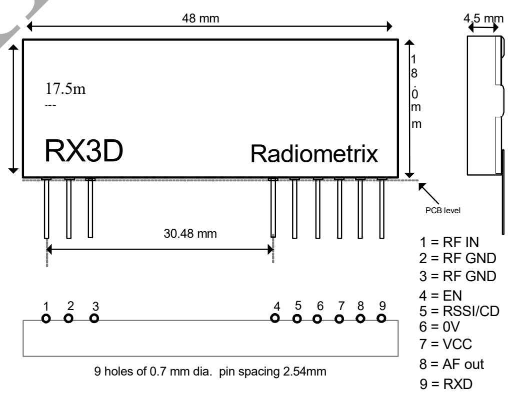

Fig. 5: Physical dimensions (Weight: 7g typ.)

RSSI *pin 5*

Received Signal Strength Indicator with 60dB range, operational when Rx is enabled. Output voltage nominally 200mV (no RF signal), 1.25V (maximum). See page.4 for typical characteristics.

0V (GND) *pins 6*

Supply ground connection and screen.

Vcc *pin 7*

DC +ve supply pin. +2.9 to +16.0 volts. The supply should be clean, <20mV$_{P-P}$ ripple.

AF *pin 8*

Filtered analogue output from FM demodulator. Standing DC bias of 0.8V approx. Useful for test purposes or for driving external decoders. External load should be >10kΩ // <100pF

RXD *pin 9*

Digital output from internal data slicer. The output is a squared version of the signal on pin 13 (AF) and may be used to drive a decoder directly. The data is true data, i.e. as fed to the transmitter. Output is “open-collector” format with internal 10kΩ pullup to VCC (pin 7).

Absolute maximum ratings

Survival Maximums:

Exceeding the values given below may cause permanent damage to the module.

Operating temperature -20°C to +70°C
Storage temperature -40°C to +100°C

WTX3D, all variants
Vcc (pin 5) -0.3V to +16.0V
Data input (pin 7) -0.3V to +16.0V
En (pin 4) -9V to +16V
RF out (pin 2) ±50V DC 10dBm RF

RX3D all variants
Vcc (pin 7) -0.3V to +16V
En (pin 4) -9V to +16V
RSSI, AF, RXD (pins 5,8,9) -0.3V to +16V
RF IN (pin 1) ±50V DC, +10dBm RF

Performance Specifications: WTX3D/WTX3DH

Figures apply to standard version @ Vcc=5.0V, temperature +20°C, unless stated.

General	pin	min.	typ.	max.	units	notes
Supply voltage	5	2.9	5.0	16	V	
Idele current	4, 5			3	µA	
Tx supply current @0.75mW	5	-	13	-	mA	914.50MHz
@5mW	5	-	18	-	mA	869.85 MHz
@10mW	5	-	21	-	mA	
@25mW			39		mA	868.30MHz
RF centre frequency (EU)	-	-	869.85/ 868.30	-	MHz	
RF centre frequency (N-America)	-	-	914.50	-	MHz	
Antenna port impedance	2	-	50	-	Ω	
TX Enable: high *(select)*	4	1.7		16	V	
low *(deselect)*	4	0		0.5	V	
Balanced code bit rate	7	-	-	64	kbps	
RF power output 0.75mW	2	-1	+0	+1	dBm	914.50MHz, 1
5mW	2	+6	+7	+8	dBm	869.85 MHz, 1
10mW	2	+9	+10	+11	dBm	1
25mW	2	+13	+14	+15	dBm	868.30 MHz, 1
TX harmonics/spurious emission	2			-40	dBm	
Initial centre frequency accuracy	-	-10	0	+10	kHz	
FM deviation	-	±20	±30		kHz	Peak
Modulation bandwidth	-	0		35	kHz	@ -3db
TX spectral bandwidth @-40dBc	2			250	kHz	worst case
TXD input level: high	7	2.8		3.0	V	2
low	7	0		0.2	V	2
TX power up to full RF	2			2	ms	3

N***ote:***
1. Measured into a 50Ω load
2. For specified FM deviation
3. EN high to > full RF output

Performance specifications: RX3D

(Vcc = 5.0V / temperature = 20 °C unless stated)

	pin	min.	typ.	max.	units	notes
DC supply						
Supply voltage	7	2.9	3.0	16	V	
Supply current	7		15		mA	1
RF sensitivity, 12dB SINAD	1, 8		-111		dBm	-64 version
RF sensitivity, 12dB SINAD	1, 8	-	-113	-	dBm	-10 version
RSSI output, no signal	5		0.05V		V	
RSSI output, max indication	5	-	1.3	1.6	V	-50dBm RF input
RSSI range	1, 5	-	60	-	dB	
IF bandwidth	8	-	180	-	kHz	
Adjacent channel ±300kHz	1		57		dB	
±2MHz	1		63		dB	
±10MHz	1		86		dB	
Image rejection	1		57	-	dB	
IF/2 rejection	1		62		dB	
IF rejection (10.7MHz)	1		64	-	dB	
Local osc. leakage, conducted	1	-		-70	dBm	
Baseband bandwidth @ -3dB	8	0	-	50	kHz	-64 version
Baseband bandwidth @ -3dB	8	0	-	7	kHz	-10 version
AF output signal level	8		350		mV p-p	Note 2
DC offset on AF output	8		0.9		V	Note 3
Distortion on recovered AF	8	-		6	%	Note 3
Ultimate (S+N)/N	8	30		40	dB	-50dBm RF input
Load capacitance, AF & RXD	8, 9	-	-	100	pF	
Dynamic Timing						
Rx power up with signal present - 3kHz (= 6kbit/sec) modulation						
RXE active to stable RSSI, $t_{PU-RSSI}$	5	-	2.5	-	ms	-10 version
RXE active to stable RXD, $t_{PU-data}$	9	-	3		ms	-10 version
RXE active to good RX AF, t_{PU-AF}	8	-	2		ms	-10 version
Rx power up with signal present - 15kHz (= 30kbit/sec) modulation						
RXE active to stable RSSI, $t_{PU-RSSI}$	5	-	2.5	-	ms	-64 version
RXE active to stable RXD, $t_{PU-data}$	9	-	3		ms	-64 version
RXE active to good RX AF, t_{PU-AF}	8	-	2		ms	-64 version
Signal applied with Rx on						
Signal to stable data, $t_{sig-data}$ 3kHz modulation (6kbit/sec NRZ)	9	-	1	-	ms	-10 version (Note 5)
Signal to stable data, $t_{sig-data}$ 15kHz modulation (30kbit/sec NRZ)	9	-	200	-	µs	-64 version (Note 5)
Time between data transitions	9	15.6	-	1000	µs	-64 version
Time between data transitions	9	0.1	-	10	ms	-10 version
Averaged code mark:space	9	40	50	60	%	Note 6

Notes:

1. Current increases at higher RF input levels (>-20dBm and above).
2. For received signal with ±30kHz FM deviation.
3. Typical figures are for signal at centre frequency, max. figures are for ±50kHz offset.
4. For 50:50 mark to space ratio (i.e. square wave).
5. Average over 10ms (15kbps version) or 3ms (64kbps version) at maximum data rate
6. Average, at max. data rate

Power supply requirement

The standard WTX3D module incorporates a built-in regulator which delivers a constant 2.8V to the module circuitry when the external supply voltage is 2.9V or greater, with 40dB or more of supply ripple rejection. This ensures constant performance up to the maximum permitted supply rail and removes the need for external supply decoupling except in cases where the supply rail is extremely poor (ripple/noise content >0.1Vp-p).

Note, however, that for supply voltages lower than 2.85V the regulator is effectively inoperative and supply ripple rejection is considerably reduced. Under these conditions the ripple/noise on the supply rail should be below 10mVp-p to avoid problems. If the quality of the supply is in doubt, it is recommended that a 10μF low-ESR tantalum or similar capacitor be added between the module supply pin (Vcc) and ground, together with a 10Ω series feed resistor between the Vcc pin and the supply rail.

The Enable pin allows the module to be turned on or off under logic control with a constant DC supply to the Vcc pin. The module current in power-down mode is less than 1μA.

NOTE: If this facility is used, the logic control signal must have a slew rate of 40mV/ms or more. Slew rates less than this value may cause erratic operation of the on-board regulator and therefore the module itself.

The RX3D also has a built-in regulator, with characteristics similar to the WTX3D description (above). A version of this unit can be supplied without the enable pin fitted (factory option)

WTX3D modulation requirements

The module will produce the specified FM deviation with a TXD input to pin 7 of 3V amplitude, i.e. 0V "low" and 3V "high". Reducing the amplitude of the data input from this value (usually as a result of reducing the supply voltage) reduces the transmitted FM deviation to typically ±25kHz at the lower extreme of 2.9V. The receiver will cope with this quite happily and no significant degradation of link performance should be observed as a result.

Where standard 2-level digital data is employed with a logic "low" level of 0V ±0.2V, the logic "high" level applied to TXD may be any value between +2.5V and +3V for correct operation. However, if using multi-level or analogue signalling the maximum positive excursion of the modulation applied to TXD must not exceed +2.5V or waveform distortion will result. If the input waveform exceeds this level a resistive potential divider should be used at the TXD input to reduce the waveform amplitude accordingly. This input is high impedance (>100kΩ) and can usually be ignored when calculating required resistor values.

Received Signal Strength Indicator (RSSI)

The RX3D receiver incorporates a wide range RSSI which measures the strength of an incoming signal over a range of approximately 60dB. This allows assessment of link quality and available margin and is useful when performing range tests.

Please note that the actual RSSI voltage at any given RF input level varies somewhat between units. The RSSI facility is intended as a relative indicator only - it is not designed to be, or suitable as, an accurate and repeatable measure of absolute signal level or transmitter-receiver distance.

The output on pin 5 of the module has a standing DC bias in the region of 0.05V with no signal, rising to around 1.3V at maximum indication (RF input levels of -50dBm and above). For any given RF input level, absolute RSSI voltage is likely to vary somewhat between individual units - please refer to specifications table on p5.

The RSSI output source impedance is high (~50k) and external loading should therefore be kept to a minimum.

Typical RSSI characteristic is shown below (this is for indicative purposes only and is not a guarantee of actual RSSI characteristics):

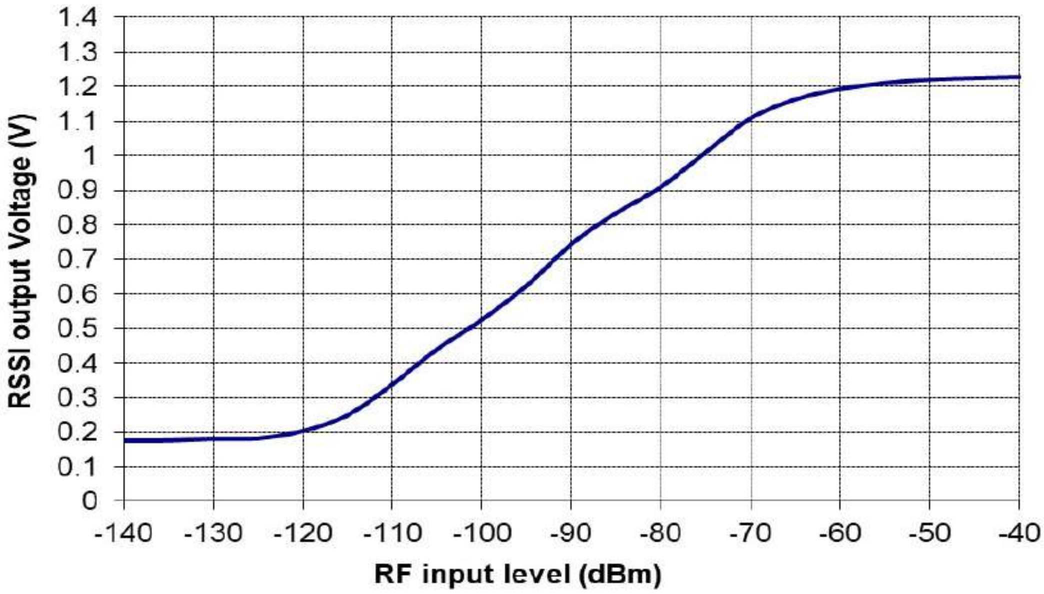

Fig.6: Typical RSSI response curve

To ensure a reasonably fast response the RSSI has limited internal decoupling of 10nF to ground. This may result in a small amount of audio ripple on the DC output at pin 5 of the module. If this is a problem further decoupling may be added at the expense of response speed, in the form of a capacitor from pin 5 to ground.

Module mounting considerations

The module may be mounted vertically or bent horizontal to the motherboard. Good RF layout practice should be observed – in particular, any ground return required by the antenna or feed should be connected directly to the RF GND pin at the antenna end of the module, and not to the OV pin which is intended as a DC ground only. All connecting tracks should be kept as short as possible to avoid any problems with stray RF pickup.

If the connection between module and antenna does not form part of the antenna itself, it should be made using 50Ω microstrip line or coax or a combination of both. It is desirable (but not essential) to fill all unused PCB area around the module with ground plane.

The module may be potted if required in a viscous compound which cannot enter the screen can.

Warning: *DO NOT wash the module. It is not hermetically sealed.*

Antenna considerations and options

The choice and positioning of transmitter and receiver antennas is of the utmost importance and is the single most significant factor in determining system range. The following notes apply particularly to integral antennas and are intended to assist the user in choosing the most effective arrangement for a given application.

Nearby conducting objects such as a PCB or battery can cause detuning or screening of the antenna which severely reduces efficiency. Ideally the antenna should stick out from the top of the product and be entirely in the clear, however this is often not desirable for practical/ergonomic reasons and a compromise may need to be reached. If an internal antenna must be used try to keep it away from other metal components and pay particular attention to the “hot” end (i.e. the far end), as this is generally the most susceptible to detuning. The space around the antenna is as important as the antenna itself.

Microprocessors and microcontrollers tend to radiate significant amounts of radio frequency hash, which can cause desensitisation of the receiver if its antenna is in close proximity. 900MHz region is generally less prone to this effect than lower frequencies, but problems can still arise. Things become worse as logic speeds increase, because fast logic edges are capable of generating harmonics across the UHF range which are then radiated effectively by the PCB tracking. In extreme cases system range can be reduced by a factor of 3 or more. To minimise any adverse effects, situate the antenna and module as far as possible from any such circuitry and keep PCB track lengths to the minimum possible. A ground plane can be highly effective in cutting radiated interference and its use is strongly recommended.

A simple test for interference is to monitor the receiver RSSI output voltage, which should be the same regardless of whether the microcontroller or other logic circuitry is running or in reset.

Depending on the application and bearing in mind applicable legal requirements (see p.11), a variety of antenna types may be used with the WTX3D and RX3D.

Integral antenna: *generally, do not perform as well as externally mounted types, however they result in physically compact equipment and are the preferred choice for portable applications. The following can be recommended:*

Whip (¼-wave): *This consists simply of a piece of wire or rod connected to the module at one end. The lengths given below are from module pin to antenna tip including any interconnecting wire or tracking. This antenna is quite simple and performs well, especially if used in conjunction with a ground plane. This will often be provided by the PCB on which the module is mounted, or by a metal case.*

Base-loaded whip: *This is a shortened whip, tuned by means of a coil inserted at the base. This coil may be air-wound for maximum efficiency, or a small SMT inductor can be used if space is at a premium. The value must be carefully chosen to tune the particular length of whip in use, making this antenna more difficult to set up than a ¼-wave whip.*

Helica: *This is a compact but slightly less effective antenna formed from a coil of wire. It is very efficient for its size, but has high Q and tends to suffer badly from detuning caused by proximity to nearby conductive objects. It needs to be carefully trimmed for best performance in a given situation and the required dimensional tolerances can be difficult to achieve repeatably, nevertheless it can provide a very compact solution.*

Loop:. *A loop of PCB track, tuned and matched with 2 capacitors. Loops are relatively inefficient but have good immunity to proximity detuning, so may be preferred in shorter range applications where very high component packing density is necessary.*

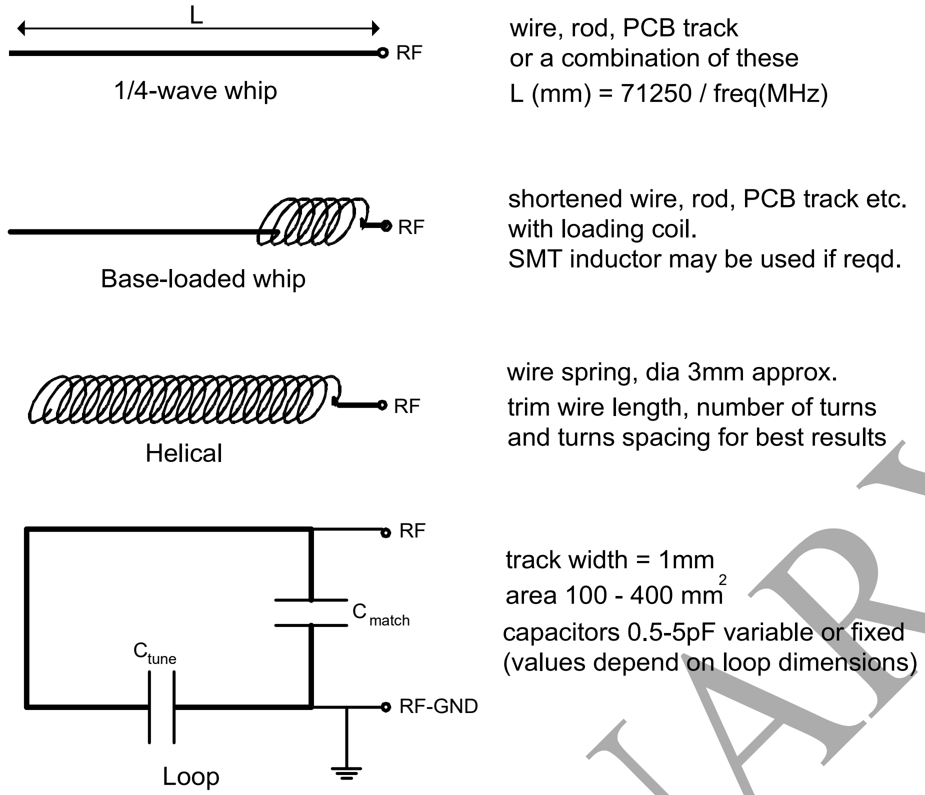

Fig.7: Integral antenna configurations

Integral antenna summary:

	whip	loaded whip	helical	loop
Ultimate performance	***	**	**	*
Ease of design set-up	***	**	*	*
Size	*	***	***	**
Immunity to proximity effects	**	*	*	***

External antennas *have several advantages if portability is not an issue. They can be optimised for individual circumstances and may be mounted in relatively good RF locations away from sources of interference, being connected to the equipment by coax feeder. Apart from the usual whips, helicals etc, low-profile types such as microstrip patches can be very effective at these frequencies. Suitable antennas are available from many different sources and are generally supplied pre-tuned to the required frequency.*

Type Approval requirements: USA

Radiometrix WTX3D & RX3D modules are sold as component devices which require external components and connections to function. They are designed to comply with FCC Part 15.249 regulations; however, they are not approved by the FCC. The purchaser understands that FCC approval will be required prior to the sale or operation of any device containing these modules.

1) *Antennas must be either permanently attached (i.e. non-removable) or must use a connector which is unique or not commonly available to the public.*

2) *The user must ensure that the WTX3D/antenna combination does not radiate more than the maximum permitted level of 50mV/m at 3m distance (FCC Part 15.249).*

3) *The appropriate FCC identifying mark and/or part 15 compliance statement must be clearly visible on the outside of the equipment containing the module(s).*

Variants and ordering information

WTX3D modules are manufactured in the following variants as standard:

Part number	***RF power*** *mW*	***Frequency*** *MHz*	***Data rate*** *kbps*
WTX3D-869.85-64	*5*	*869.85*	*64*
WTX3DH-868.30-64	*25*	*868.30*	*64*
WTX3D-914.50-64	*0.75*	*914.50*	*64*

RX3D modules are manufactured in the following variants as standard:

Part number	**Frequency (MHz)**	**Data rate (kbps)**
RX3D-869.85-64	869.85	64
RX3D-869.85-10	869.85	10
RX3D-868.30-64	868.30	64
RX3D-868.30-10	868.30	10
RX3D-914.30-64	914.50	64
RX3D-914.30-10	914.50	10

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The Intrastat commodity code for all our modules is: 8542 6000

Radio Equipment Directive (RED)

Before it can be placed on the UK market, radio control equipment must first comply with the provisions of the Radio Equipment Directive 2014/53/EU.

To comply, all equipment must meet a set of Essential Requirements that are based on voluntary Harmonised European Standards. Manufacturers can meet the essential requirements by ensuring equipment meets the applicable harmonised standards or by seeking the opinion of a Radio Equipment Directive Notified Body. Once this assessment has been carried out, the manufacturer can declare compliance, affix the CE mark to the equipment and then place it on the market anywhere in the European Community.

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