

## NTR2

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## UHF Narrow Band FM Transceiver

*The NTR2 transceiver offers a low power, reliable data link in a Radiometrix SIL standard pin out and footprint. This makes the NTR2 ideally suited to those low power applications where existing single frequency wideband UHF modules have insufficient range.*



Figure 1: NTR2-434.650-10

### Features

- Conforms to ETSI EN 300 220-3 (radio) and EN 301 489-3 (EMC)
- Standard frequencies: 434.075MHz, 434.650MHz and 458.700MHz
- Custom frequencies available in 433MHz (EU) and 458MHz (UK) band
- Data rates up to 10kbps
- Usable range over 500m
- 25kHz Channel spacing
- Longer range compared to Wide Band FM modules

Available for licence-exempt operation in the 433MHz (EU) and 458MHz (UK) bands, the NTR2 modules combine effective screening with internal filtering to minimise spurious radiation and susceptibility thereby ensuring EMC compliance. They can be used in existing low data rate (<10kbps) applications where the operating range of the system using wide band transceivers need to be extended. Because of their small size and low power consumption, NTR2 is ideal for use in battery-powered portable applications.

### Applications

- EPOS equipment, barcode scanners
- Data loggers
- Industrial telemetry and telecommand
- In-building environmental monitoring and control
- High-end security and fire alarms
- DGPS systems
- Vehicle data up/download

### Technical Summary

- 3 stage crystal controlled VCXO
- Data bit rate: 10kbps max.
- Transmit power: +10dBm (10mW)
- Double conversion FM superhet
- SAW band pass filter, image rejection: 50dB
- RX sensitivity: -118dBm (for 12dB SINAD)
- RX Adjacent Channel: -70dBm
- Supply 2.9V - 15V @ 18mA (internal 2.8V voltage regulator)
- Size: 57 x 24 x 8mm

**Evaluation platforms:** NBEK + NTR carrier

## Functional description

The transmit section of the NTR2 consists of a frequency modulated Voltage Controlled Crystal Oscillator (VCXO) feeding a frequency multiplier with two stage amplifier and RF filter. Final Power Amplifier stage is factory pre-set to appropriate band power level. Operation can be controlled by the TXE line. The transmitter achieves full RF output typically within 5ms of this line being pulled low. The RF output is filtered to ensure compliance with the appropriate radio regulations and fed to the 50Ω antenna pin. The RF output is filtered to ensure compliance with the appropriate radio regulations and fed via a fast Tx/Rx changeover switch to the 50Ω antenna pin.

The receive section is a double conversion NBFM superhet with IF at 21.4MHz and 455kHz fed by a Low Noise Amplifier (LNA) on the RF front-end. Quadrature detector output is available as Audio Frequency (AF) output and transmitted digital data is regenerated from AF using adaptive data slicer. A Received Signal Strength Indicator (RSSI) output with some 60dB of range is provided.

## User interface

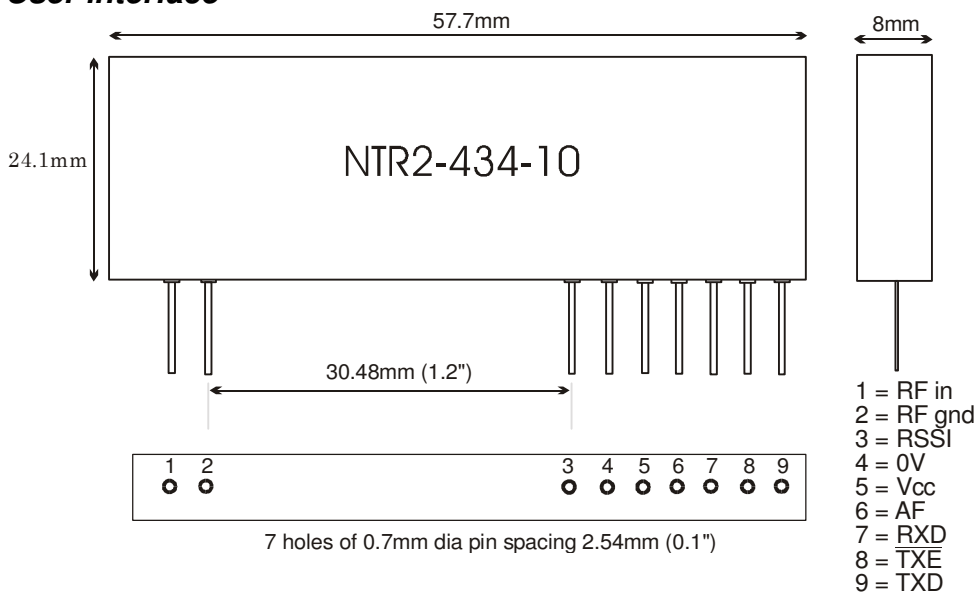


Figure 2: NTR2 pin-out and dimension

NTR2 pin	Name	Function
1	RF in/out	50Ω RF input from the antenna
2	RF gnd	RF Ground is internally connected to the module screen and pin 4 (0V). These pins should be directly connected to the RF return path - e.g. coax braid, main PCB ground plane etc.
3	RSSI	Received Signal Strength Indicator with >60dB range. DC level between 0.5V and 2V
4	0V	Ground
5	Vcc	2.9 – 15V DC power supply
6	AF	500mV <sub>pk-pk</sub> audio. DC coupled, approx 0.8V bias
7	RXD	Logic data output from the internal data slicer. The data is squared version of the Audio signal on pin 6 and is true data, i.e. as fed to the transmitter. Output is "open-collector" format with internal 10kΩ pull-up to Vcc (pin 5). Suitable for bi-phase codes
8	TXE	Low = TX enable (3V CMOS logic)
9	TXD	DC coupled input (3V CMOS logic). R <sub>in</sub> = 100kΩ

- Notes:**
1. TXE has 47kΩ internal pullup to 2.8V
  2. Compatible with NiM2, NRX2 and NTX2.
  3. Pinout resembles an NRX2 receiver with 2 added pins ( N\_TXE and TXD)
  4. There is no complete unit enable pin: the user must switch the Vcc.
  5. There are two versions of the interface pinning:
    - Batten & Allen 'edge leadframe' for vertical SIL mounting
    - Conventional 0.1" pitch square pin headers for minimum height horizontal mount.

## Performance specifications

(Vcc = 3V / temperature = 20°C unless stated)

General	pin	min.	typ.	max.	units	notes
Operating temperature		-10	-	+60	°C	
Storage temperature		-30	-	+70	°C	
<b>DC supply</b>						
Supply voltage	5	2.9	3.0	15	V	
TX Supply current	5	-	20	-	mA	
RX Supply current	5	-	15	-	mA	
Antenna pin impedance	1	-	50	-	□	
RF centre frequency		-	434.650	-	MHz	1
NTR2-434.650-10		-	434.075	-		
NTR2-434.075-10		-	458.700	-		
NTR2-458.700-10		-		-		
Channel spacing		-	25	-	kHz	
Number of channels		-	1	-		
<b>Transmitter</b>						
<b>RF</b>						
RF power output	1	9	10	11	dBm	2
Spurious emissions	1	-	-	-40	dBm	
Adjacent channel TX power		-	-37	-	dBm	
Frequency accuracy		-	-	±2.5	kHz	3
FM deviation (peak)		±2.5	±3.0	±3.5	kHz	4
<b>Baseband</b>						
Modulation type		-	FSK	-		F3D
Modulation bandwidth @ -3dB		0	-	5	kHz	
TXD input level (logic low)	9	-	0	-	V	5
TXD input level (logic high)	9	-	3.0	-	V	5
Distortion		-	-	10	%	6
<b>Dynamic timing</b>						
TX Enable to full RF	8	-	-	5	ms	

	pin	min.	typ.	max.	units	notes
<b>Receiver</b>						
<b>RF/IF</b>						
RF sensitivity @ 12dB SINAD	1, 6	-	-118	-	dBm	
RF sensitivity @ 1ppm BER	1, 7	-	-112	-	dBm	
RSSI threshold	1, 3	-	-125	-	dBm	7
RSSI range	1, 3	-	60	-	dB	7
IF bandwidth		-	TBA	-	kHz	
Blocking	1	-	84	-	dB	
Image rejection	1	-	55	-	dB	
Adjacent channel	1	-	70	-	dB	
Spurious response rejection	1	-	55	-	dB	
LO re-radiation	1	-	-	-60	dBm	8
<b>Baseband</b>						
Baseband bandwidth @ -3dB	6	0	-	5	kHz	
AF level	6	-	500	-	mV <sub>P-P</sub>	9
DC offset on AF out	6	-	0.8	-	V	
Distortion on recovered AF	6	-	-	10	%	
<b>Dynamic timing</b>						
<i>Power up with signal present</i>						
Power up to valid RSSI	3, 5	-	3	-	ms	
Power up to valid AF	5, 6	-	2	-	ms	
Power up to stable data	5, 7	-	-	10	ms	
<i>Signal applied with supply on</i>						
Signal to valid RSSI	1, 3	-	2	-	ms	

	pin	min.	typ.	max.	units	notes
Signal to valid AF	1, 6		1		ms	
Signal to stable data	1, 7	-	-	5	ms	10
Time between data transitions	7	-	-	0.1	ms	

**Notes:**

1. Available in 25kHz channel steps on other custom frequencies in 433MHz/458MHz band
2. Measured into 50Ω resistive load.
3. Total over full supply and temperature range.
4. With 0V – 3.0V modulation input.
5. To achieve specified FM deviation.
6. For 1V<sub>pk-pk</sub> signal biased at 1.4V
7. See applications information for further details.
8. Exceeds EN/EMC requirements at all frequencies.
9. For received signal with ±3kHz FM deviation
10. For 50:50 mark to space ratio (i.e. squarewave).

## Applications information

### Power supply requirements

The NTR2 has built-in regulator which deliver 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 rail, and removes the need for external supply decoupling except in cases where the supply rail is extremely poor (ripple/noise content  $>100\text{mV}_{\text{pk-pk}}$ ).

### TX modulation requirements

The module is factory-set to produce the specified FM deviation with a TXD input to pin 9 of 3V amplitude, i.e. 0V "low", 3V "high"

If the data input level is greater than 3V, a resistor must be added in series with the TXD input to limit the modulating input voltage to a maximum of 3V on pin 9. TXD input resistance is  $100\text{k}\Omega$  to ground, giving typical required resistor values as follows:

Vcc	Series resistor
$\leq 3\text{V}$	-
3.3V	10 k $\Omega$
5V	68k $\Omega$
9V	220k $\Omega$

### NTR2 Received Signal Strength Indicator (RSSI)

The NTR2 incorporates a wide range RSSI which measures the strength of an incoming signal over a range of 55dB or more. This allows assessment of link quality and available margin and is useful when performing range tests.

The output on pin 3 of the module has a standing DC bias of  $<0.5\text{V}$  with no signal, rising to 2V at maximum indication.

Typical RSSI characteristic is as shown below:

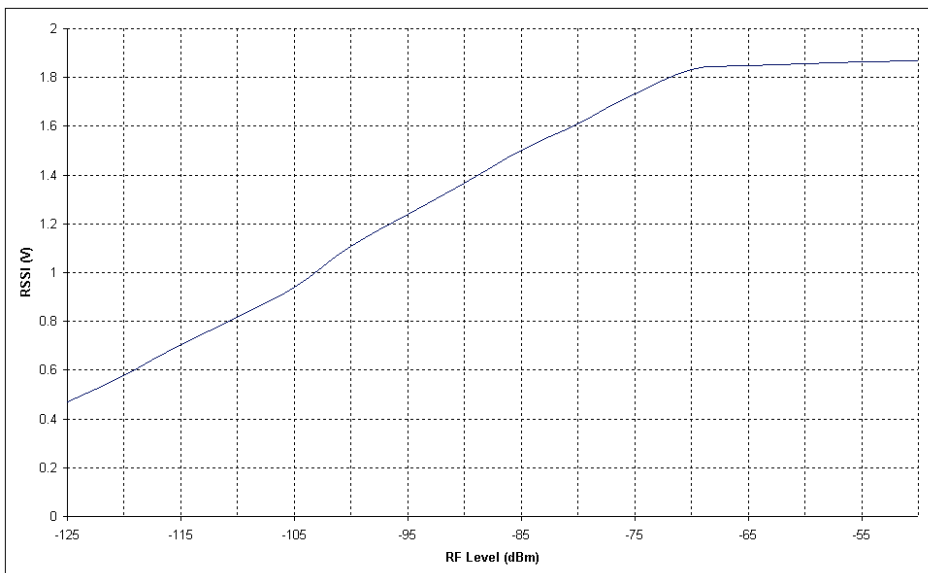


Figure 3: RSSI response curve

### **Expected range**

Predicting the range obtainable in any given situation is notoriously difficult since there are many factors involved. The main ones to consider are as follows:

- Type and location of antennas in use
- Type of terrain and degree of obstruction of the link path
- Sources of interference affecting the receiver
- “Dead” spots caused by signal reflections from nearby conductive objects
- Data rate and degree of filtering employed

The following are typical examples – but range tests should always be performed before assuming that a particular range can be achieved in a given situation:

<b>Data rate</b>	<b>Tx antenna</b>	<b>Rx antenna</b>	<b>Environment</b>	<b>Range</b>
10kbps	¼ wave	¼ wave	urban/obstructed	300m
10kbps	¼ wave	¼ wave	Rural/open	500m
10kbps	helical	helical	in-building	100m

### **Data formats and range extension**

The NTR2’s TXD input is normally driven directly by logic levels but will also accept analogue drive (e.g. 2-tone signalling). In this case it is recommended that TXD (pin 9) be DC-biased to 1.2V approx. with the modulation ac-coupled and limited to a maximum of  $2V_{p-p}$  to minimise distortion over the link. The varactor modulator in the NTR2 introduces some 2<sup>nd</sup> harmonic distortion which may be reduced if necessary by predistortion of the analogue waveform.

Although the modulation bandwidth of the NTR2 extends down to DC it is not advisable to use data containing a DC component. This is because frequency errors and drifts between the transmitter and receiver occur in normal operation, resulting in DC offset errors on the NTR2’s audio output.

The NTR2 in standard form incorporates a low pass filter with a 5kHz nominal bandwidth. This is suitable for transmission of data at raw bit rates up to 10kbps.

## Antennas

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 are intended to assist the user in choosing the most effective antenna type for any given application.

### *Integral antennas*

These are relatively inefficient compared to the larger externally-mounted types and hence tend to be effective only over limited ranges. They do however result in physically compact equipment and for this reason are often preferred for portable applications. Particular care is required with this type of antenna to achieve optimum results and the following should be taken into account:

1. 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.
2. 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. The problem becomes worse as logic speeds increase, because fast logic edges generate harmonics across the UHF range which are then radiated effectively by the PCB tracking. In extreme cases system range may be reduced by a factor of 5 or more. To minimise any adverse effects situate 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.

*The following types of integral antenna are in common use:*

**Quarter-wave whip.** This consists simply of a piece of wire or rod connected to the module at one end. At 434MHz the total length should be 164mm from module pin to antenna tip including any interconnecting wire or tracking. Because of the length of this antenna it is almost always external to the product casing.

**Helical.** This is a more compact but slightly less effective antenna formed from a coil of wire. It is very efficient for its size, but because of its high Q it suffers badly from detuning caused by proximity to nearby conductive objects and needs to be carefully trimmed for best performance in a given situation. The size shown is about the maximum commonly used at 434MHz and appropriate scaling of length, diameter and number of turns can make individual designs much smaller.

**Loop.** A loop of PCB track having an inside area as large as possible (minimum about 4cm<sup>2</sup>), 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 high component packing density is necessary.

*Integral antenna summary:*

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

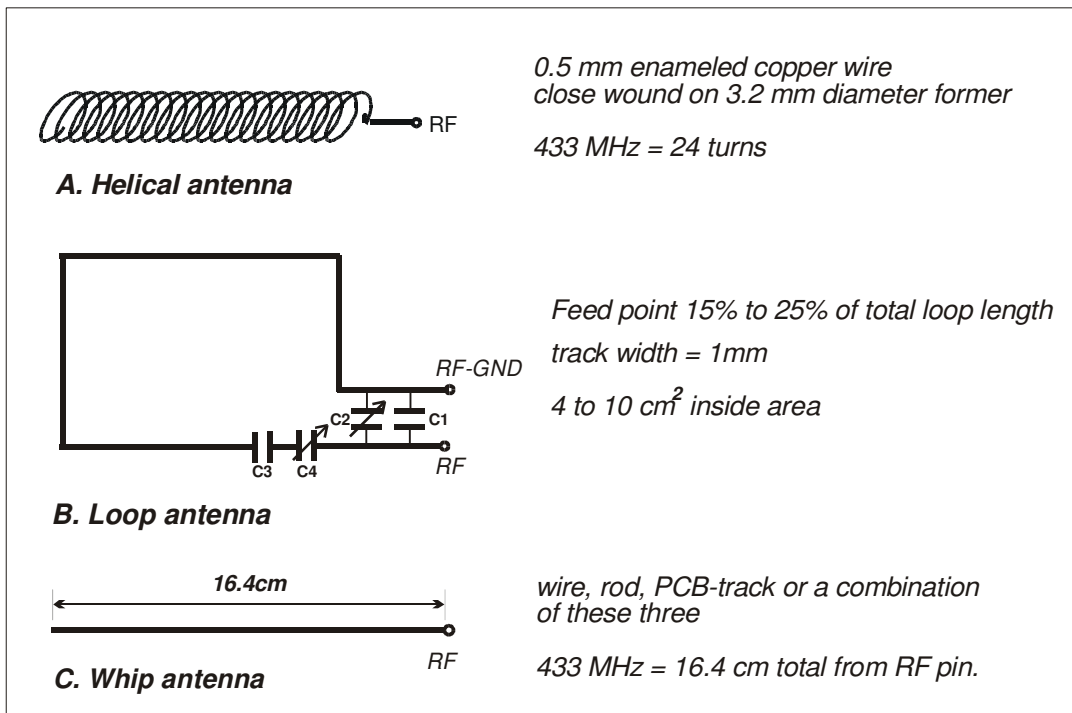


Figure 4: integral antenna configurations

### External antennas

These have several advantages if portability is not an issue, and are essential for long range links. External antennas 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.

**Helical.** Of similar dimensions and performance to the integral type mentioned above, commercially-available helical antennas normally have the coil element protected by a plastic moulding or sleeve and incorporate a coax connector at one end (usually a straight or right-angle BNC/SMA type). These are compact and simple to use as they come pre-tuned for a given application, but are relatively inefficient and are best suited to shorter ranges.

**Quarter-wave whip.** Again similar to the integral type, the element usually consists of a stainless steel rod or a wire contained within a semi-flexible moulded plastic jacket. Various mounting options are available, from a simple BNC/SMA connector to wall brackets, through-panel fixings and magnetic mounts for temporary attachment to steel surfaces.

A significant improvement in performance is obtainable if the whip is used in conjunction with a metal ground plane. For best results this should extend all round the base of the whip out to a radius of the length of the whip used (under these conditions performance approaches that of a half-wave dipole) but even relatively small metal areas will produce a worthwhile improvement over the whip alone. The ground plane should be electrically connected to the coax outer at the base of the whip. Magnetic mounts are slightly different in that they rely on capacitance between the mount and the metal surface to achieve the same result.

A ground plane can also be simulated by using 3 or 4 quarter-wave radials equally spaced around the base of the whip, connected at their inner ends to the outer of the coax feed. A better match to a 50Ω coax feed can be achieved if the elements are angled downwards at approximately 30-40° to the horizontal.



### ***Module mounting considerations***

The modules may be mounted vertically or bent horizontal to the motherboard. Note that the components mounted on the underside of the NTR2 is relatively fragile – avoid direct mechanical contact between these and other parts of the equipment if possible, particularly in situations where extreme mechanical stresses could routinely occur (as a result of equipment being dropped onto the floor, etc).

Good RF layout practice should be observed. 50Ω microstrip line or coax or a combination of both should be used to connect RF pin of the module to RF connector or antenna. It is desirable (but not essential) to fill all unused PCB area around the module with ground plane.

### ***Variants and ordering information***

The NTR2 transceivers are manufactured in the following variants as standard:

*At 434.650MHz: **NTR2-434.650-10***

*At 434.075MHz: **NTR2-434.075-10***

*At 458.700MHz: **NTR2-458.700-10***

***Other frequency variants can be supplied to individual customer requirements in the 433MHz (European) and 458MHz (UK) licence exempt bands***

# **Radiometrix Ltd**

**Hartcran House  
231 Kenton Lane  
Harrow, Middlesex  
HA3 8RP  
ENGLAND**

**Tel: +44 (0) 20 8909 9595  
Fax: +44 (0) 20 8909 2233  
sales@radiometrix.com  
www.radiometrix.com**

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

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After 7 April 2001 the manufacturer can only place finished product on the market under the provisions of the R&TTE Directive. Equipment within the scope of the R&TTE Directive may demonstrate compliance to the essential requirements specified in Article 3 of the Directive, as appropriate to the particular equipment.

Further details are available on The Office of Communications (Ofcom) web site:

***<http://www.ofcom.org.uk/>***

### *Information Requests*

*Ofcom*

*Riverside House*

*2a Southwark Bridge Road*

*London SE1 9HA*

*Tel: +44 (0)300 123 3333 or 020 7981 3040*

*Fax: +44 (0)20 7981 3333*

*information.requests@ofcom.org.uk*

### *European Communications Office (ECO)*

*Pebblinghus*

*Nansensgade 19*

*DK 1366 Copenhagen*

*Tel. +45 33896300*

*Fax +45 33896330*

*ero@ero.dk*

*www.ero.dk*

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