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NiM1B

Issue 1, 18 February 2015

# Frequency Programmable 25kHz NBFM VHF Transceiver

***The narrow band NiM1B transceiver offers a low power, reliable data link in a Radiometrix transceiver standard pin out and footprint. The NiM1B is a frequency programmable, narrowband design, suitable for licensed and unlicensed VHF allocations, FCC part 90 and part 95 (MURS) operations.***

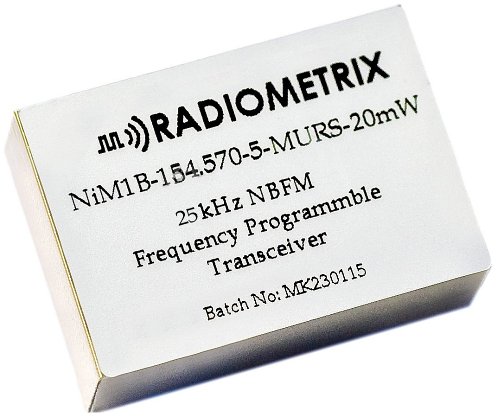


*Figure 1: NiM1B (MURS)*

## Features

- Conforms to EN 300 220-3 and EN 301 489-3 (10mW version only)
- Compliant with FCC part 90 and part 95 (MURS)
- Standard frequency 154.570MHz or 154.600MHz (re-programmable)
- Other frequencies from 120MHz to 175MHz
- Data rates up to 5kbps for standard module
- Usable range over 1km
- Fully screened
- Low power requirements
- 25kHz Channel spacing
- Feature-rich interface (true analogue and/or digital baseband)

The NiM1B is a half duplex radio transceiver module for use in long range bi-directional data transfer applications at ranges up to 1kilometres. The module operates on the US 154MHz MURS band allocation. NiM1B is also available as separate NiM1BT transmitter and NiM1BR receiver, which can be, used as dual-in-line equivalents of TX1 transmitter and RX1/NRX1 receiver respectively.

## Applications

- Multi-Use Radio Service (MURS)
- Industrial telemetry and telecommand
- High-end security systems
- Vehicle data up/download
- ROV/machinery controls

## Technical Summary

- Fully integrated sigma-delta PLL synthesizer based design
- High stability TCXO reference
- Data bit rate: 5kbps max.
- Transmit power: +13dBm (20mW)
- Image rejection: >70dB
- Receiver sensitivity: -120dBm (for 12dB SINAD)
- RSSI output with >50dBm range
- Supply: 3.3V - 15V @ 30mA transmit, 18mA receive
- Dimensions: 33 x 23 x 11mm (fully screened)

**Evaluation platforms**: NBEK + BiM / SMX carrier

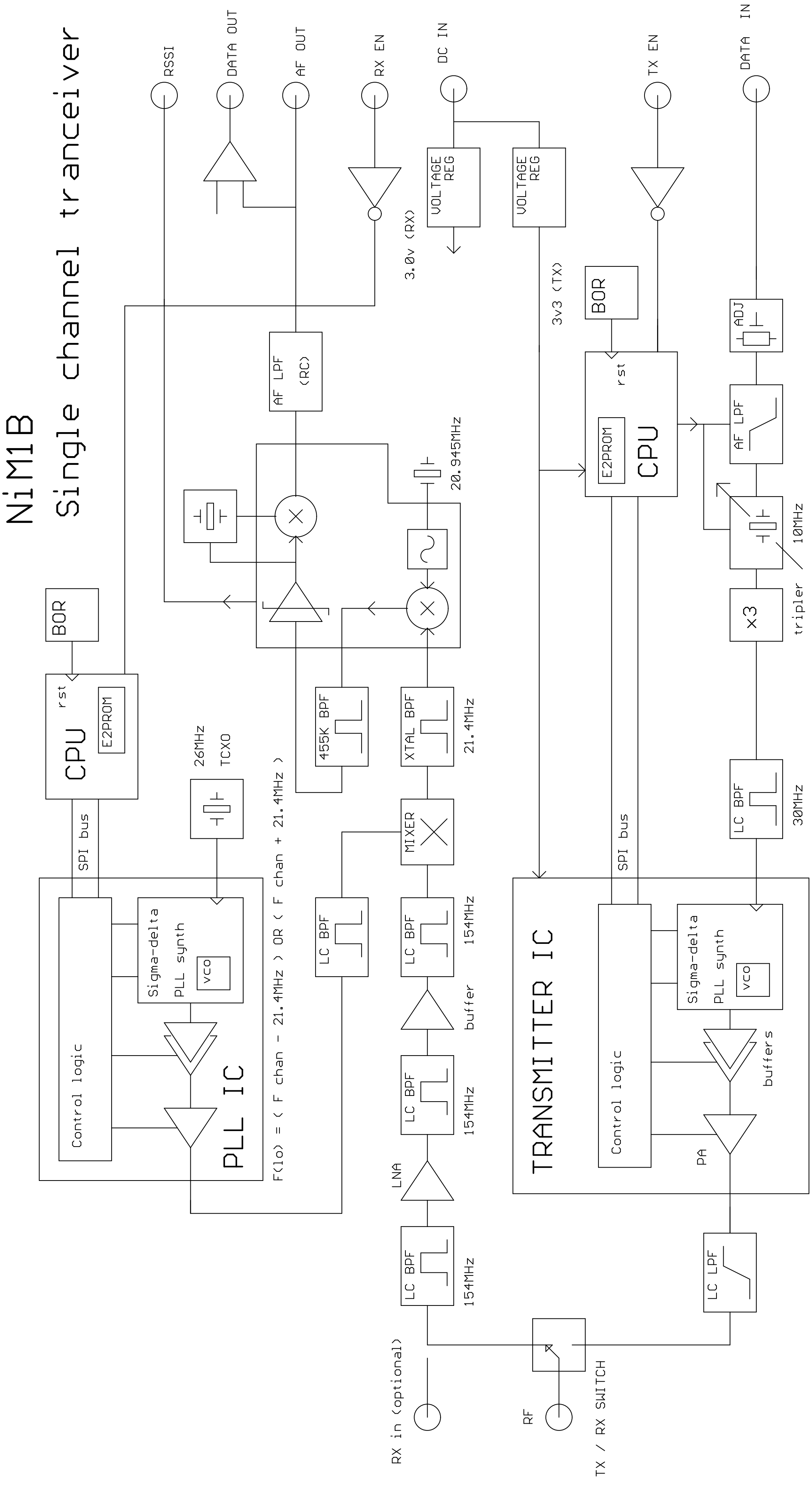


*Figure 2: NiM1B schematics*

## Functional description

The transmit section of the NiM1B consists of a highly integrated sigma delta (fractional N) synthesizer based single chip RF device, configured over an SPI serial bus by an on-board microcontroller. The primary frequency reference for the transmitter is a 30MHz VC-TCXO. Modulation is applied directly to this reference via an AF baseband filter (rather than using the chip's internal modulator) to permit a wider range of baseband data rates and waveforms. Operation is controlled by the N_TXE line, the transmitter achieving 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 receiver section of the NiM1B consists of a highly integrated sigma delta (fractional N) synthesizer based Local Oscillator (LO), configured over an SPI serial bus by an on-board microcontroller. The primary frequency reference for the LO is a 26MHz VC-TCXO. The remainder of the reciever is a conventional dula conversion superhet, using a wide dynamic range mosfet mixer and crystal / ceramic filter elements for optimum performance. The RF input is filtered using a multi-stage LC filter in the front end to provide image rejection and enhanced blocking performance. This reduces the user programmable frequency range to the filter passband, but can easily be re-banded (in the factory) to other frequencies.

## User interface

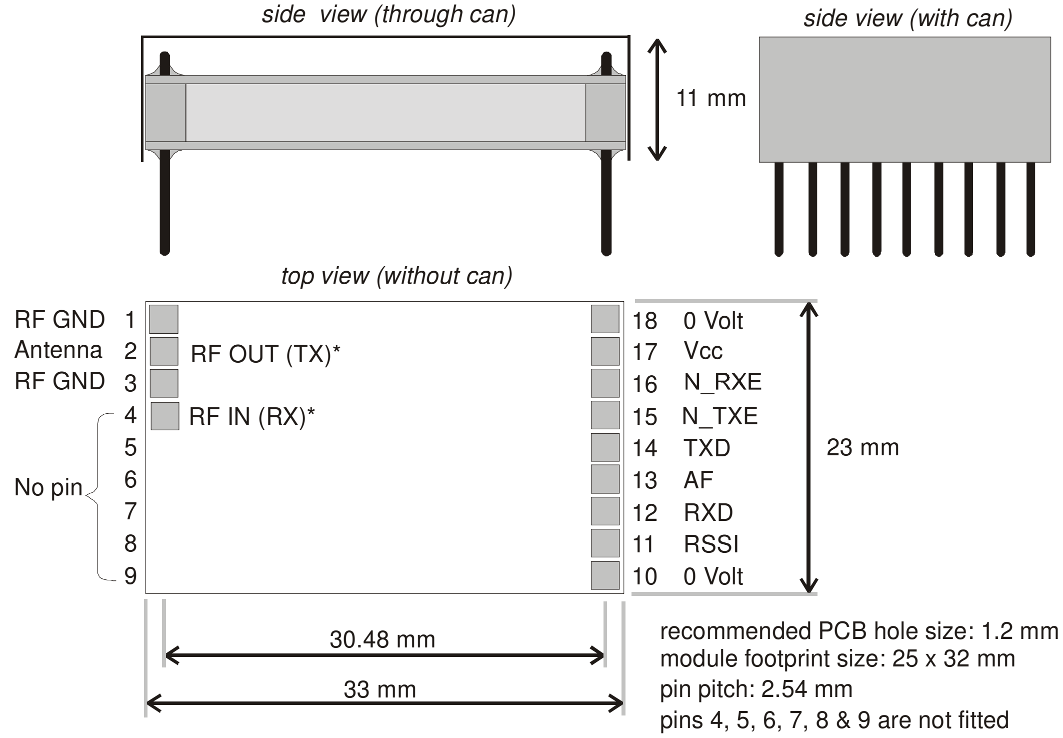


*Figure 3: NiM1B pin-out and dimension*

| NiM1B Pin | Name | Function |
|---|---|---|
| 1, 3, 10, 18 | 0V | Ground |
| 17 | VCC | 3.3 – 15V DC power supply |
| 16 | N_RXE / RX PGM | Pull low to enable Receiver / receive programming in put |
| 15 | N_TXE / TX PGM | Pull low to enable Transmitter / transmit programming in put |
| 14 | TXD | DC coupled input for 3V CMOS logic. $R_{in}$ = 100kΩ |
| 13 | AF | 500mV $_{pk-pk}$ audio. DC coupled, approx 1.5V bias |
| 12 | RXD | Open collector output, with a 10kΩ pullup to Vcc. Suitable for Biphase codes |
| 11 | RSSI | DC level between 0.5V and 2V. 50dB dynamic range |

***NOTES***:

1. *N_Rxe and N_Txe have (10K approx.) pullups to +Vin*
2. *Unit is programmable using the N_Rxe or N_Txe pins. Contact Radiometrix for details*
   *Reprogramming requires a 0v to +Vin logic level non-inverted RS232 data-stream to pin 3 or 4*
   *An RS232 port can be directly connected to the enable pin for programming*
3. *Avoid N_Rxe and N_Txe both low: undefined module operation (but damage will not result)*
4. *Pinout is as BiM1. On RF connector end only pins 1,2,3 are present (*except for NiM1B with separate RX and TX ports which has 4 pins. See ordering info ( p10) for further details on this special built).*
5. *Switching time as controlled by N_Txe or N_Rxe pins is <5mS, but when power is first applied to the unit there is a 20mS long “calibration” period before the transmitter becomes active.*
   *If the rail is switched (as opposed to the EN pin) then this should be considered as a 25mS device*

### *Absolute maximum ratings*

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

| | |
|---|---|
| Operating temperature | -20°C to +70°C |
| Storage temperature | -30°C to +85°C |
| | |
| RF in (pin 1) | ±50V @ <10MHz, +13dBm @ >10MHz |
| All other pins | -0.3V to +15.0V |

## *Performance specifications:*

*(Vcc = 5V / temperature = 20°C unless stated)*

| General | pin | min. | typ. | max. | units | notes |
|---|---|---|---|---|---|---|
| *DC supply* | | | | | | |
| Supply voltage | 17 | 3.3 | - | 15 | V | |
| TX Supply current (20mW) | 17 | | 30 | | mA | |
| RX Supply current | 17 | | 18 | | mA | |
| | | | | | | |
| Antenna pin impedance | 2 | | 50 | | Ω | |
| RF centre frequency | | | 154.570 / 154.600 | | MHz MHz | 1 |
| Channel spacing | | | 25 | | kHz | |
| Number of channels | | | 1 | | | 1 |
| | | | | | | |
| ***Transmitter*** | | | | | | |
| ***RF*** | | | | | | |
| RF power output | 2 | +12 | +13 | +14 | dBm | 2 |
| Spurious emissions | 2 | | -50 | | dBm | 3 |
| Adjacent channel TX power | | | -37 | | dBm | |
| Frequency accuracy | | | ±1.5 (5ppm) | | kHz | 4 |
| FM deviation (peak) | | ±2.5 | ±3.0 | ±3.5 | kHz | 5 |
| | | | | | | |
| ***Baseband*** | | | | | | |
| Modulation bandwidth @ -3dB | | 0 | | 3.5 | kHz | DC coupled |
| TXD input level (logic low) | 14 | | 0 | | V | 6 |
| TXD input level (logic high) | 14 | | 3.0 | | V | 6 |
| | | | | | | |
| ***Dynamic timing*** | | | | | | |
| TX select to full RF | | | | 5 | ms | |
| | | | | | | |
| ***Receiver*** | | | | | | |
| ***RF/IF*** | | | | | | |
| RF sensitivity @ 12dB SINAD | 2, 13 | | -120 | | dBm | |
| RF sensitivity @ 1ppm BER | 2, 12 | | -112 | | dBm | |
| RSSI range | 2, 11 | 50 | 50 | | dB | 7 |
| Blocking | 2 | | 84 | | dB | |
| Image rejection | 2 | | 70 | | dB | |
| Adjacent channel rejection | 2 | 63 | | | dB | 3 |
| Spurious response rejection | 2 | | 70 | | dB | |
| LO leakage, radiated | | | | -70 | dBm | 4 |
| | | | | | | |
| ***Baseband*** | | | | | | |
| Baseband bandwidth @ -3dB | 13 | | 5 | | kHz | |
| AF level | 13 | | 500 | | $mV_{P-P}$ | 8 |
| DC offset on AF out | 13 | | 1.5 | | V | |
| Distortion on recovered AF | 12 | | 5 | | % | |

| General | pin | min. | typ. | max. | units | notes |
|---|---|---|---|---|---|---|
| ***Dynamic timing*** | | | | | | |
| *RX enable with signal present* | | | | | | |
| N_RXE active (low) to stable AF output | 16, 13 | | 10 | | | |
| N_RXD active (low) to stable RXD output | 16, 12 | | 25 | | ms | |
| *Signal applied with receiver enabled* | | | | | | |
| Signal to valid AF | 2, 11 | | 10 | | ms | |
| Signal to stable data | 2, 12 | | 25 | | ms | |

***Notes:***

1. Programs to any 154MHz MURS 25kHz bandwidth frequencies
2. Measured into 50Ω resistive loads.
3. Exceeds EN/EMC requirements at all frequencies.
4. 5ppm TCXO. Total over full supply and temperature range.
5. With 0V – 3.0V modulation input.
6. To achieve specified FM deviation.
7. See applications information for further details.
8. For received signal with ±3kHz FM deviation.

# Applications information

### *Power supply requirements*

The NiM1B have built-in regulators, which deliver a constant 3.3V to the transmitter and the receiver circuitry when the external supply voltage exceeds 3.3V. 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 >0.1Vp-p). The unit will continue to function with a 3v supply, but power output will fall

### *TX modulation requirements*

The module is factory-set to produce the specified FM deviation with a TXD input to pin 14 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 around 3V on pin 14. TXD input resistance is 100kΩ to ground, giving typical required resistor values as follows:

| Vcc | Series resistor |
|---|---|
| ≤3V | - |
| 3.3V | 10 kΩ |
| 5V | 68kΩ |
| 9V | 220kΩ |

### *RX Received Signal Strength Indicator (RSSI)*

The NiM1B wide range RSSI which measures the strength of an incoming signal over a range of 50dB or more. This allows assessment of link quality and available margin and is useful when performing range tests.

The output on pin 11 of the module has a standing DC bias of up to 0.5V (approx.) with no signal, rising to around 2.0V at maximum indication. DVmin-max is typically 1V and is largely independent of standing bias variations. Output impedance is 56kΩ. Pin 11 can drive a 100µA meter directly, for simple monitoring.

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.
Typical RSSI characteristic is as shown below:

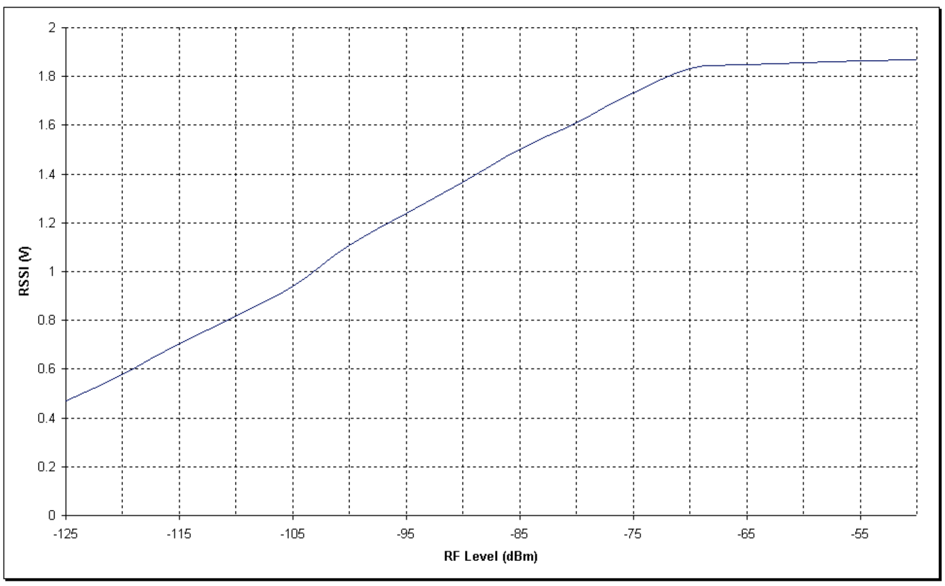


*Figure 4: RSSI level with respect to received RF level at NiM1B antenna pin*

## *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:

| Data rate | Tx antenna | Rx antenna | Environment | Range |
|---|---|---|---|---|
| 5kbps | half-wave | half-wave | rural/open | 3-4km |
| 5kbps | helical | half-wave | urban/obstructed | 500m-1km |
| 5kbps | helical | helical | in-building | 100-200m |

The NiM1B TXD input is normally driven directly by logic signals, but will also accept analogue drive (e.g. 2-tone signalling). In this case the TXD pin can either be directly DC driven with a 3v pp waveform with a 1.5v centre point, or a 3v pp signal can be AC coupled (when the input circuits will self-bias to 1.5v). Do not exceed 3v pp, or the baseband waveform will begin to clip. The VC-TCXO in the NiM1B is highly linear, and tx distortion figures well under 5% should be seen. At the other end of the link the NiM1B AF output (or the RXD pin) may be used to drive an external decoder or other signal processing circuitry.

Although the modulation bandwidth of the NiM1B 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 NiM1B audio output.

The NiM1B in standard form incorporates a low pass filter with a 3.5kHz nominal bandwidth. This is suitable for transmission of data at raw bit rates up to 5kbps.

In applications such as long range fixed links where data speed is not of prime concern, a considerable increase in range can be obtained by using the slowest possible data rate together with filtering to reduce the receiver bandwidth to the minimum necessary.

## 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 VHF 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 151MHz the total length should be 471mm 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 151MHz 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 5cm$^2$), 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:

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

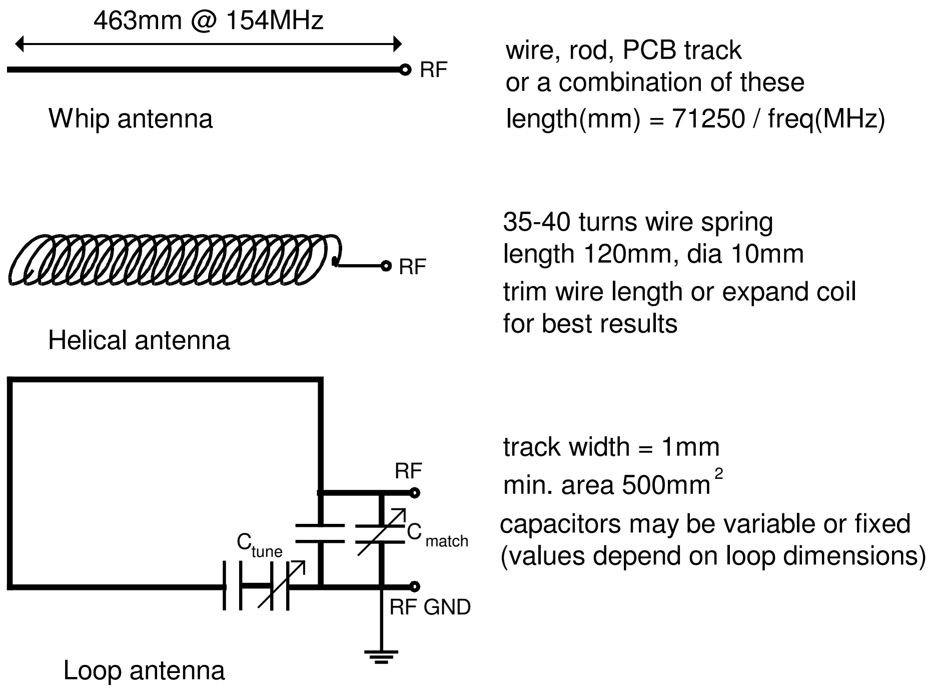


*Figure 5: integral antenna configurations*

***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 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 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 300mm or more (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.

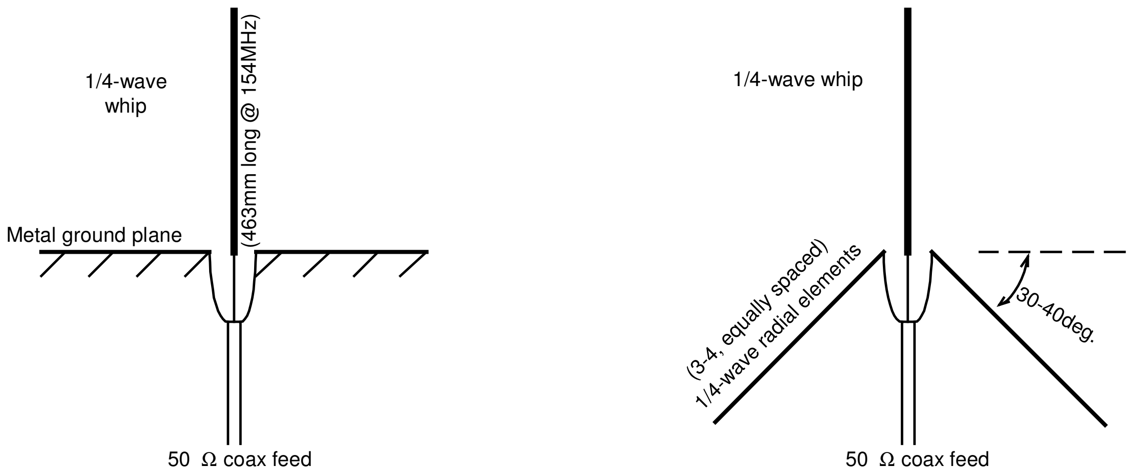


*Fig.6: Quarter wave antenna / ground plane configurations*

***Half-wave.*** There are two main variants of this antenna, both of which are very effective and are recommended where long range and all-round coverage are required:

1. The half-wave dipole consists of two quarter-wave whips mounted in line vertically and fed in the centre with coaxial cable. The bottom whip takes the place of the ground plane described previously. A variant is available using a helical instead of a whip for the lower element, giving similar performance with reduced overall length. This antenna is suitable for mounting on walls etc. but for best results should be kept well clear of surrounding conductive objects and structures (ideally >1m separation).

2. The end-fed half wave is the same length as the dipole but consists of a single rod or whip fed at the bottom via a matching network. Mounting options are similar to those for the quarter-wave whip. A ground plane is sometimes used but is not essential. The end-fed arrangement is often preferred over the centre-fed dipole because it is easier to mount in the clear and above surrounding obstructions.

***Yagi.*** This antenna consists of two or more elements mounted parallel to each other on a central boom. It is directional and exhibits gain but tends to be large and unwieldy – for these reasons the yagi is the ideal choice for links over fixed paths where maximum range is desired.

Please note: Using a Yagi or other gain antenna with the NiM1B will exceed the maximum radiated power permitted by UK type approval regulations. It can be used in the UK only in conjunction with the NiM1BR receiver.

For best range, in fixed link applications use a half-wave antenna on NiM1BT transmitter and a half-wave or Yagi on NiM1BR receiver, both mounted as high as possible and clear of obstructions.

Good RF layout practice should be observed. If the connection between module and antenna is more than about 20mm long use 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.

### *Module mounting considerations*

Good RF layout practice should be observed. If the connection between module and antenna is more than about 20mm long use 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.

### *Variants and ordering information*

The NiM1BT transmitters, NiM1BR receivers and NiM1B transceivers are manufactured in the following variants as standard:

| | | |
|---|---|---|
| *At* 154.570*MHz*: | NiM1B-154.570-5 | Transceiver |
| | NiM1BT-154.570-5 | Transmitter |
| | NiM1BR-154.570-5 | Receiver |
| *At* 154.600*MHz*: | NiM1B-154.600-5 | Transceiver |
| | NiM1BT-154.600-5 | Transmitter |
| | NiM1BR-154.600-5 | Receiver |

(Depending on the built state, NIM1B can be reprogrammed on any frequencies with in the 120 - 175MHz band)

### ***NiM1B with separate TX and RX RF ports:*** NiM1B-154.570-5-TR

The NiM1B can be factory built with separate RX and TX ports.
This special built will have 4 pins on the RF connector instead of three (refer to figure 3)

Pin 1 RF GND
2 RF OUT (TX)
3 RF GND
4 RF IN (RX)

The RF IN (RX) port MUST be externally AC coupled, as it has a bias voltage on it

This is useful if an application requires using an external TX power amp, RX pre-amp, or separate antennas TX and RX.

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

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Further details are available on The Office of Communications (Ofcom) web site:
***http://www.ofcom.org.uk/***

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