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# Frequency Programmable 25kHz NBFM VHF Transceiver

***The narrow band AiM1 transceiver offers a low power, reliable data link in a Radiometrix transceiver standard pin out and footprint. The AiM1 is a frequency programmable, narrowband design, suitable for licensed and unlicensed VHF allocations and 2M amateur band applications.***


*Figure 1: AiM1-144.390-5*

## Features

- Conforms to EN 300 220-3 and EN 301 489-3 (10mW version only)
- Standard frequency 144.390MHz
- Other frequencies from 120MHz to 175MHz: see BiM1B
- Data rates up to 5kbps for standard module
- Usable range over 1km
- Low power requirements
- 25kHz Channel spacing
- Feature-rich interface (true analogue and/or digital baseband)

The AiM1 is a half duplex radio transceiver module for use in long range bi-directional data transfer applications at ranges up to 1kilometres. AiM1 is available for operation on the amateur 144MHz band allocation as standard. AiM1 is also available as separate AiM1T transmitter and AiM1R receiver, which can be, used as dual-in-line equivalents of TX1 transmitter and RX1/NRX1 receiver respectively.

## Applications

- Amateur radio
- APRS systems
- Packet operation
- FM simplex telephony
- Repeater monitoring

## 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 9mm

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

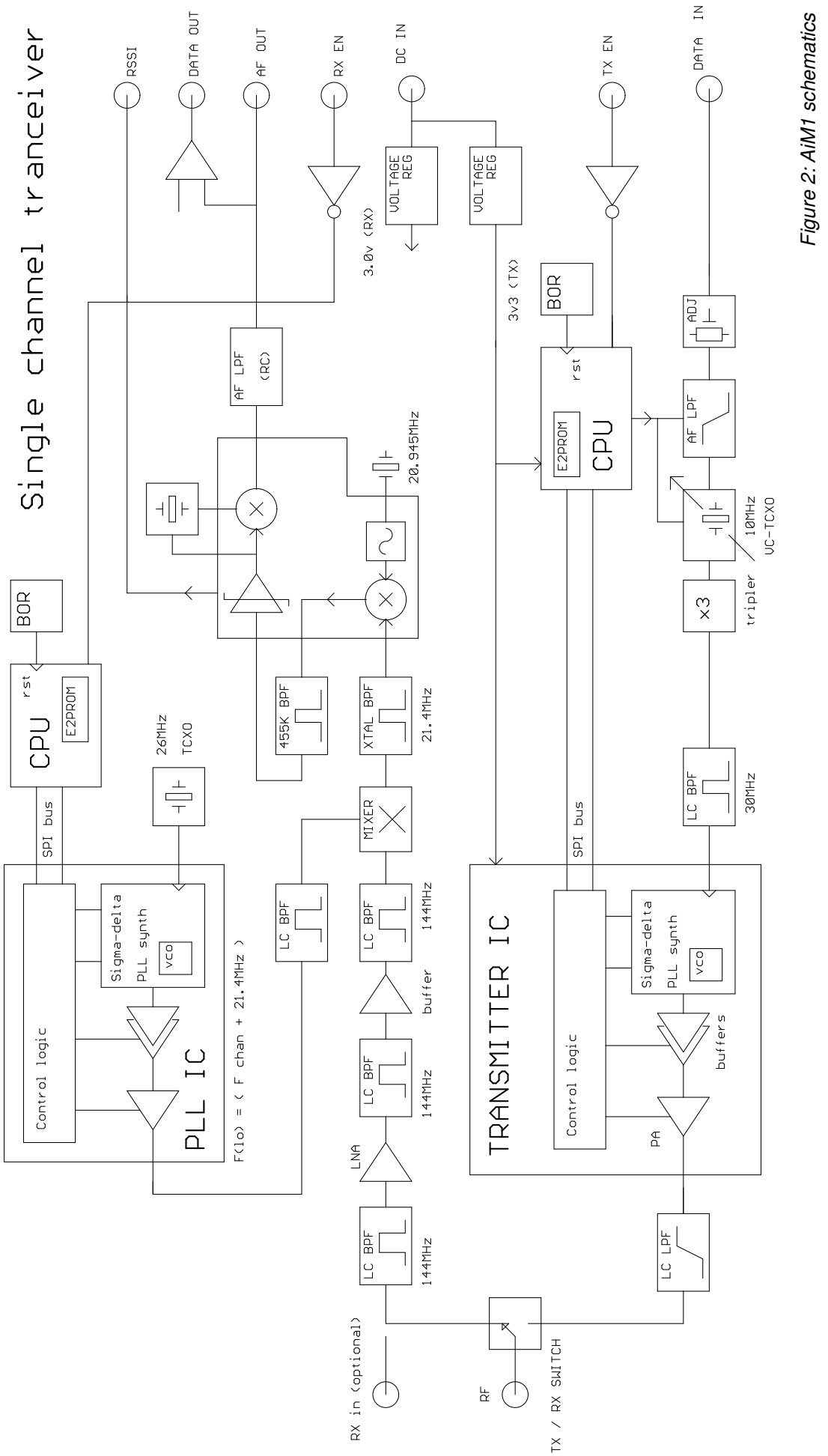


*Figure 2: AiM1 schematics*

## *Functional description*

The transmit section of the AiM1 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 AiM1 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 frontend 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*

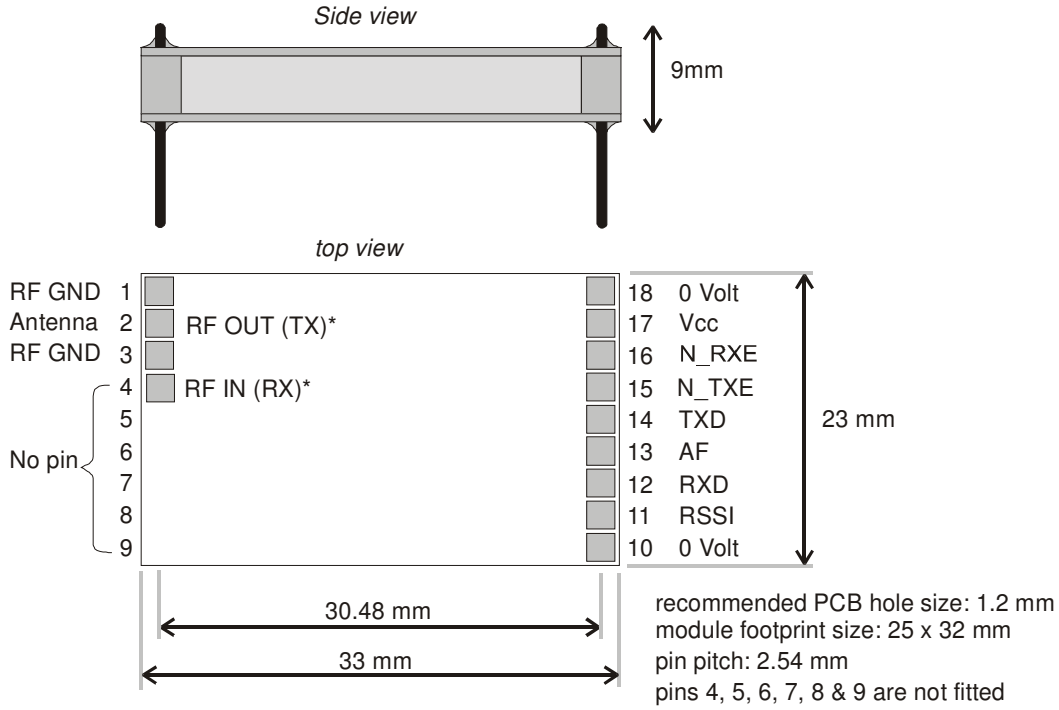


*Figure 3: AiM1 pin-out and dimension*

| AiM1 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 AiM1 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 | | | 144.390 | | 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 frequency with in the 120 - 175MHz range
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 AiM1 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 AiM1 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:

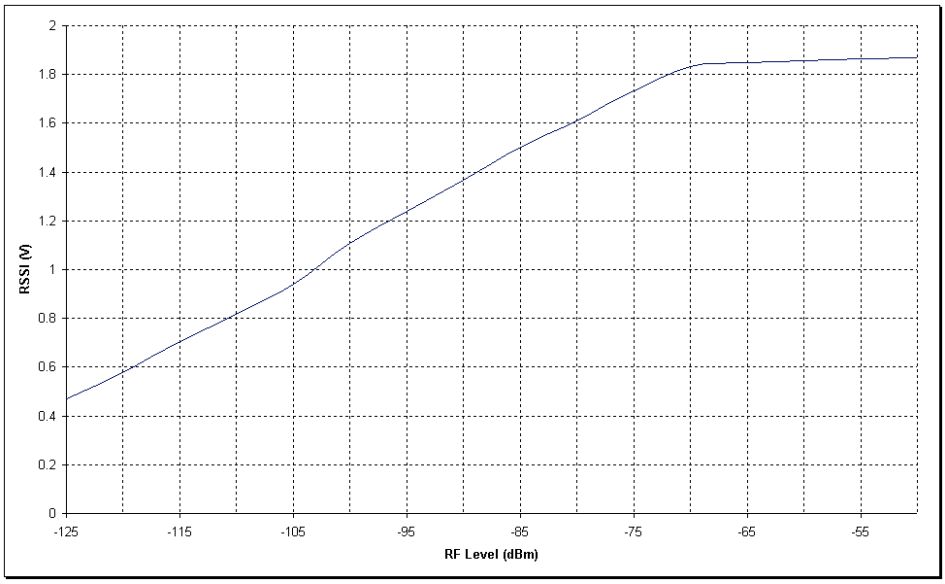


*Figure 4: RSSI level with respect to received RF level at AiM1 antenna pin*

## *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 AiM1 TXD input is often driven directly by logic signals, but will also accept analogue drive (e.g. suitably conditioned voice). 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 AiM1 is highly linear, and tx distortion figures well under 5% should be seen. At the other end of the link the AiM1 RXD pin may be used to drive an external decoder, or the audio can be taken from the AF out pin to further audio processing and amplification circuits

Although the modulation bandwidth of the AiM1B 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 AiM1B audio output.

The AiM1B 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.

### *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 AiM1T transmitters, AiM1R receivers and AiM1 transceivers are manufactured in the following variants as standard:

| | | |
|---|---|---|
| *At* 144.390*MHz*: | AiM1-144.390-5 | Transceiver |
| | AiM1T-144.390-5 | Transmitter |
| | AiM1R-144.390-5 | Receiver |

*(These can be reprogrammed on any frequencies with in the 144 - 146MHz band)*

### ***AiM1 with separate TX and RX RF ports:*** AiM1-144.390-5-TR

The AiM1 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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