Radiometrix

Hartcran House, Gibbs Couch, Watford, WD19 5EZ, England

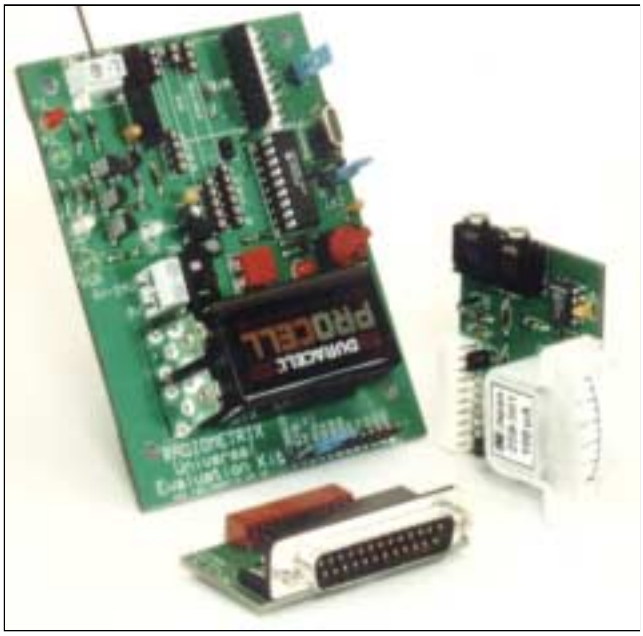
Tel: +44 (0) 20 8428 1220, Fax: +44 (0) 20 8428 1221

Issue 0202-1-1WW ***10 January 2002***

Universal Evaluation Kit

For TX1/RX1, TX2/RX2, TX3A/RX3, BiM, BiM2 and BiM3

This development system can be used to evaluate all the Radiometrix VHF/UHF transmitter, receiver and transceiver modules. LED indicators are provided to show system status and to facilitate range testing and site surveys. The board is controlled by the Eval-RPC chip and incorporates several useful diagnostics & debug modes. Link-selectable 9.6kbps or 40 kbps data rate caters for all modules in the Radiometrix range.



Universal Evaluation Board

Range of facilities include:

- Range Testing
- Target Environment Testing
- Noise and Interference Identification
- Antenna Evaluation
- TX1/RX1, TX2 /RX2, TX3A/RX3 and BiM/2/3 hardware test
- Transient Analysis
- Communication Eye Diagram
- Analogue and digital data transmission
- Received Signal Strength Indicator (RSSI) meter
- Linking external hardware directly or via on board Eval RPC
- Responses up to 9.6kbps (A) or 40 kbps (F)

The Eval-RPC (PIC16F84A-20I/P microcontroller) is based upon a modified RPC-000-DIL design and provides management of all the necessary data and control lines. The user can define both operational mode and data bit rate simply by selecting the required positions on the provided DEBUG switch and the various jumpers. Indication of unit status is provided by means of LEDs for Power, Transmit, Receive, Carrier Detect, Signal and OK (link success) functions.

Check List

The Universal Evaluation Kit should include the following components and documentation:

2	Analogue input/output boards
2	Parallel port interface adaptor
2	9V battery (PP3)
2	1/4 wavelength whip for 418/433MHz, 869/914MHz and helical antennas for 173MHz
2	16.384MHz crystals for 64kbps operation

In addition to the above a 2-channel (or even better, a 4-channel) digital storage oscilloscope is highly recommended as a means of monitoring system operation.

Visual Facilities

The following status LEDs will be activated depending on which mode is selected:

LED	Indication
TX (Red):	Transmitter enabled;
RX (Green):	Receiver enabled;
CD (Orange):	Carrier / Interference detected
SIGNAL (bright Red):	Preamble detected
OK (bright Yellow):	Valid packet received / Test passed

The Received Signal Strength Indicator (RSSI) meter on the analogue I/O board provides an indication of the received RF signal power level, useful in range testing and when checking for interference.

Diagnostic Modes

Mode	Name	Function
0	RX-ON	Preamble detector on (SIGNAL LED lit = preamble detected)
1	RX-PULSE	10ms on: 10ms off, preamble detector on SIGNAL LED
2	TX-ON-PRE	Preamble modulation – send continuous preamble on TX
3	TX-ON-SQ	100Hz square wave modulation, for TX testing using spectrum analyser, etc.
4	TX-ON-255	40kbps pseudo-random data for eye diagram tests, sync on RXR
5	TX-PULSE	10ms on / 10ms off, preamble bursts for Rx lock-in tests
6	ECHO	Transponder mode, unit re-transmits any valid packets received
7	RADAR	Send ASCII test packet "Universal Eval Kit XX" and listen for echo
8	SELF-TEST	Local loop test, TX → RX (OK on RXR)
9 to E		For future updates on additional Modes, check the Radiometrix web site: www.radiometrix.co.uk/products/uniek.htm
F	Normal RPC	Normal Eval RPC mode allows external host microcontroller or PC interface

Jumper Links

Jumper Link	Function
LK1	Short TXR to 0V pin to enter diagnostic modes.
LK2	Select the data rate according to module requirements: Across left & middle pins (A position) for 9.6kbps, Across middle & right pins (F position) for 40kbps.
LK3	Remove to isolate Eval-RPC drive from the module TXD line when using external analogue or data input.
LK4	Insert to reduce Eval-RPC drive amplitude to TXD from 0-5V to 0-3V (for TX1, TX3A & BiM3 only).

LK1

Eval RPC has two modes of operation:

1) Normal mode
2) Diagnostic mode

In normal mode, the Eval-RPC behaves similarly to a Radio Packet Controller (RPC). The board can be used in conjunction with a host microcontroller or PC to transmit & receive packetised data. Diagnostic mode can be used to evaluate system performance in the intended environment.

LK2

This link connects the appropriate crystal to the Eval-RPC oscillator circuit for data bit rate selection.

Crystal Frequency

All timings within the Eval RPC (except sleep) are determined by the clock frequency. The standard frequencies are 2.4576MHz and 10.24MHz.

$$\text{Data Rate} = \frac{f_{crystal}}{256} \quad \text{bps}$$

Figure 1: Jumper selection for data rate

When the Jumper is placed as shown on the above left diagram, 2.4576MHz, the Eval RPC will transmit data at 9.6kbps.

$$\text{Data rate} = \frac{2.4576\times10^6}{256} = 9600\text{bps} \qquad \text{Data rate} = \frac{10.24\times10^6}{256} = 40000\text{bps}$$

TX3A/RX3 and BiM2/3 module performance at 64kbps can be evaluated by replacing one of the standard crystals with the16.384MHz unit supplied.

LK3

The module TXD line is normally driven directly with data from the Eval-RPC chip. However, it can also be driven from an external digital or analogue source if required. In this case, removing LK3 allows the TXD line to be isolated from the internal Eval-RPC drive for correct operation.

LK4

The TX2, BiM and BiM2 operate on 5V supply and hence their TXD input can be in 0-5V range. However, TX1, TX3 operate internally on 3V supply and their data input should be in 0-3V range (TX1) or 0-2.5V range (TX3A).

Very high input impedance of TXD with R4 (3.3k) resistor in parallel combination will give effective impedance equivalent to R4 (3.3k) resistor. R3 (2.2k) and R4 (3.3k) will form a potential divider reducing the logic level from 0-5V to 0-3V range.

$$V_{TXD} = \frac{3.3\text{k}\Omega}{3.3\text{k}\Omega + 2.2\text{k}\Omega}\times 5\text{V} = 3\text{V}$$

Diagnostic Modes

To enter the DEBUG mode, Jumper Link (LK1) (below the 9V battery) should be connected across TXR and 0V pin. The RESET button should be pressed while the Jumper Link is connected across TXR and 0V.

Note: All the Oscilloscope screen capture and Spectrum Analyser screen capture given on the manual are instantaneous and they will vary with time.

Mode 0 - Preamble Detector

Applies to Evaluation Kit with Receiver:

Insert Receiver module in one of the Evaluation Kit and Transmitter module on another.
Transmitting and Receiving unit should operate at same data rate. i.e. LK2 position on both evaluation kit should be same position on both evaluation kits.
If the jumper LK2 is at position A, the preamble will be a 4.8kHz or 9.6kbps square wave signal.

In this mode, receiver is continuously powered up (RX LED on) and if preamble, 20kHz or 40kbps square wave signal, with jumper LK2 at position F, is detected the SIGNAL line is pulled low lighting the SIGNAL LED. RXR will also be pulled low lighting the OK LED to indicate that valid preamble was received.

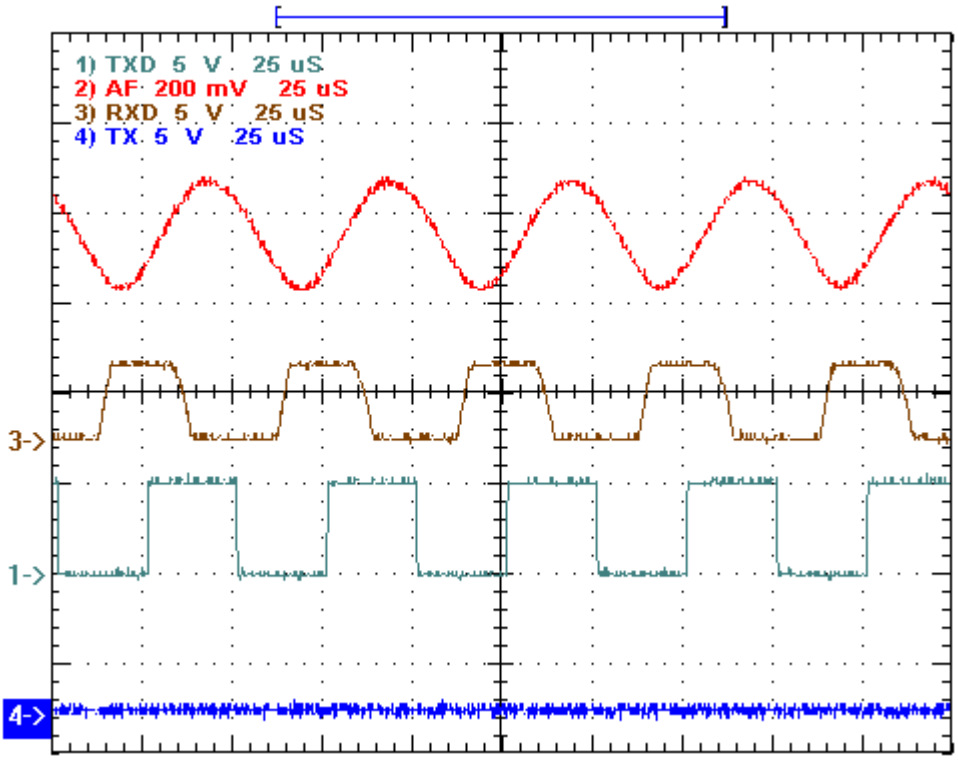


Figure 2: Transmitted and received preamble (40kbps square wave signal)

In the above screen capture of a 4-channel oscilloscope:

An Evaluation Kit with TX2 is powered on (TX LED on) continuously (Mode 2) to transmit preamble. The TX line is held low (blue TX waveform) by the Eval-RPC and it feeds 20kHz square wave signal into TXD pin (green TXD waveform) of the TX2. Oscilloscope is triggered on TXD.

Other Evalation Kit with RX2 is also powered on (green TX LED on) continuously (Mode 0). AF output (red AF waveform) and RXD output (brown RXD waveform) are monitored.

The AF output is at 1.16V DC with about 240mV AC sine wave, which is digitised by the Adaptive Data Slicer in the RX2 to re-produce the received preamble. (Ground level of AF is at the bottom of the screen)

Note: Mode 0, with LK3 removed, can be also be used as RX On mode to switch on the receiver, when feeding analogue signal or external data.

Mode 1 - Pulsed Receiver

Applies to Evaluation Kit with Receiver:

Receiver is switched on for 11ms and Eval RPC checks for preamble. If preamble is detected the SIGNAL line is pulled low. This will light up the SIGNAL LED. If not, the Receiver is turned off for 8ms and the process is repeated. OK LED will also light up if a valid Preamble is detected.

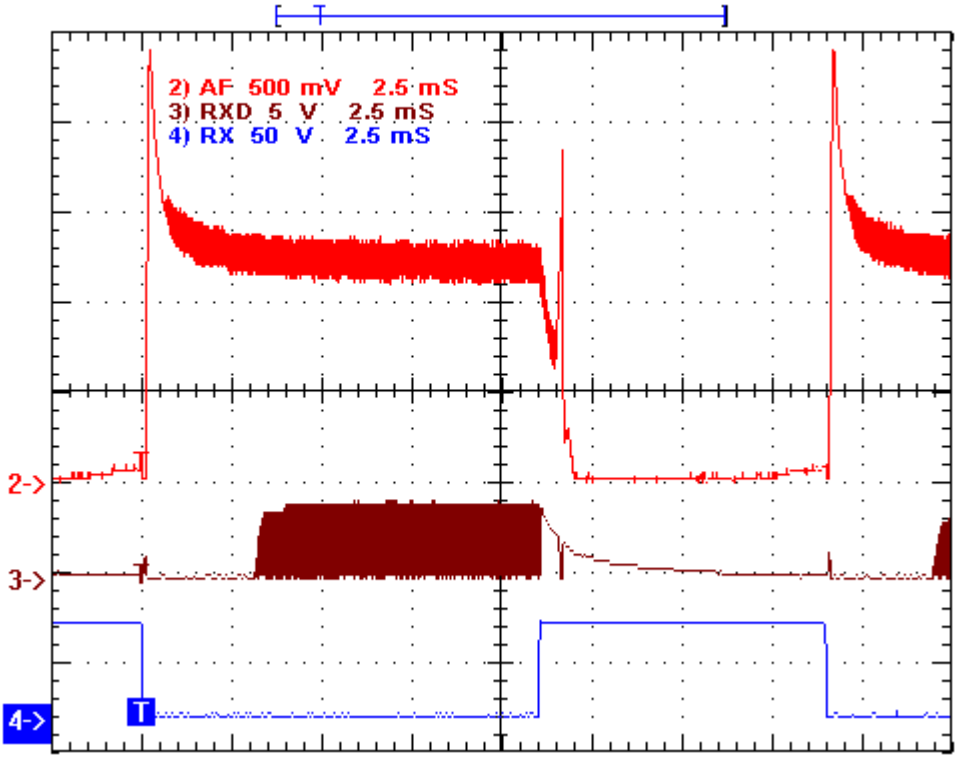


Figure 2: Transmitted and received preamble (40kbps square wave signal)

This mode can be used to test the power up time and settling time of the receiver module.

Mode 2 - Transmit Preamble Modulation

Applies to Evaluation Kit with Transmitter:

Transmitter is turned on continuously and preamble is transmitted. This complement mode can be used with Mode 0 as a pair.

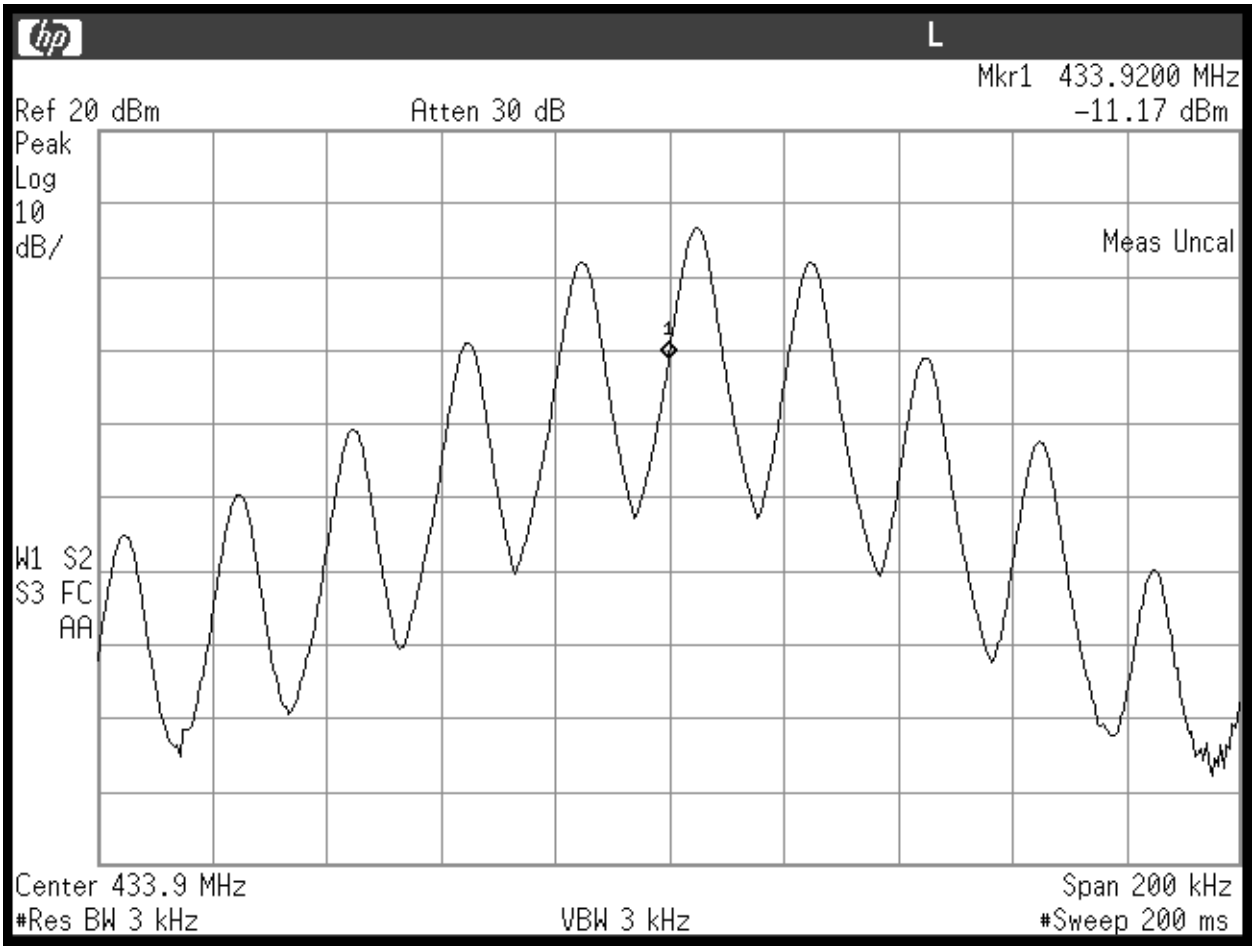


Figure 4: TX2-433-40 transmitter spectrum with 20kHz (40kbps) square wave modulation

The above frequency spectrum shows a Carrier Frequency in the middle and FM side bands on both sides. Each side band is spaced 20kHz apart.

Note: Mode 2, with LK3 removed, can be also be used as TX On mode to switch on the transmitter, when feeding analogue signal or external data.

Mode 3 - Transmit 100Hz (200bps) square wave modulation

Applies to Evaluation Kit with Transmitter

Transmitter is turned on and the carrier is modulated by 100Hz or 200bps square wave signal. This mode can be used to test the Transmitter on a Spectrum Analyser. It can be used to measure RF power output, FM deviation, bandwidth, etc.

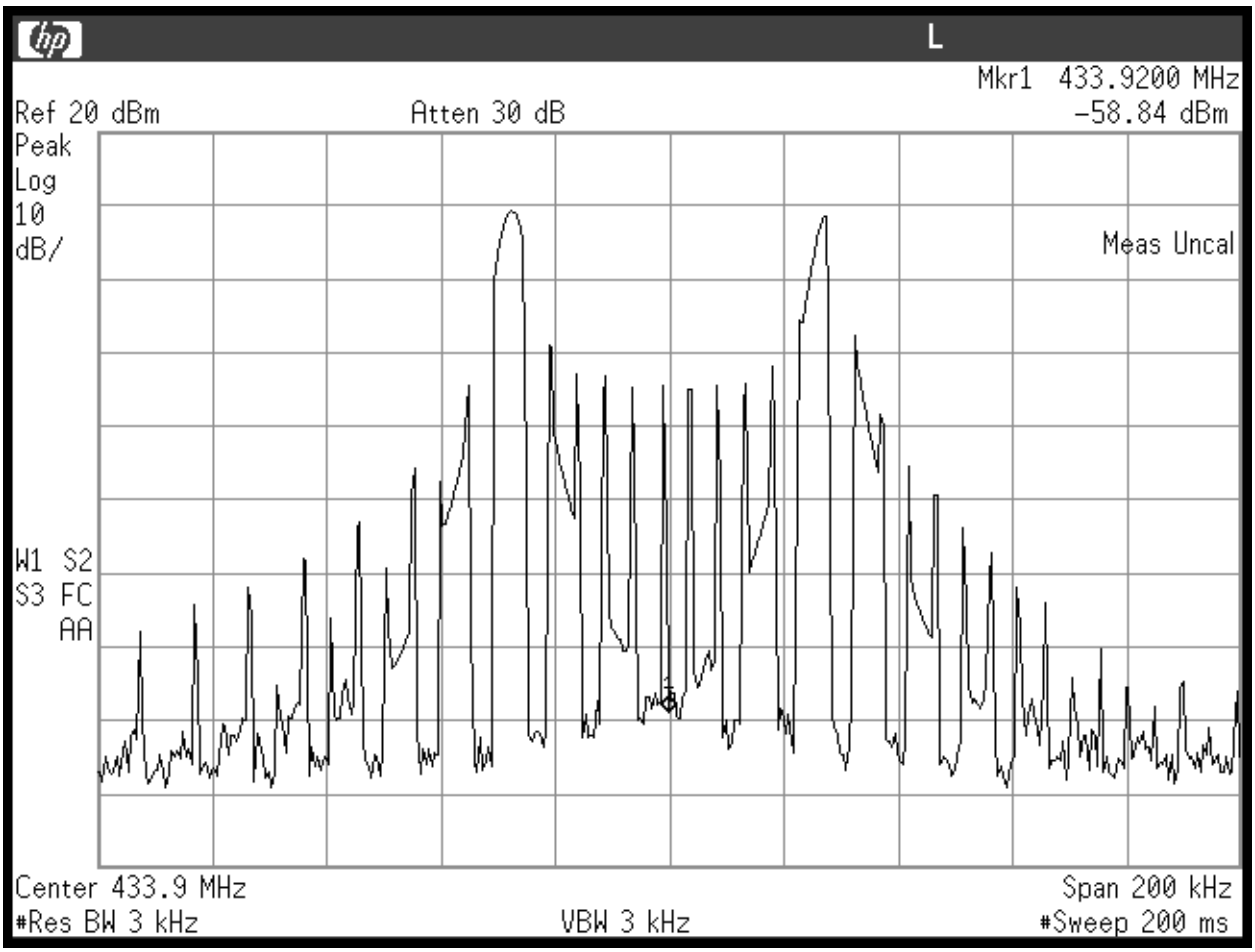


Figure 5: TX2-433-40 transmitter spectrum with 100Hz (200bps) square wave modulation

The RF output power on the above spectrum is the maximum peak value of about +10dBm. The above spectrum shows 2 prominent peaks. The peak to peak width is twice the FM deviation value. Left peak will be at same position as unmodulated carrier when TXD is at 0V. Right peak will be at the same position as unmodulated carrier when TXD is at 5V.

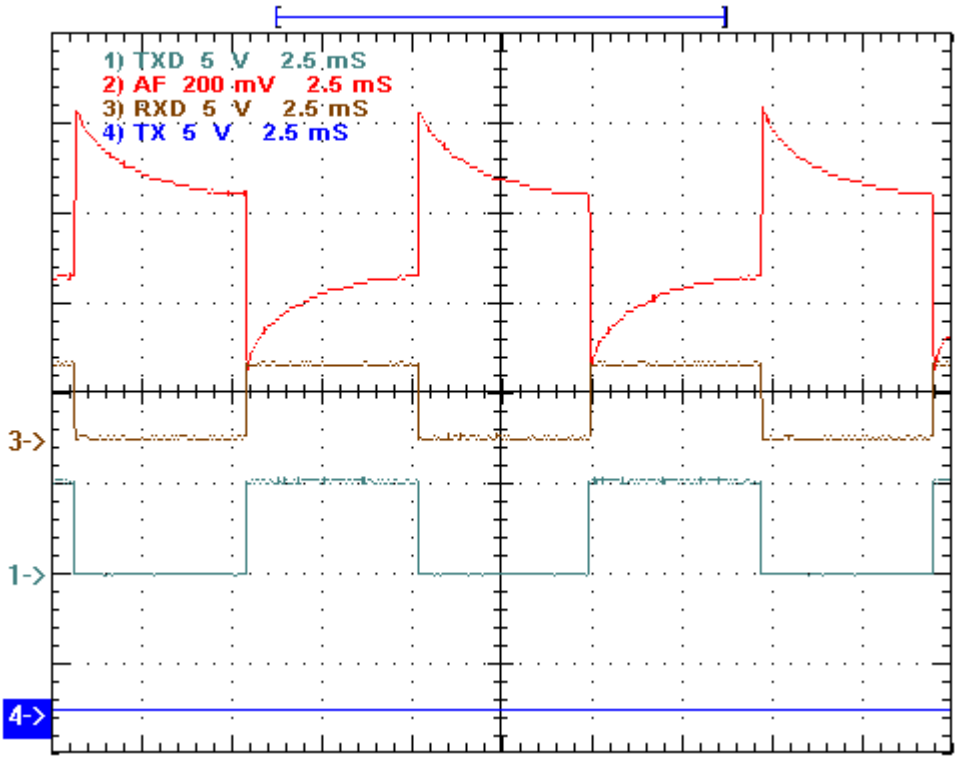


Figure 6: Transmitted and received 100Hz (200bps) square wave signal

RF Carrier will not be modulated by the data from Eval RPC if the LK3 is removed. The spectrum of unmodulated carrier with TXD held at 0V is given below.

Figure 7: Unmodulated TX2-433-40 transmitter spectrum when TXD is at 0V

Mode 4 - Transmit Random Code

Applies to Evaluation Kit with Transmitter:

Transmitter is turned on and the carrier is modulated by a 8 bit maximal length (255) pseudo-random code at 25.6µs per bit (at 40kbps). On the receiving end, the data output RXD line can be connected to an Oscilloscope to obtain an eye diagram.

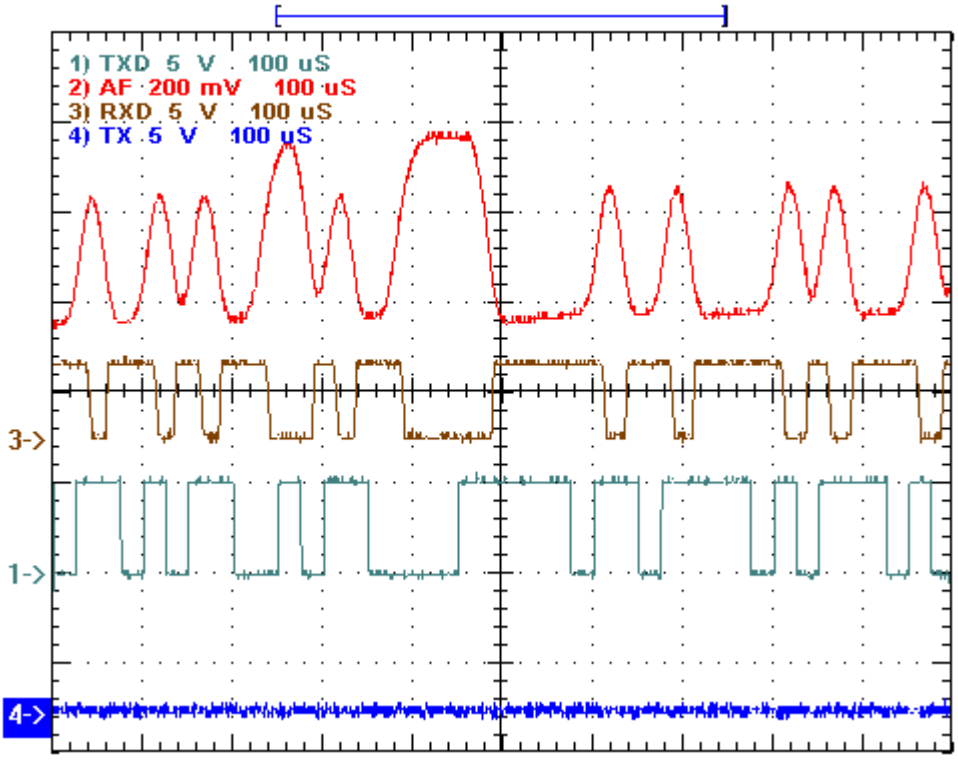


Figure 8: Transmitted and received pseudo-random code

An eye diagram is an oscilloscope display in which a pseudo-random digital data signal from AF output of a receiver is repetitively sampled and applied to the vertical input, while the data rate (RXR) on the transmitting unit is used to trigger the horizontal sweep. The picture one obtains is a superposition of ones and zeros output.

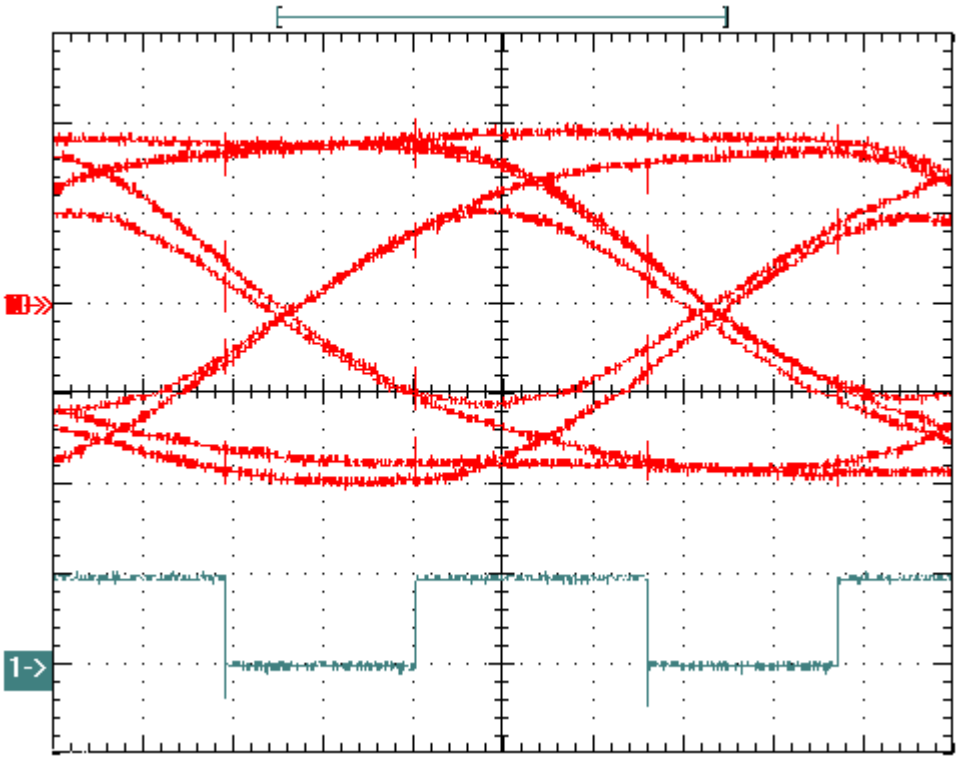


Figure 9: eye diagram of RX2-433-40 receiver

System performance information can be derived by analyzing the display. The horizontal width of the lines gives the jitter (phase noise) and the rise and fall times of the data pulses can be measured from the "crossings". An open eye pattern corresponds to minimal signal distortion. Distortion of the signal waveform due to intersymbol interference and noise appears as closure of the eye pattern.

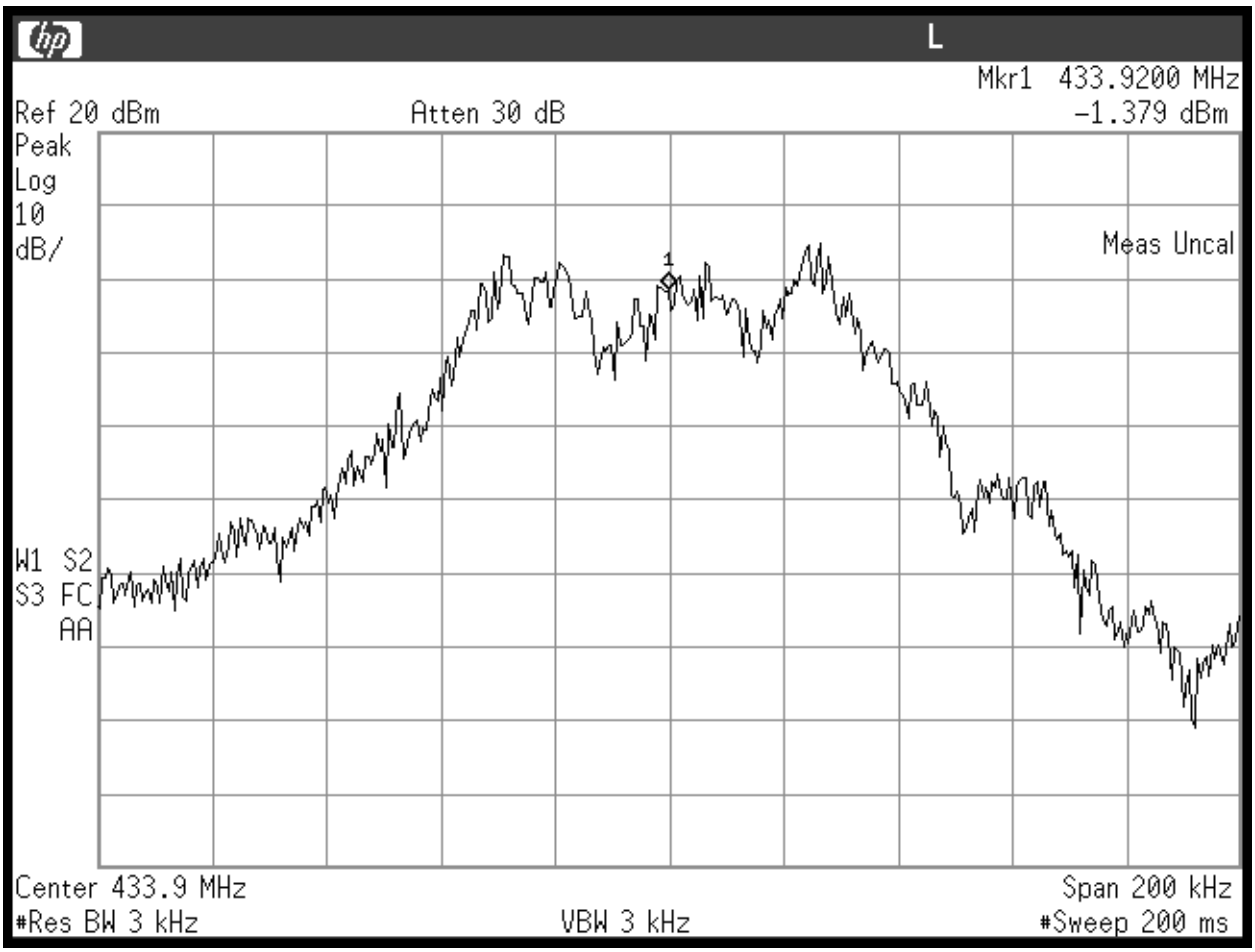


Figure 10: spectrum of TX2-433-40 when transmitting pseudo-random

Mode 5 - Pulsed Preamble Transmitter

Applies to Evaluation Kit with Transmitter:

The transmitter is turned on and normal preamble (length used for normal data transmission) is sent. Then transmitter is turned off and waits for equal amount of time before another cycle.

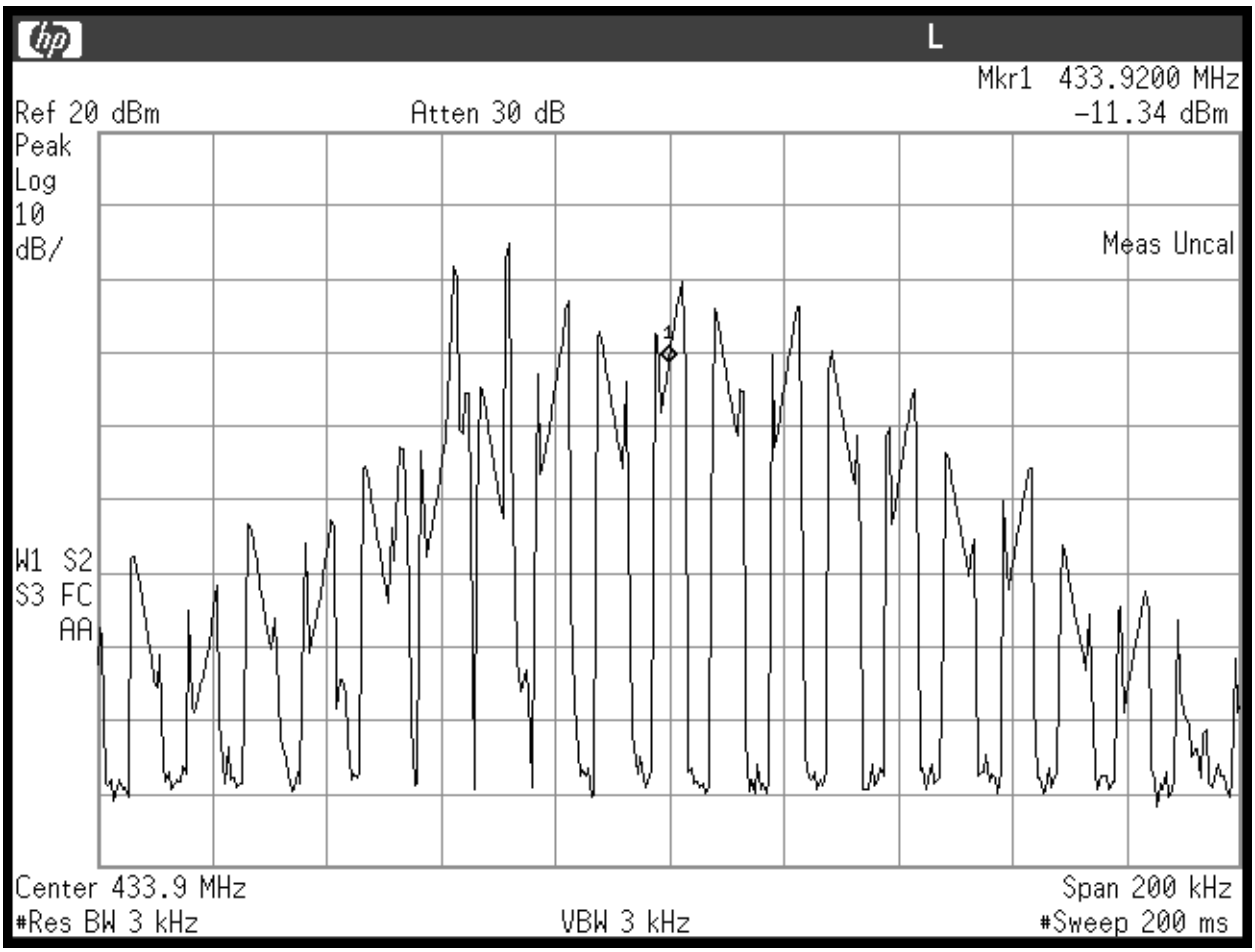


Figure 11: spectrum of TX2-433-40 when transmitter is pulsed to transmit preamble

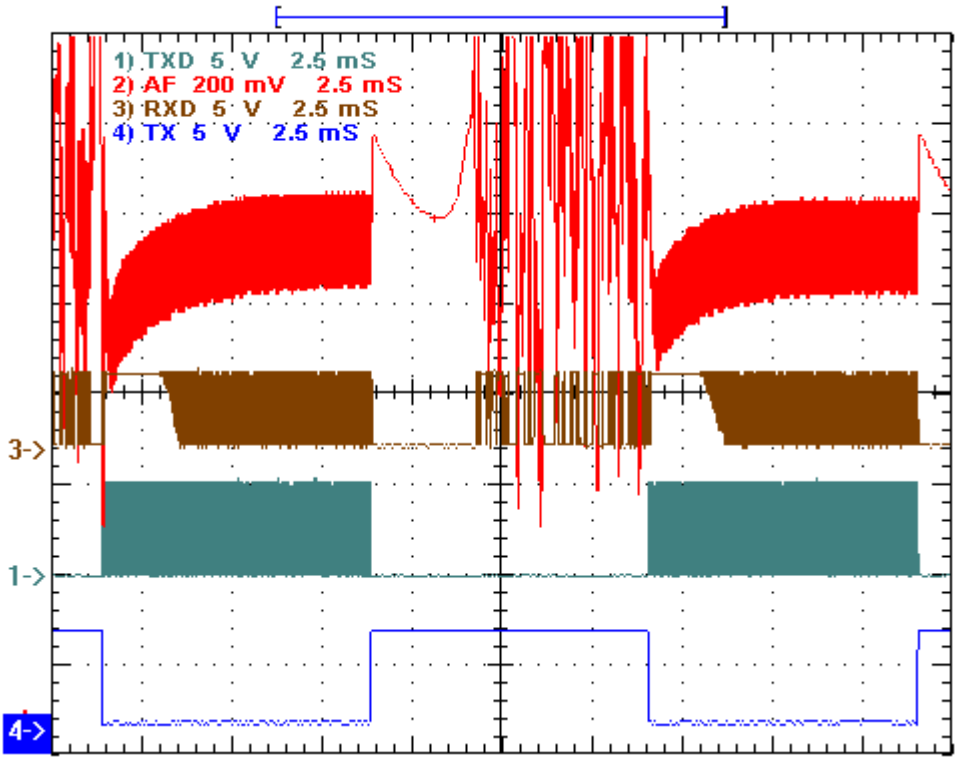


Figure 12: pulsed preamble transmission and received preamble

This mode can be used to test the power up time of transmitter and settling time of the receiver module when receiver is powered up.

Mode 6 – Echo

Applies to Evaluation Kit with Receiver (and Transmitter):

Receiver is turned on. Checks for preamble and if it finds a preamble, then it locks on to the data and receives the data packet. SIGNAL LED will be turned on if the preamble is detected.
Then error check is carried out and if it passes, the OK LED is turned on and waits for a Transmit to Receive Change Over Delay period. Then it retransmits (echoes back) the packet to the transmitter.

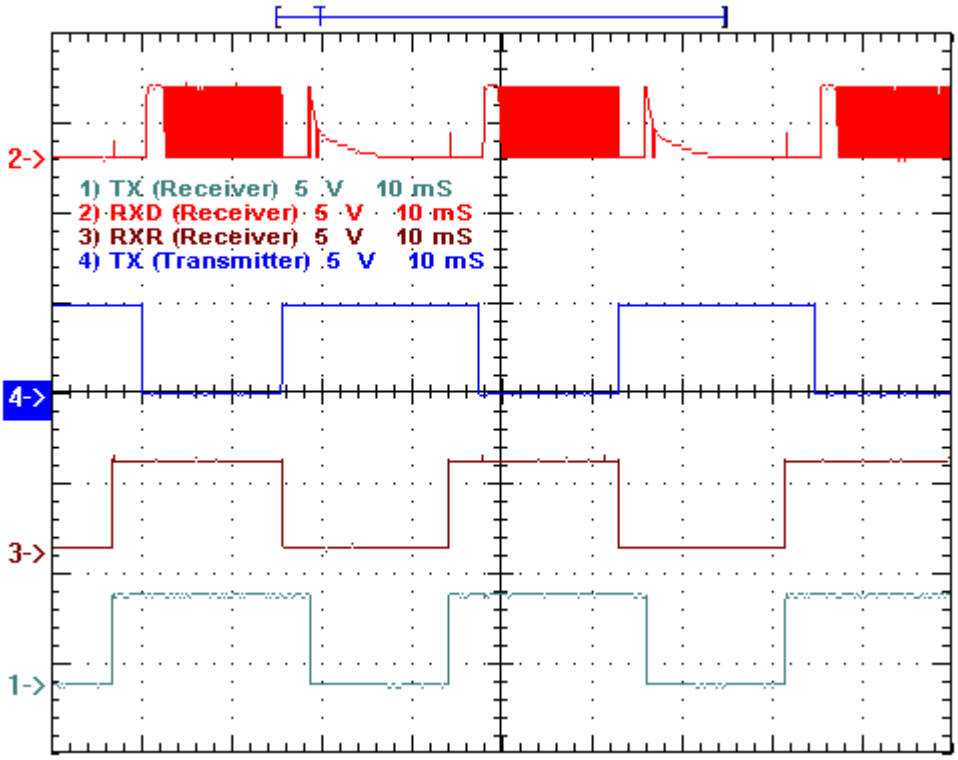


Figure 13: Receiver unit echoing back to transmitting unit on every valid packet

The above oscilloscope screen capture shows RXR line pulled Low every time valid packet is received. Same RXR line activates the OK LED.

In the oscilloscope screen capture below, the receiving (mode 6) unit's echo did not reach the transmitting (mode 7) unit. Therefore, transmitting moves onto transmitting next packet after waiting for the time required to detect preamble of the echo packet.

Note: This may also happen if the Transmitter is removed from the receiving (mode 6) unit.

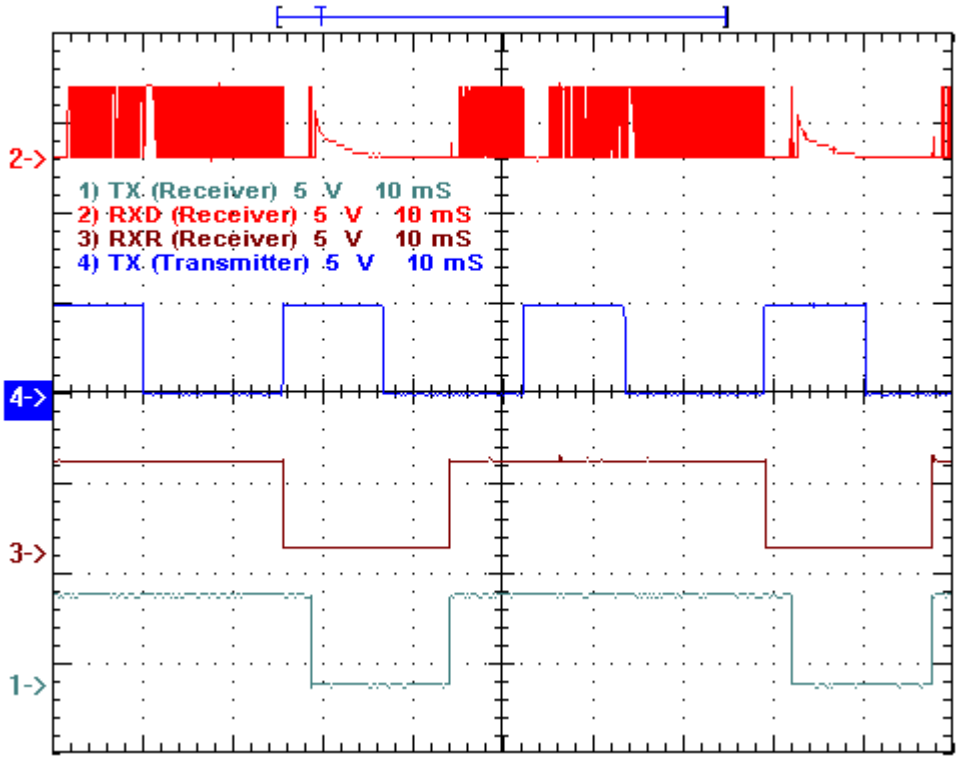


Figure 14: Transmitting unit moves to next transmission because echo was not received

Mode 7 – Radar

Applies to Evaluation Kit with Transmitter (and receiver):

Transmitter is turned on and sends a packet with **Universal Eval Kit XX** as data where XX will be a Packet Counter from 00 to 63. Then transmitter is turned off and receiver is turned on for 8ms. Checks for preamble and if it finds a preamble, then it locks on to the data and receives the packet. Then error check is carried out and if it passes, the SIGNAL LED is turned on.

Nevertheless, it will continue the above process but the packet counter value will be increased with each transmission.

This mode can be used along with Mode 6 (Echo Mode) to function as a 'Pin-Pong' system. This provides a very effective method for Range Testing and Antenna Type Evaluation.

If one eval kit is set to Mode 6, then other eval kit can be set to Mode 7. By walking around the site where the final product based on the Radiometrix Modules are going to be used, the range and antenna type requirements, interference, etc could identified well in advance. The OK LED will be ON as long as the 'Ping-Pong' the units are within the radio range and the wireless link is error free.

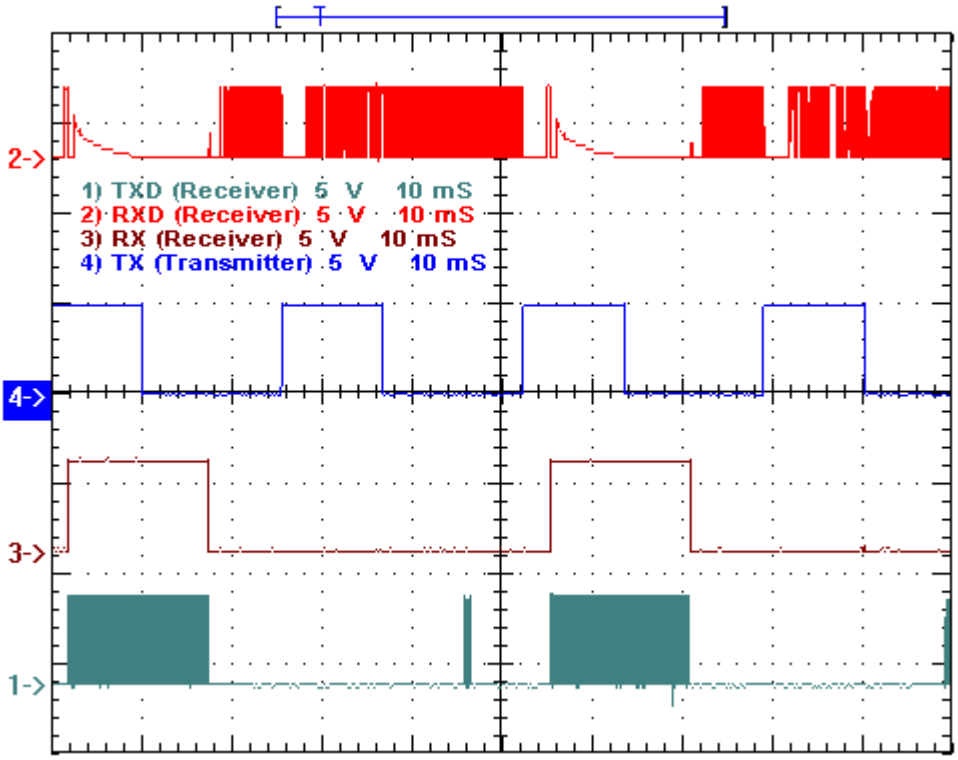


Figure 15: Receiver unit sampling (TXD output) received data bit but echo was not received

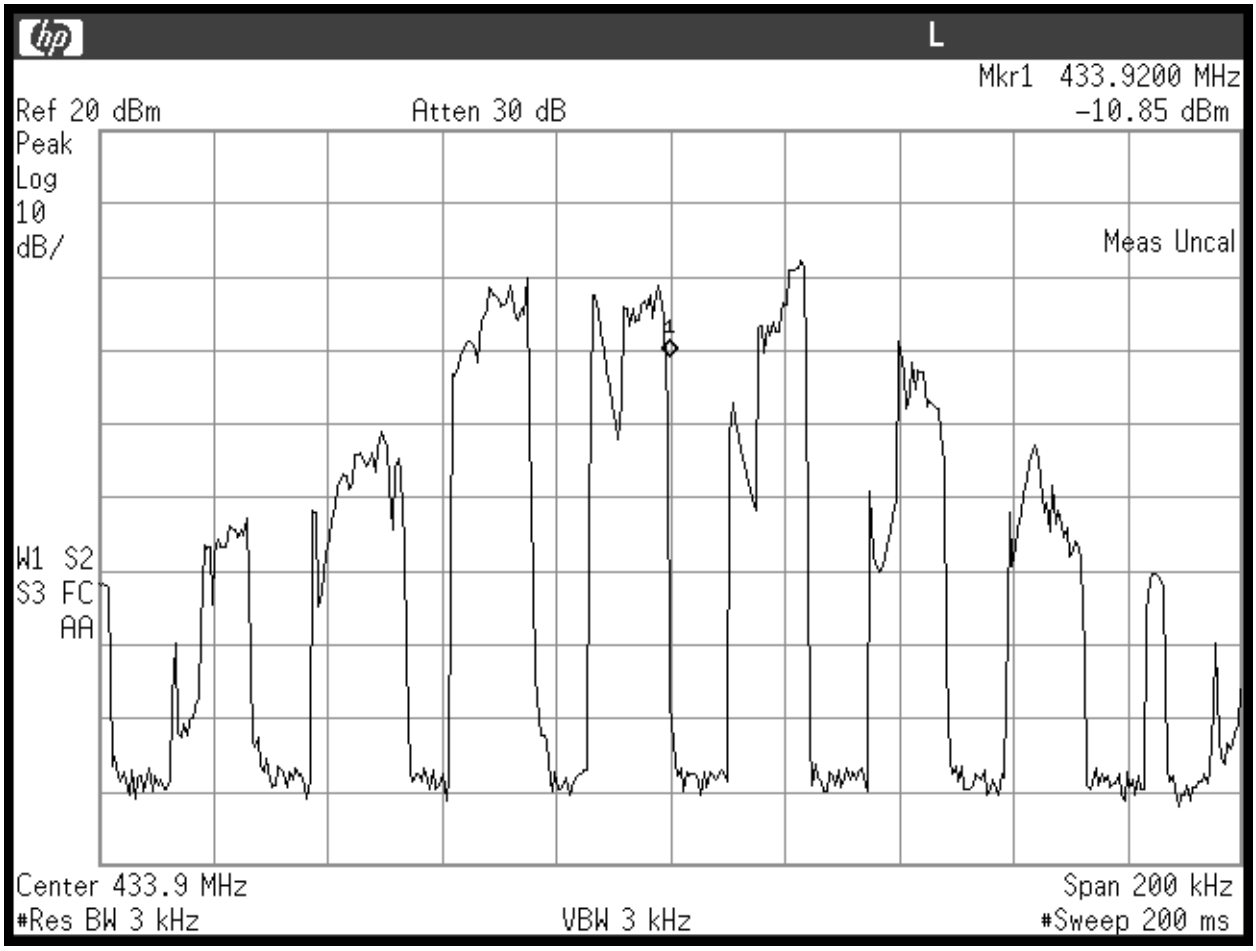


Figure 16: spectrum of TX2-433-40 when transmitting radar mode ASCII data packet

Mode 8 – Local Loop Test

Applies to Evaluation Kit with both Transmitter and Receiver:

This RPC-000-DIL puts the transceiver or transmitter & receiver pair into a local loop back (both TX & RX on), a test code is continuously sent and recovered. The SIGNAL LED will light to indicate a pass.

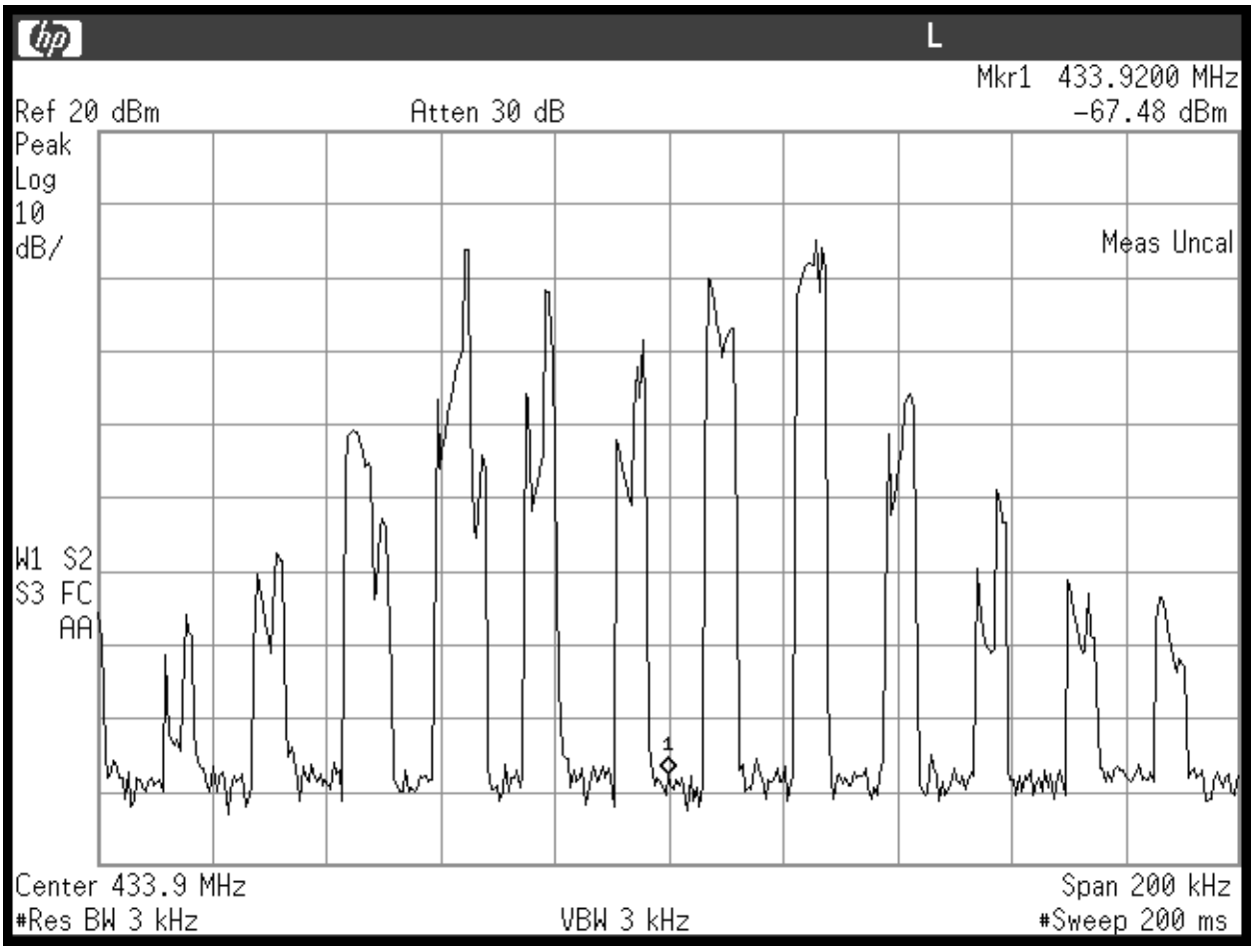


Figure 17: spectrum of TX2-433-40 when transmitting unbalanced test code

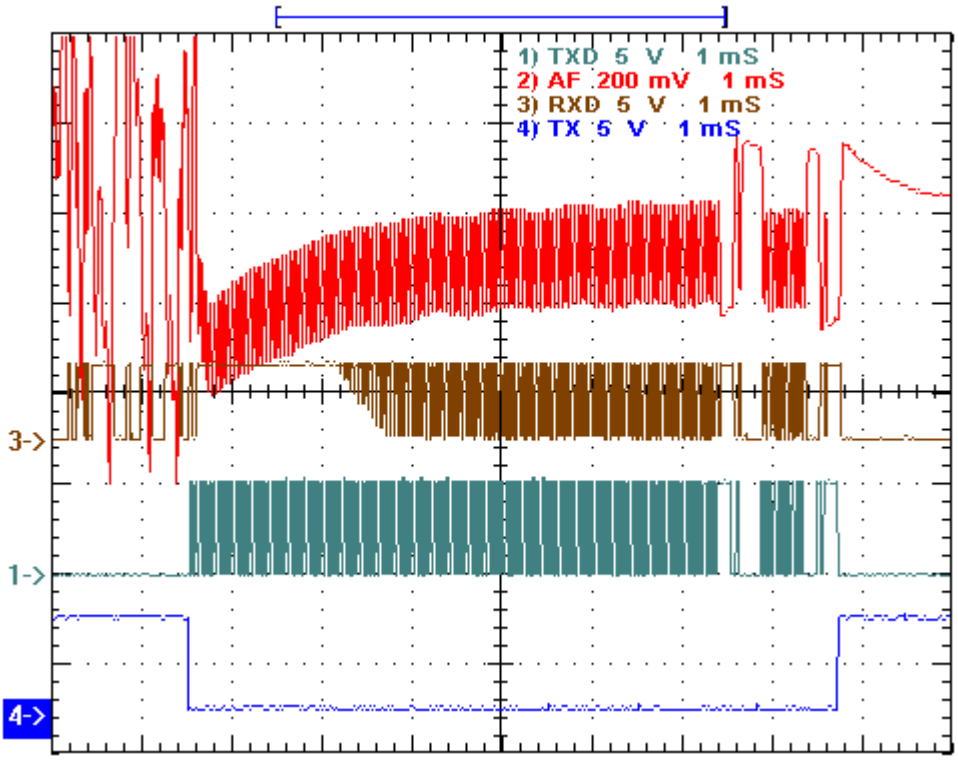


Figure 18: Transmitted and received unbalanced test code

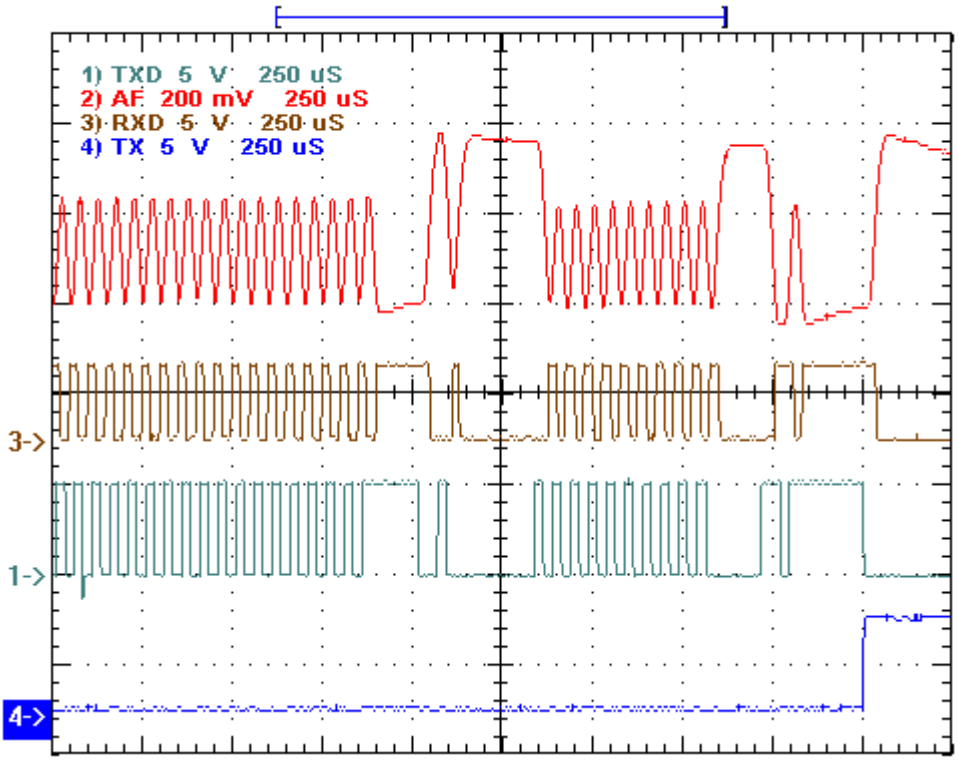


Figure 19: expanded view of the unbalanced test code

The above waveform shows the test pattern used to evaluate receiver and its Adaptive Data Slicer.

Mode F – Normal RPC Mode

Jumper Link (LK1) (below the 9V battery) should be removed and the RESET button should be depressed.

This will effectively put the Eval RPC into normal (non-diagnostic) mode. Therefore, any interface cable with Host Microcontroller or Parallel Port of a PC can be interfaced with the Eval Kit.

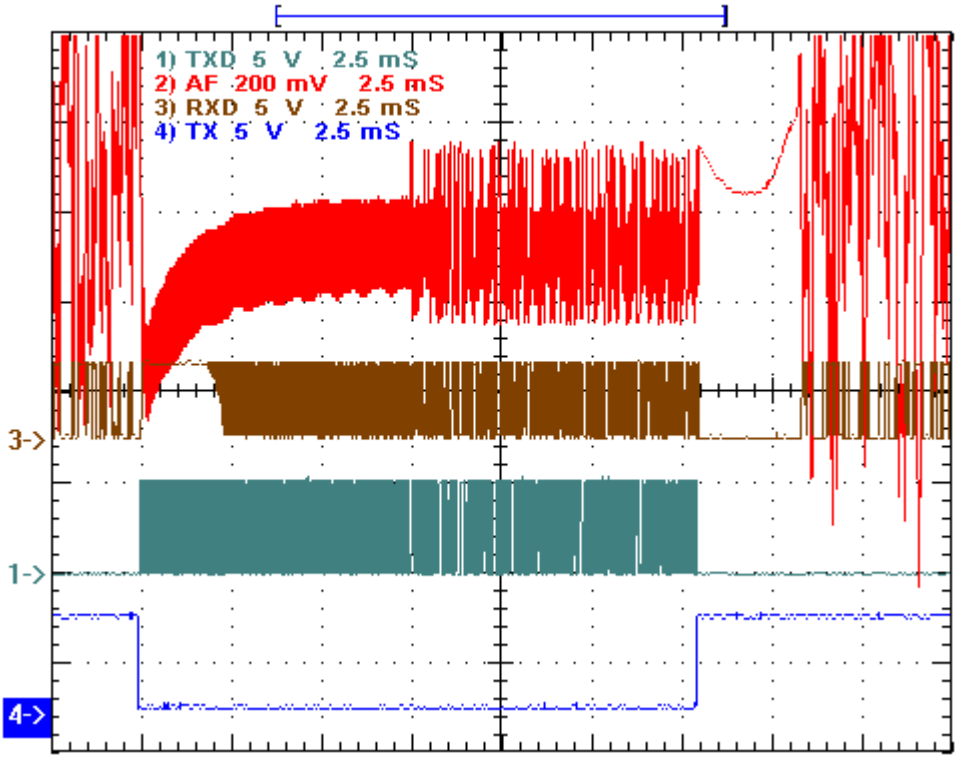


Figure 20: Transmitted and received 27-byte (full length) data packet

The trace below is a close up of the transition from preamble to Data to 12-bit encoded data bytes with 7 bit Barker sequence in the middle used to identify the start of the encoded data bits.

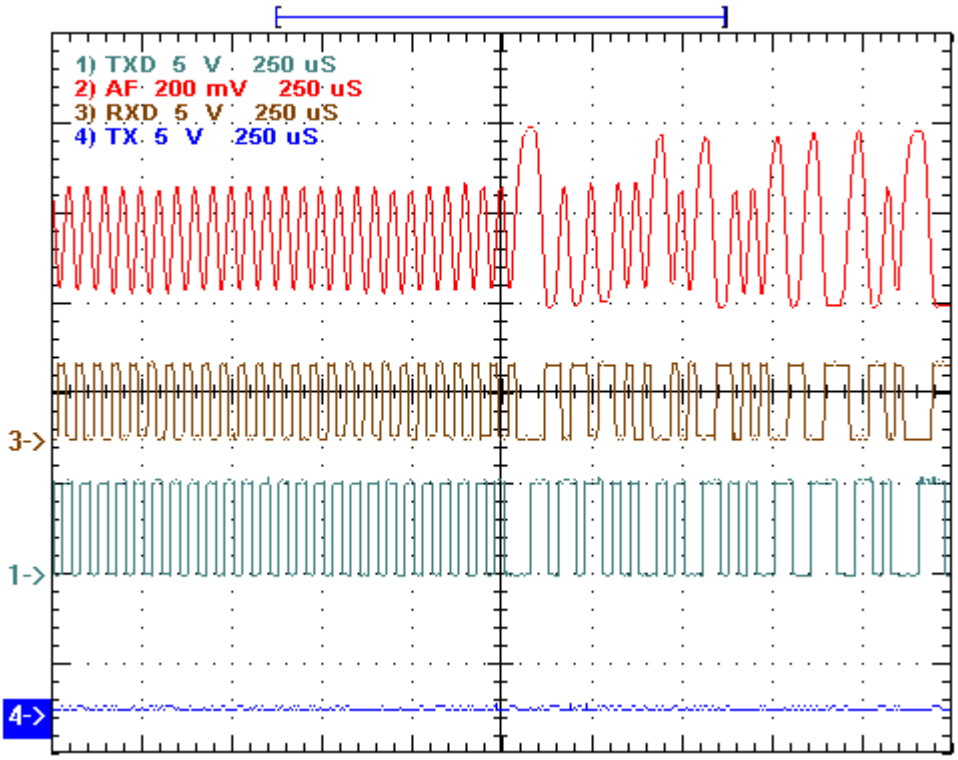


Figure 20: Expanded view of the preamble to encoded data bit transition

More details on the above data packet format is given on pages 18-20 of the RPC data sheet.
http://www.radiometrix.co.uk/products/rpcsheet.htm

PC Interface

Parallel Port Interface Adaptor can be used to interface the Universal Evaluation Kit to Parallel port using standard D25 parallel port extension cable (One to One connection with D25 plug connector on one end and D25 socket on other end)

RPC Development Kit software can be used to view/modify the RPC EEPROM values. Data transmission can also be monitored using the same software.
This feature will help debug the host software routines in the design & development stage of a product..

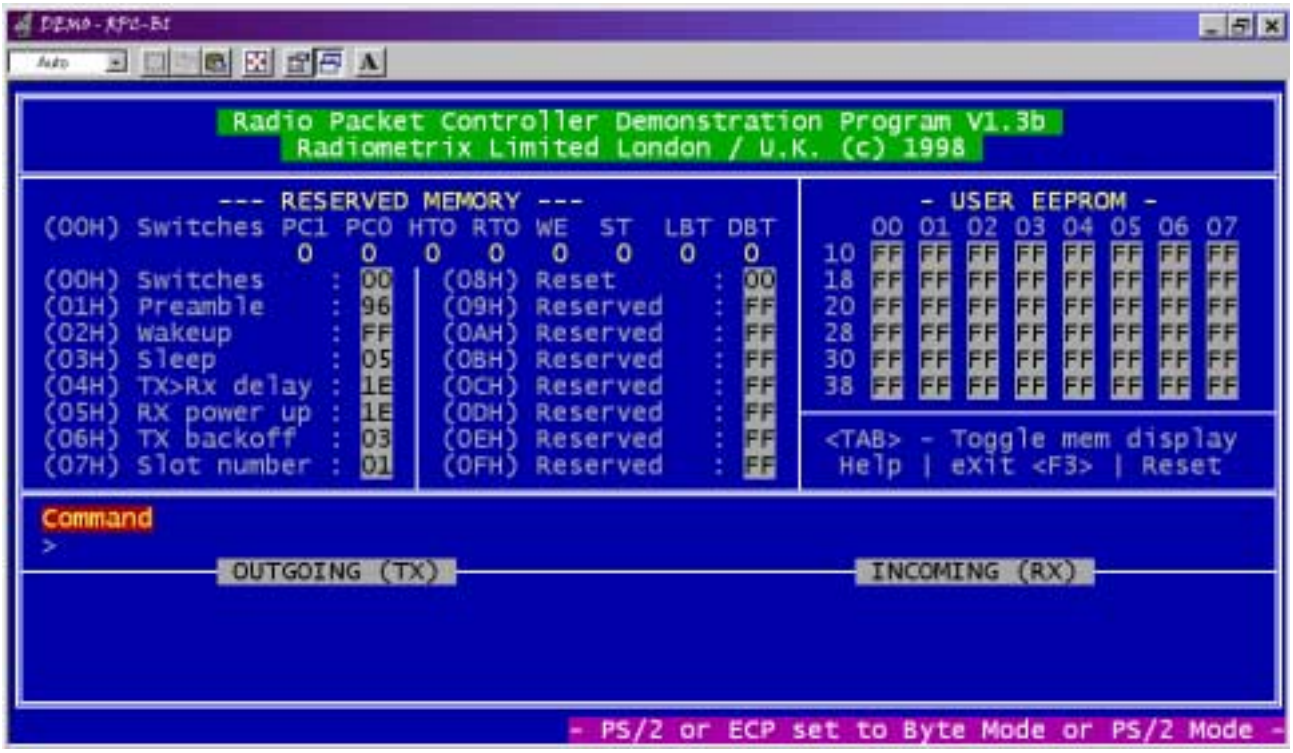


Figure 21: RPC Development Kit software showing the default EEPROM values of Eval RPC

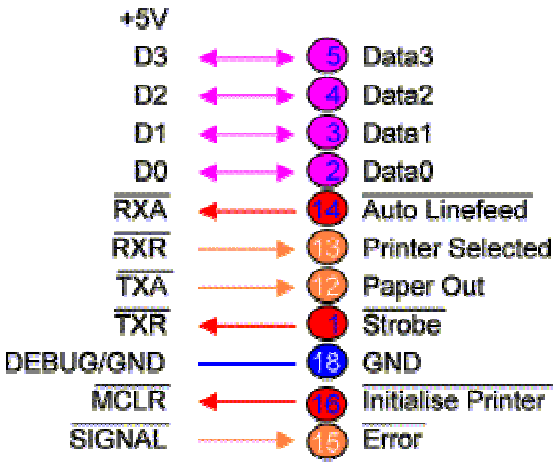


Figure 22: Eval RPC to Parallel port interface

Analogue Signal

Even though the Radiometrix modules are specifically designed for data transmission, they can also be used for analogue transmission excluding signals which contain DC level or very low frequency components.

Analogue I/O board should be connected to the 10-pin header (J12) on top right hand corner of the Evaluation Kit. Jumper link on LK3 should also be removed to isolate the TXD line from Eval RPC.

Analogue I/O contains

1) Small signal analogue input with amplifier
2) Buffered audio output for stereo headphone/speaker.

DC component in the analogue signal is removed via capacitor. A simple common emitter amplifier with negative feedback is used to amplify the small AC signal from few mV to few Volts. Signal level on TXD pin should be large enough to cause enough FM deviation on the RF carrier of the transmitter. Otherwise, the small demodulated AF output, under poor signal to noise ratio (S/N) conditions, will be indistinguishable or submerged in the noise. The AC signal is also biased slightly below the mean DC level of the TXD to minimise signal distortion.

User can either feed an AF signal generator output through the Analogue In and receive the analogue output on the other kit to evaluate the performance of the module under various signal frequencies and amplitudes.

Note: a large signal on the Analogue input will saturate the amplifier and clipping may occur on the amplified signal.

Audio Frequency (AF) output can be monitored with an headphone or speaker to identify any noise or interference source in the environment. It can also be connected to Line In of a PC. User can walk around the building or field with the receiving kit while constantly listening to the Analogue Out. A crackling sound can be heard whenever user passes through a null spot or poor reception area. Any interference source can be clearly distinguished from expected analogue sound.

Warning: Headphone should be worn after switching on the transmitting kit and it should only be worn while the transmitter is on. It should be removed before switching off the transmitter. The output on the headphone will be too loud if the transmitter is switched off.

AF output will contain noise if the RF signal level drops. The unmuted noise level on the AF output has significantly higher amplitude compared to data signal level.

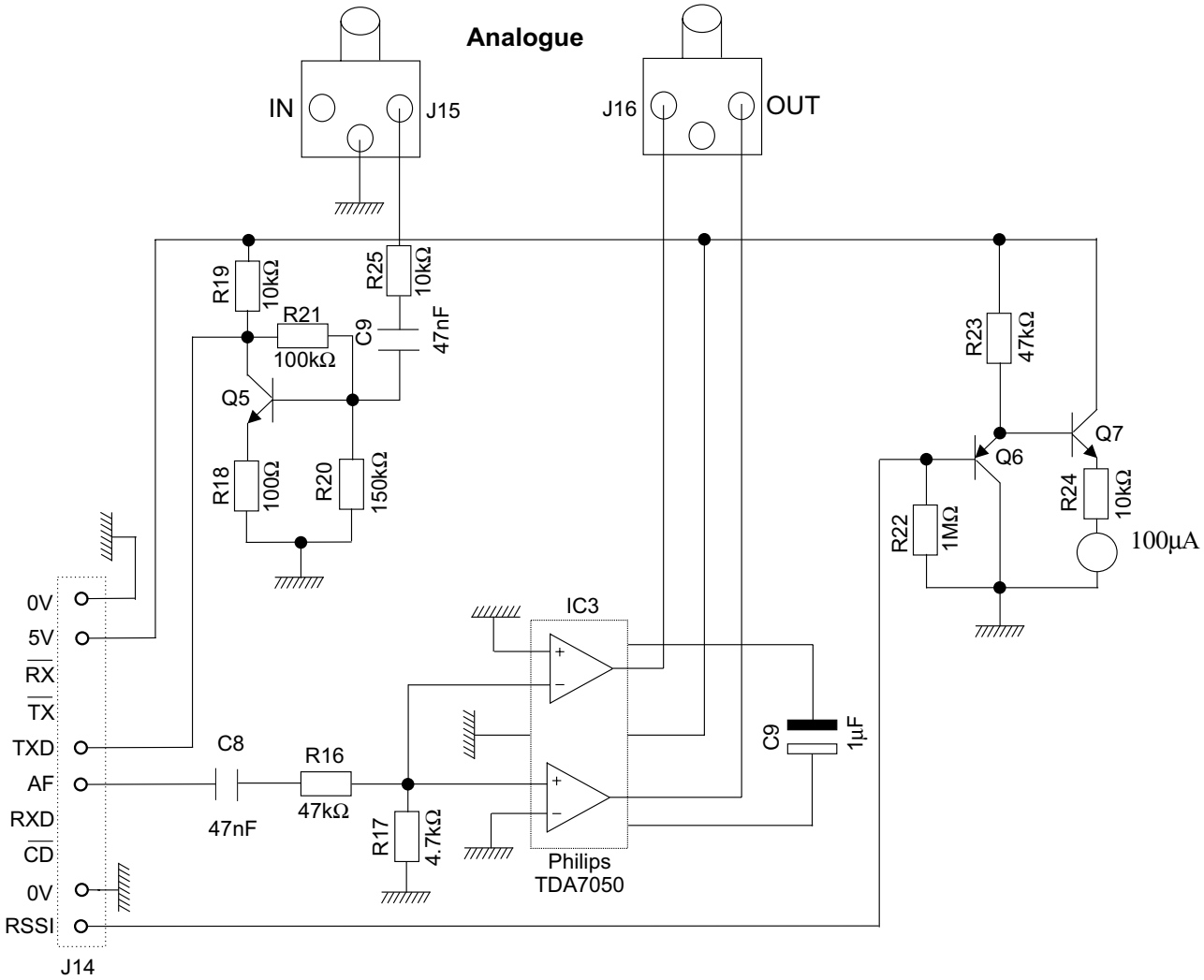


Figure 23: Analogue I/O board circuit diagram

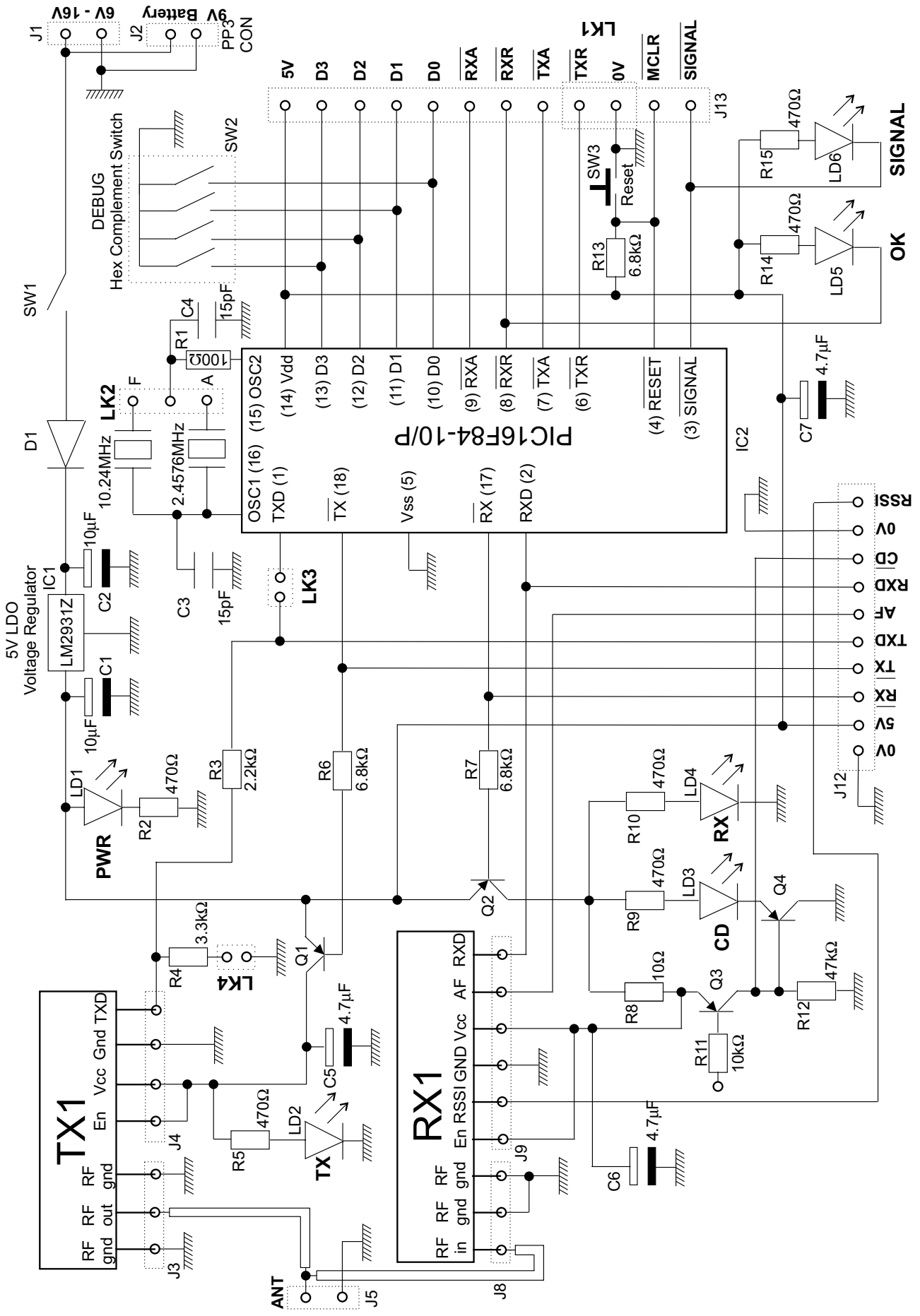


Figure 24: Evaluation of TX1 & RX1 using Universal Evaluation Kit

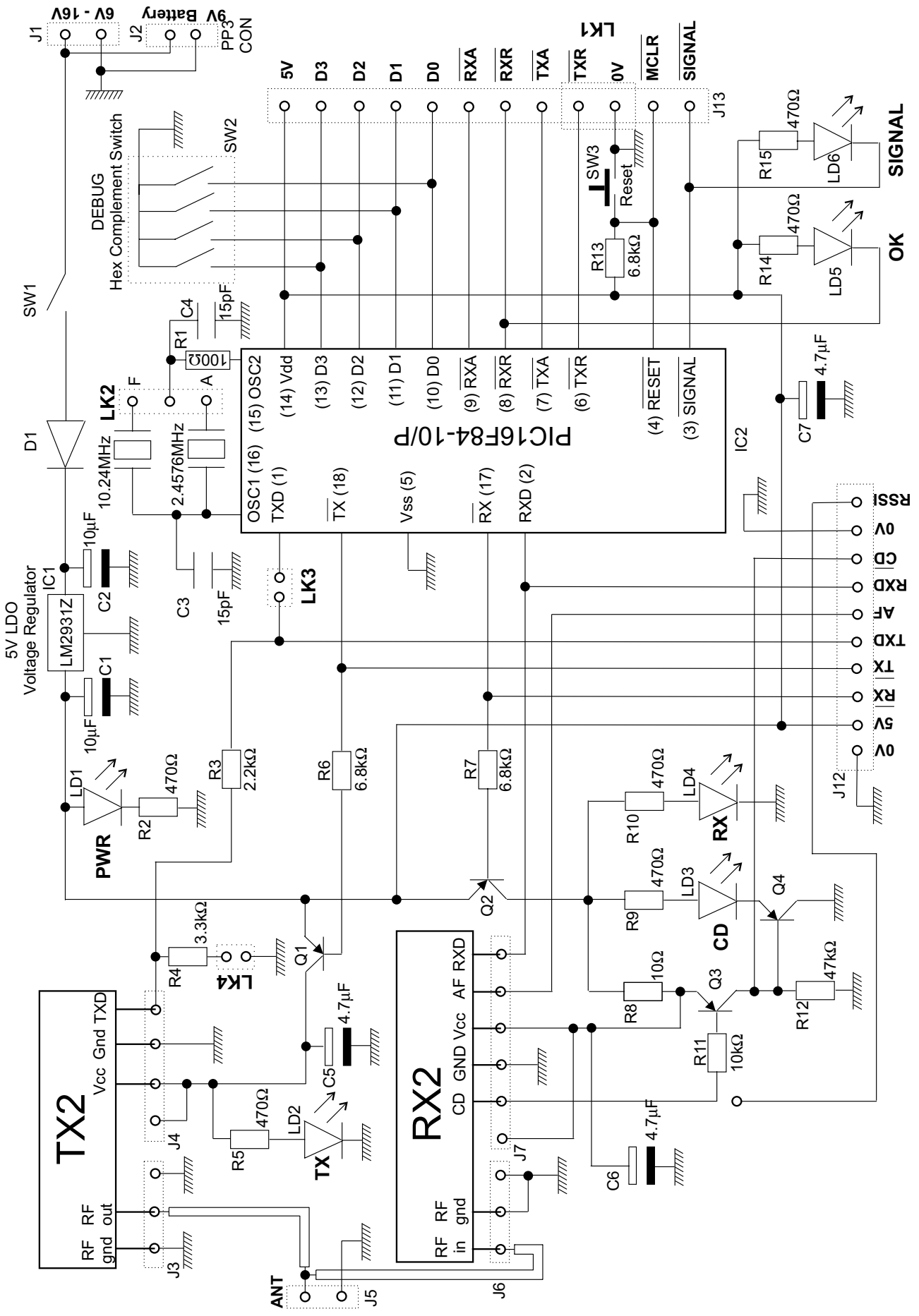


Figure 25: Evaluation of TX2 & RX2 using Universal Evaluation Kit

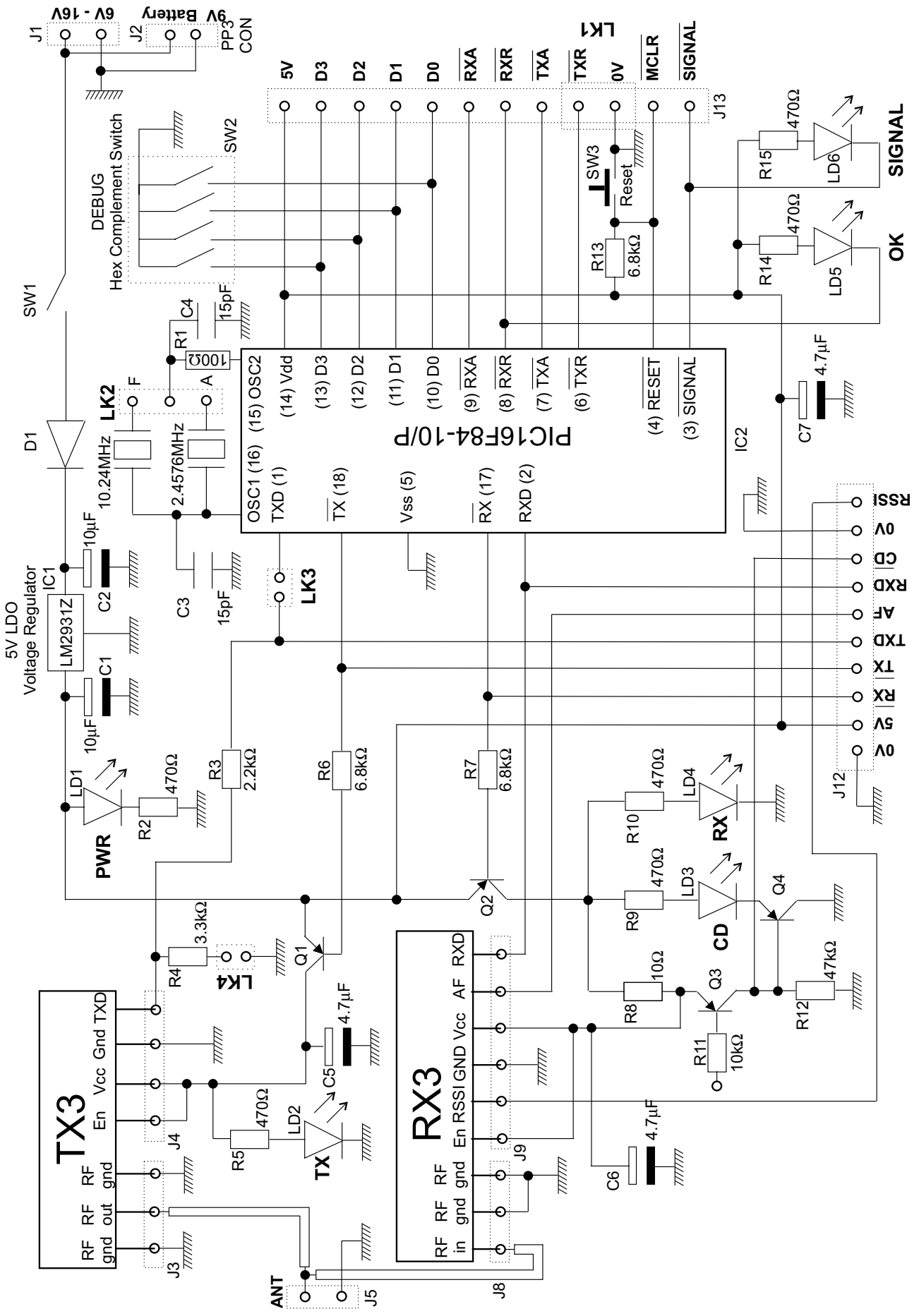


Figure 26: Evaluation of TX3 & RX3 using Universal Evaluation Kit

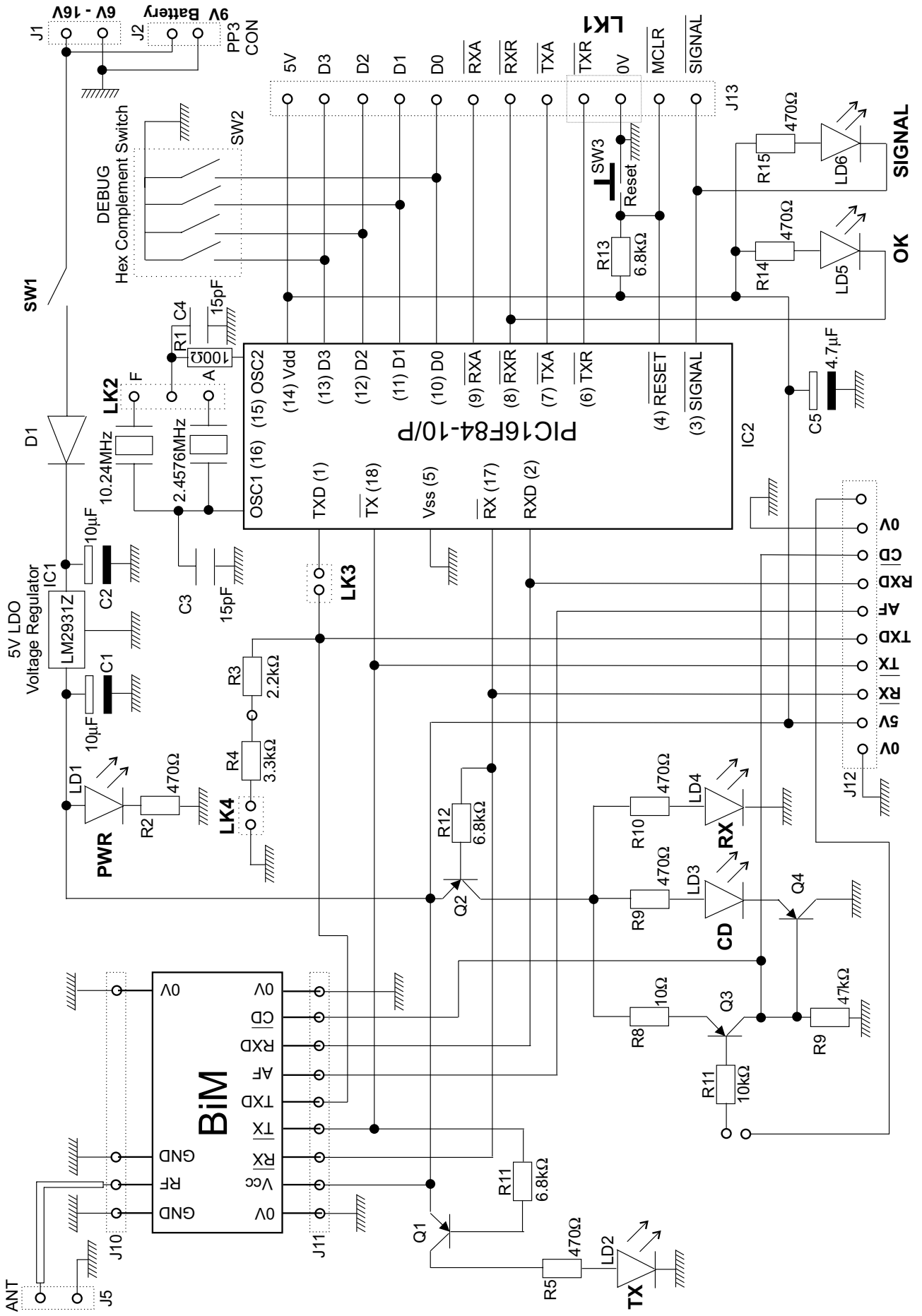


Figure 27: Evaluation of BiM or BiM2 using Universal Evaluation Kit

Radiometrix Ltd

Hartcran House
Gibbs Couch
Watford
WD19 5EZ
ENGLAND
Tel: +44 (0)20 8428 1220
Fax: +44 (0)20 8428 1221
info@radiometrix.co.uk
www.radiometrix.co.uk

Copyright notice

Limitation of liability

The information furnished by Radiometrix Ltd is believed to be accurate and reliable. Radiometrix Ltd reserves the right to make changes or improvements in the design, specification or manufacture of its subassembly products without notice. Radiometrix Ltd does not assume any liability arising from the application or use of any product or circuit described herein, nor for any infringements of patents or other rights of third parties which may result from the use of its products. This data sheet neither states nor implies warranty of any kind, including fitness for any particular application. These radio devices may be subject to radio interference and may not function as intended if interference is present. We do NOT recommend their use for life critical applications.
The Intrastat commodity code for all our modules is: 8542 6000

R&TTE Directive

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 Radiocommunications Agency (RA) web site:
http://www.radio.gov.uk/topics/conformity/conform-index.htm

The Library and Information Service
The Radiocommunications Agency
Wyndham House
189 Marsh Wall
London
United Kingdom
E14 9SX
Tel: +44 (0)20 7211 0502/0505
Fax: +44 (0)20 7211 0507
library@ra.gsi.gov.uk
For further information on radio matters contact the Agency's 24 Hour Telephone Enquiry Point: +44 (0)20 7211 0211

European Radiocommunications Office (ERO)
Midtermolen 1
DK 2100 Copenhagen
Denmark
Tel. +45 35250300
Fax +45 35250330
ero@ero.dk
www.ero.dk