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USX2 Issue 1, 07 May 2009

NBFM Multi-channel UHF Transceiver

USX2 is small multi-channel half duplex UHF transceiver available for operation on 315MHz, 433MHz and 458MHz bands with the user programmable RF power output of up to 100mW.
USX2 offers up to 128 frequency channels in 25kHz channel spacing. USX2 also features dual VCO which allows



Figure 1: USX2-433-5

Features

- Conforms to ETSI EN 300 220-3 and EN 301 489-3
- High performance double superhet, 128 channel PLL synthesizer
- 100mW RF power output: adjustable via serial command
- Data rates up to 5 kbps for standard module
- Usable range over 500m
- Fully screened. Low profile
- Feature-rich interface (RSSI, analogue and digital baseband)
- Digital RSSI output
- Incorporate a 1200baud modem
- Re-programmable via RS232 interface
- Low power requirements

Applications

- Wireless handheld terminals
- Heavy vehicle/machine remote controls
- EPOS equipment, barcode scanners
- Data loggers
- Industrial telemetry and telecommand
- In-building environmental monitoring and control
- High-end security and fire alarms
- Vehicle data up/download

Technical Summary

- Operating frequency: 315MHz (USA), 433MHz (European) and 458MHz (UK) bands
- 128 channels controlled via RS232 interface
- 16 channels selected by parallel interface
- Transmit power: 100mW (+20dBm) nominal. Adjustable 0.1 – 100mW
- Supply range: 3.6 - 15V
- Current consumption: 100mA (at 100mW output) transmit, 25mA receive
- Data bit rate: 5kbps max. (standard module)
- Receiver sensitivity: -118dBm (for 12 dB SINAD)
- Size: 50 x 30 x 12mm

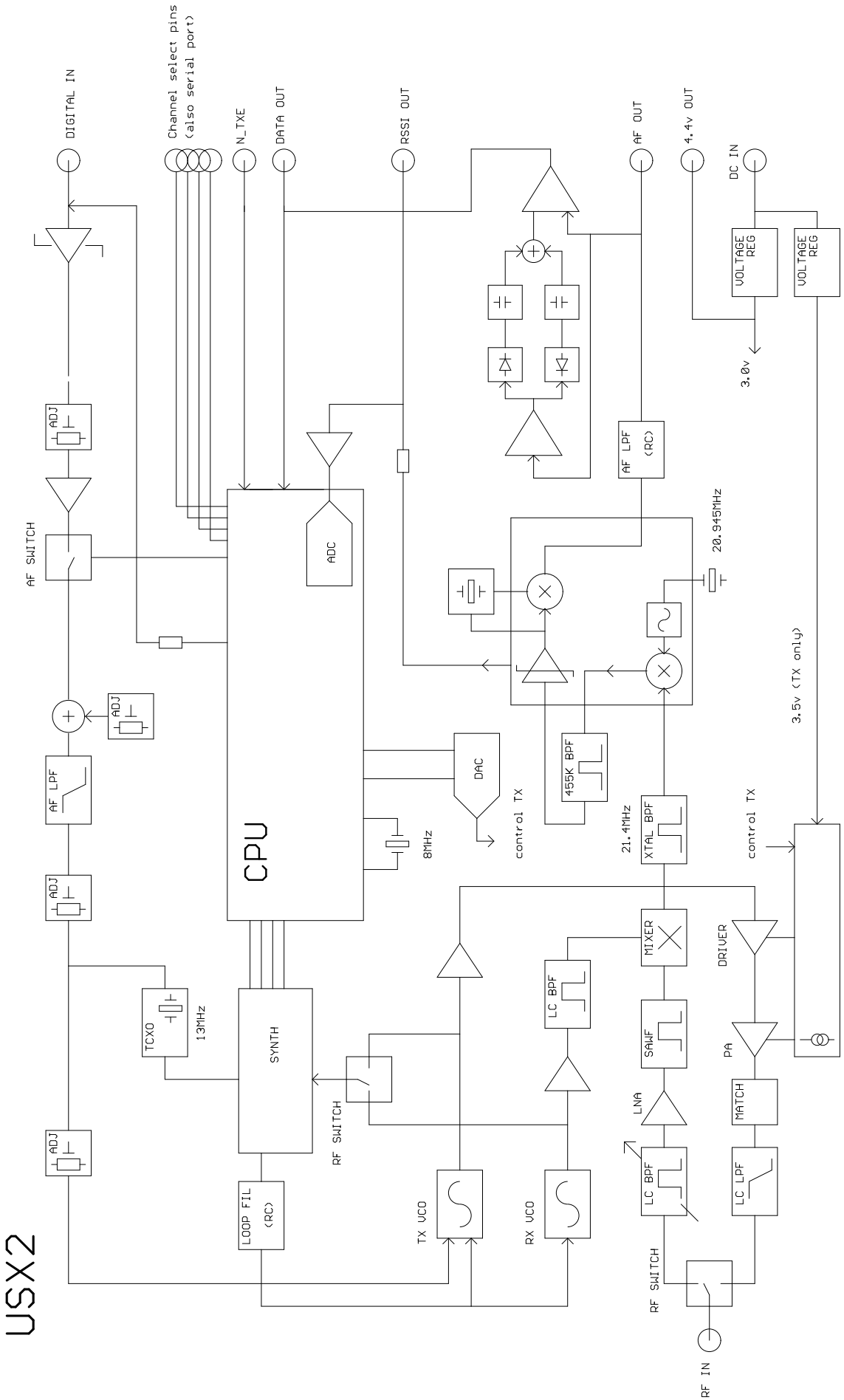


Figure 2: USX2 block diagram

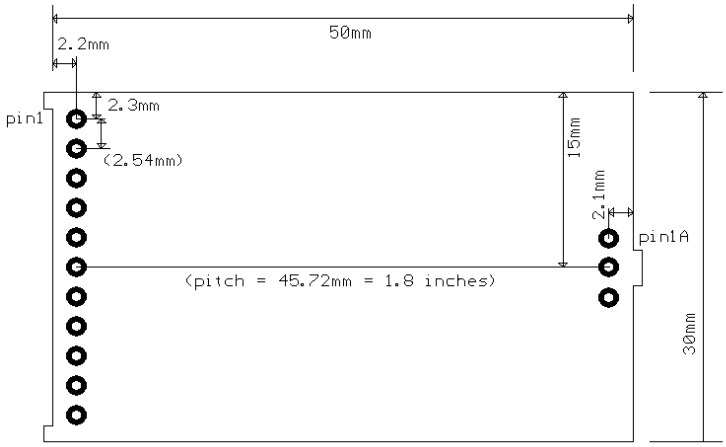


Figure 3: Provisional USX2 footprint (Top)

Pin Description

Pins	Normal mode		Serial mode	Modem mode
1A	RF Gnd	RF ground		
2A	RF in/out	To the antenna		
3A	RF Gnd	RF ground		
1	TXD	DC coupled input for TTL/ CMOS logic		NC
2	$\overline{\text{TXE}}$	Transmit enable. Low = RX mode. High = TX. (10k□ pull down)		NC
3	GND	(0V)		
4	Vcc	DC supply input (3.6 –15V)		
5	P3	Parallel channel select MSB	Serial read back	BUSY
6	P2	Parallel channel select	TBA	MOD TXD
7	P1	P1 - Parallel channel select	TBA	MOD RXD
8	P0	P0 - Parallel channel select LSB	PGM in	PGM in
9	RSSI	DC level between 0.5V and 2.5V. 60dB dynamic range		
10	RXD	Open collector output of data slicer		NC
11	AF out	500mV p-p audio. DC coupled, approx 0.8V bias		NC

NOTES:

1. No inversion occurs between TXD and RXD. However AF out *is* inverted relative to TXD.
2. Parallel channel selects (P0-P3) and $\overline{\text{TXE}}$ are active LOW and have 47k□ internal pullups to 3V
3. Open collector output RXD has a 47 k□ pullup to 3V.
4. The software incorporates a 1200 baud modem, compatible with that implemented in other Radiometrix narrowband units (i1200 tones and format). Modem operation is selected by serial command.
5. Main serial port (P0, P3) operates at 9600 baud. (Command set is not the same as TR2M, SMX families). The unit is capable of operating in 'basic' parallel channel select only mode, or in serial controlled 'expanded' mode
6. Transmit power can be set by serial command
7. RSSI can be read back as a digital value. (on P3)
8. If analogue transmit modulation is needed, then connect a series 1□F cap + 500k□ trimmer (a multiturn is advised) in the TXD circuit. Adjust trimmer for 90% of peak deviation (+/- 2.7KHz) at mean input level.

USX2 serial interface details (version 4): PRELIMINARY

The USX2 user interface is accessed through the four parallel pins (P0/serial through P3).
It has four operating modes:

1. **Parallel:** Frequency of operation is selected as one of 16 (chans 0-15), by means of a 4 bit inverted value applied to P0-P3. The P0 pin will also respond to a LOCKSERIALMODE datastream (inverted rs232, 9600 baud), which will cause the radio to enter **serial** mode. In parallel mode, the IDENT command string is still decoded, but the unit remains in parallel mode.

2. **Serial:** Frequency of operation, radio set up, power output and various other parameters are controlled by command strings sent to P0. Pin P3 functions as a 'readback' port while P1,2 are not used in this mode.

In this mode, decimal values are used (to simplify direct manual programming via a terminal)

Commands include :

:	empty command buffer		
? or /	read back buffer contents		
<**backspace**>	delete last character		
<**cr**>	process buffer		
PARALLEL	return to the basic, **parallel** mode (and turn modem off)		
DUMP	read back contents of eeprom (output on P3)		
MODEM	activate 1200 baud modem		#
NOMODEM	de-activate 1200 baud modem		#
DEFCH ccc	set default channel	(non-volatile)	#
DEFPOW pp	set default tx power	(non-voltatile)	#
CHAN ccc	jump to channel	(volatile)	
POWER pp	select tx power	(volatile)	
RSSI	single read of RSSI	(output on P3)	
SHORT	enter **short** command mode		#

(The following commands are used to set up the radio operating characteristics, and should be viewed with caution. Especially the CALPOWER command, which initiates a multiple write operation to the power calibration table)

NDIV nnnnn	force N divider value	(volatile)	
RDIV rrrrr	force R divider value	(volatile)	
RLOAD rrrrr	Set R divider value		#
OFFSET ooooo	Set RX offset		#
LOAD aa nnnnn	Set N values for first 16 channels		#
START nnnnn	Set N value for ch 16		#
STEP i	Set increment for table		#
LIMIT ccc	Set highest permitted channel number		#
SETPOW eee	Set maximum power output (100mW)		
CALPOWER (etc)	(see factory procedures for more details)		
TEST	Generate a 250Hz test modulation (only fuctions in TX mode, cancelled by sending a <cr> byte)		
IDENT	Readback a single byte, depending on current mode: Parallel: **P** Serial **S** Short **1** Modem **M**		

(Channels 0-15 are individually programmed by the **LOAD** operation. Channels 16-127 are a consecutive table, using the **START** value as a start point (=channel 16) and increasing the N value by **STEP** with each increase in channel number)

ccc = a channel number from 00 to 127
aa = a **two** digit channel number from 00 to 15
nnnnn = synthesizer N register value, (up to 65535)
rrrrr = synthesizer R register value, (up to 16383)
pp = power setting value (0 - 30)
i = table step (increments of N) (0-7)
ooooo = receive mode frequency offset
eee = power calibration figure

N = channel frequency / (13MHz / R)
13MHz / R = 25KHz , so R = 520 (usually)
receive offset = 21.4MHz / (13MHz / R) , so = 856 (usually)

A pause of at least 50mS must be allowed after operations which result in eeprom programming operations (all except NDIV, RDIV, GOTO, PSET and RSSI). This allows the programming cycle to complete.

Instructions marked ' # ' output a three byte ' OK<cr> ' sequence after sucessfully completing their eeprom programming cycles

When first powered up, the unit will operate on channel and output level specified by the last CHAN and POWER instructions, irrespective of previous NDIV, RDIV, CHAN or PSET operations)

3. **Short:** A limited range of radio functions are controlled by sending a single byte to PO

0 - 127	select channel		(volatile)
128 - 159	select power	(= byte -128)	(volatile)
200	single read of RSSI	(output on P3)	
201	single byte read, as for IDENT command		
222	reception of 16 consecutive 222 bytes returns radio to **serial** mode.		

This mode of operation is intended to provide a simple, fast, serial command mode.

4. **Modem:** Commands are interpreted as in SERIAL mode (and 'short' mode may be selected.) In this mode the unit operates as a simple 1200 baud packet modem, with TXD (in) on P2 and RXD (out) on P1. The N_TXE pin does not control tx switching in this mode, but rather the presence of valid data in the tx buffer initiates a transmit burst. No handshaking is provided, and the unit has a sufficient over-link data rate to transparently 'stream' continuous data. Error correction, re-transmission of corrupt packets and addressing are not provided.
This mode is compatible with other Radiometrix 'i 1200' mode equipment, including the narrow band eval kit.

Notes:

- Unlike in the RLC and TLC units, the LOCKSERIALMODE (and FAST) commands are non-volatile. Once a serial mode is selected, the unit will power up in this mode until a PARALLEL command is received.
- The command interpreter IS case sensitive. Use upper case.
- Spaces are optional (they are not decoded), provided the command line does not exceed 16 characters.
- When manually programming this unit we recommend setting your terminal to local echo. The 'backspace' key functions normally.
- All serial communications use 9600baud 'inverted RS232' 8 bit data, no parity, 1 start bit, 1 or 2 stop bits
- A simple 'driver' program will be made available to simplify programming of these units, if desired.
- RSSI read operations only function correctly if the unit is in RX mode (n_TXE pin is high or floating)

Condensed specifications (All details are provisional)

Frequency	315 - 315.375MHz (US band) 433.875 - 434.650MHz (433 MHz EU band) 458.525 - 459.1MHz (458MHz UK band)
Frequency stability	±1.5kHz
Channel spacing	25kHz
Number of channels	128 channels selected via serial RS232 interface First 16 are individually programmable Next 112 are a sequential table 16 channels selected via parallel interface
Supply *voltage*	3.6 -15V
Current	45mA transmit (at 10mW output)
	100mA transmit (at 100mW output)
	25mA receive (or modem 'idle')
Operating temperature	-20 to +70 ^{o}C (Storage -30 to +70 ^{o}C)
Size	50x 30 x 12 mm
Spurious radiations	Compliant with ETSI EN 300 220-3 and EN 301 489-3
Interface	
User	11 pin 0.1" pitch molex
RF	3 pin 0.1" pitch molex
Reprogram	5 pin 0.1" pitch socket in top of case
Recommended PCB hole size	1.2mm (min.)
Transmitter	
Output power	100mW (+20dBm); Adjustable via serial command 0.1 - 100mW
TX on switching time	<50 ms
Modulation type	FM, FSK (F1D, F3D)
TX modulation bandwidth	DC – 3kHz
Deviation	±3kHz
Adjacent channel TX power	-37dBm
TX spurii	<-40dBm
Inputs	Data (CMOS/TTL compatible)
Receiver	
Sensitivity	-118dBm for 12dB SINAD
image / spurious	-60dB
blocking	-84dB
adjacent channel	-60dB
Outputs	RSSI, Audio, Data

Notes: 1. The data slicer cannot be depended upon for data waveform frequencies below 250Hz

2. When RX is on and a transmitter keys up, again a 50ms period is required to stabilise data output mark/space. i.e. allow at least 50ms of preamble

RX Received Signal Strength Indicator (RSSI)

The USX2 has wide range RSSI that measures the strength of an incoming signal over a range of 60dB or more. This allows assessment of link quality and available margin and is useful when performing range tests.

The output on pin 9 of the module has a standing DC bias of up to 0.5V with no signal, rising to 2.5V at maximum indication (RF input levels of -40dBm and above). ΔVmin-max is typically 2V and is largely independent of standing bias variations. Output impedance is 4.7kΩ. The pin has a 1nF cap to ground.

Digital RSSI output

In serial mode, RSSI can be read back as a digital value on pin P3. The RSSI read back command initiates a read of the analogue RSSI value (as present on pin 9) by an internal 8 bit A/D converter.
This converter uses the 3.0v rail as it's reference (so an RSSI voltage of 3v will give a read back of 255, while a voltage of 0v will read back 00).

Practically, the RSSI circuit produces about 0.5 - 2.5v (read back value 40 - 212) and this voltage is related (approximately) to the receiver input level by the graph below.

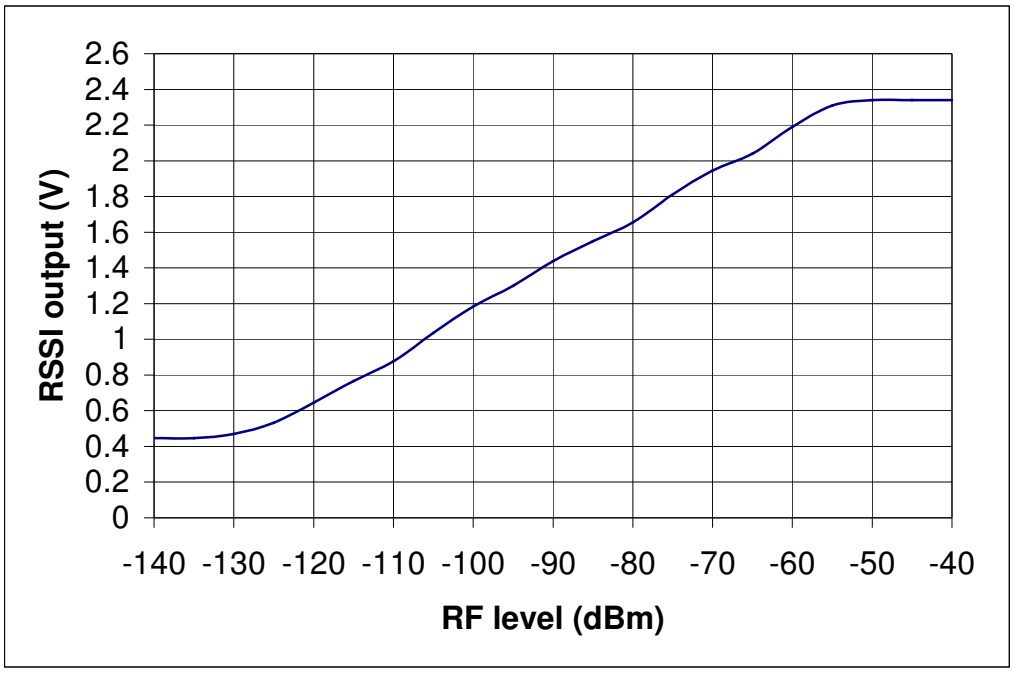


Figure 4: typical RSSI level with respect to received RF level at USX2 antenna pin

The table below relate the receiver input level to the typical analogue voltage output at pin 9 and the corresponding digital RSSI value read back at pin 3 (in serial mode).

RF power (dBm)	Analogue RSSI (V) at pin 9	Digital RSSI value (on pin 3)
No signal	0.45	36 (24h)
-120	0.65	53 (35h)
-110	0.85	75 (4Bh)
-100	1.2	101 (65h)
-90	1.4	123 (7Bh)
-80	1.65	141 (8Dh)
-70	1.95	166 (A6h)
-60	2.2	187 (BBh)
-50	2.3	198 (C6h)
-40	2.35	200 (C8h)

Please note, the RSSI graph and the table values above are for indicative purposes only and is not a guarantee of actual RSSI characteristics.

Antenna requirements

Three types of integral antenna are recommended and approved for use with the module:

A) ***Whip*** This is a wire, rod ,PCB track or combination connected directly to RF pin of the module. Optimum total length is 16.4cm (1/4 wave @ 433MHz). Keep the open circuit (hot) end well away from metal components to prevent serious de-tuning. Whips are ground plane sensitive and will benefit from internal 1/4 wave earthed radial(s) if the product is small and plastic cased

B) ***Helical*** Wire coil, connected directly to RF pin, open circuit at other end. This antenna is very efficient given it's small size (20mm x 4mm dia.). The helical is a high Q antenna, trim the wire length or expand the coil for optimum results. The helical de-tunes badly with proximity to other conductive objects.

C) ***Loop*** A loop of PCB track tuned by a fixed or variable capacitor to ground at the 'hot' end and fed from RF pin at a point 20% from the ground end. Loops have high immunity to proximity de-tuning.

The antenna choice and position directly controls the system range. Keep it clear of other metal in the system, particularly the 'hot' end. The best position by far, is sticking out the top of the product. This is often not desirable for practical/ergonomic reasons thus a compromise may need to be reached. If an internal antenna must be used, try to keep it away from other metal components, particularly large ones like transformers, batteries and PCB tracks/earth plane. The space around the antenna is as important as the antenna itself.

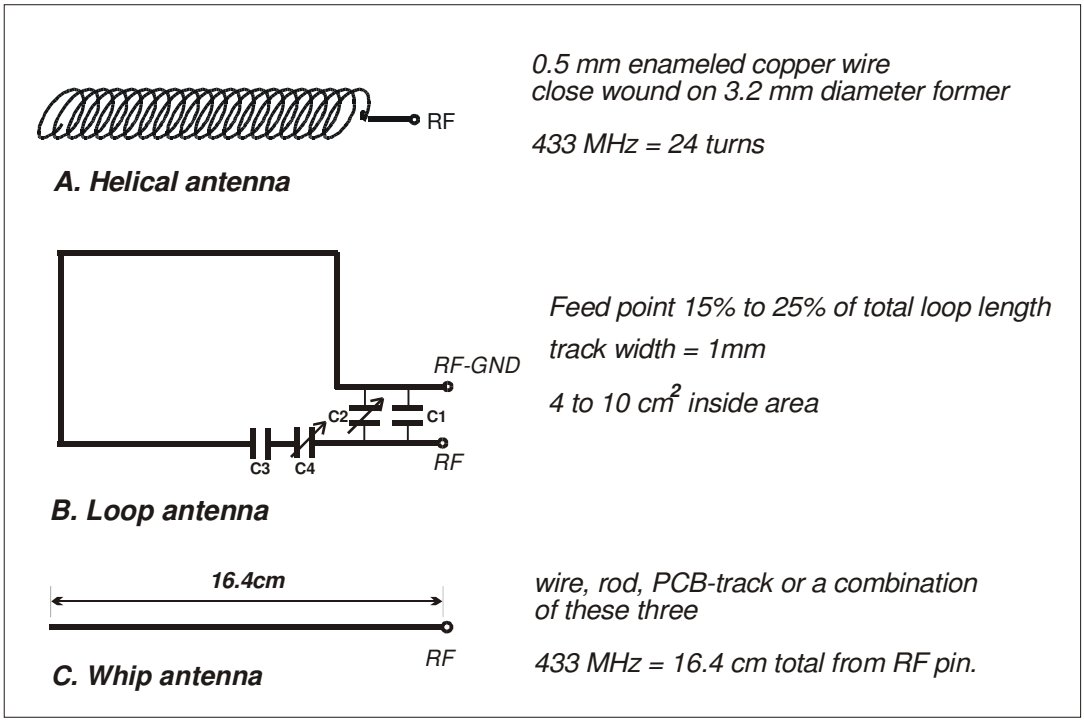


Figure 5: Antenna types

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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 The Office of Communications (Ofcom) web site:
http://stakeholders.ofcom.org.uk/spectrum/technical/rtte/

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