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40-node Mesh Networked Alarm Control System

These simple application boards constitute a Mesh networked bidirectional remote control system. Each board has 3-input switches, 2-outputs, global address and a Unit ID 00-39. A complete system consists of a master board (which initiates communication burst cycles) and up to 39 slave units. Any input activation on any slave (or the master) closes the relays on all units on the system. This makes the A40 an ideal platform for an alarm system. In addition a display board can be added to give an indication of unit that has alarmed. The 3 inputs are used as momentary switches with one giving alarm, one for test (outputs do not operate, but LED indication of alarm) and the third one for clearing the alarm.

Figure 1: A40 Alarm controller

Features

- Site address (01-15), Unit ID (00- 39)
- 1 Master, 39 Slave Units per site
- 10 or more Satellite units for input only (e.g. smoke detector)
- Unlimited Drone units for output only (e.g. sounder / siren)
- Usable with any BiM footprint radios (up to 100mW) with a switching & settling time of <10ms
- ETSI EN 300 220-2 Category 1 receivers for safety critical applications. (e.g. CVR1, BiM1)
- 4x operating range of radio module used (e.g. 2km using 10mW 25kHz narrowband transceiver)
- Alarm, Test, Cancel inputs
- Siren, NO/NC relay output to control devices rated up to 8A 250VAC or 5A 30VDC
- Alarm response time <4s to 60s (worst case for whole network)
- Frame synchronisation codes, check sums and address are used to prevent false triggering
- Lost units can be detected and reported via serial port.
- 2.8kbps bi-phase encoded data burst of 70ms duration
- Visual LED indication of communication status and relay state
- 3.1mA average current (e.g. 8 months operating life from 6x D cells)
- Simple “plug-and-play” setup. No complex programming needed

Applications

- Temporary wireless fire alarm system
- Multi-building alarms
- Door alarms in buildings
- Fence alarms
- Medical alarm in hospitals or care homes
- Classroom emergency alarm

Kit Contents

The A40 Application kit is supplied with the following contents:

2 A40 Mesh alarm controller boards
2 BiM footprint Transmitter & Receiver or Transceiver module *(ordered separately)*
2 1/4-wavelength UHF monopole or VHF helical antennas depending on module frequency
1 A40D Display board *(ordered separately)*

Additional requirement

- External DC power supply
- Antenna with SMA plug
- Full-colour Red Green Blue LED (optional)

A40 controller and application board

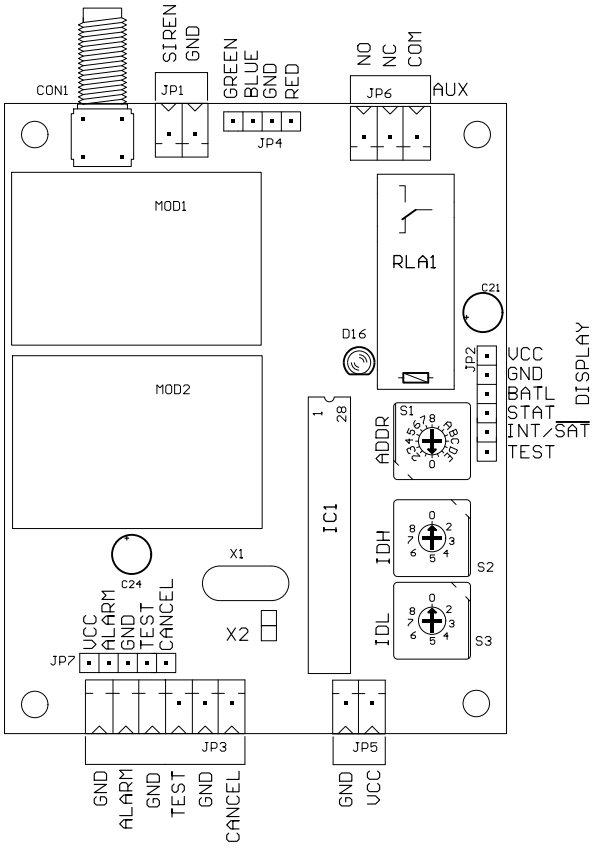


Figure 2: A40 application board interface

Interfaces	Pins	Description
JP1	SIREN	1A VCC rated open drain p-channel MOSFET output to drive Siren/Sounder
JP2 A40D Display	VCC GND BATL STAT INT or SAT TEST	Same Supply voltage as fed into JP5 VCC Ground 100ms pulse output every 4s to drive LED for Battery Low indication 9600 baud 3.3V TTL (inverted RS232) Status output to Display 1ms pulse output every 32s to wake-up Display before outputting Status or active low Satellite mode select input Test output (Leave floating) I/O pins are 3.3V logic with 1k series resistor
JP3 Inputs	ALARM TEST CANCEL	Alarm activation input Test mode activation input to check for network status of all installed units Cancel input to deactivate Alarm or Test mode 3.5mm pitch 2-way Terminal Blocks Compatible with Normally Open (NO) Volt-Free Closing Contact
JP4 RGB LED	GREEN BLUE GND RED	Outputs to drive an external full-colour Hyper-Red Blue Green LED (e.g. Kingbright L-154A4SUREQBFZGEC) 0.1” pitch pin header Average current and battery life quoted are without RGB LED.
JP5 Power Supply	VCC GND	12V DC (standard). 5V / 9V (relay version available) 3.5mm pitch 2-way Terminal Blocks 3.1mA average current (relay off, using 10mW NiM1B/NiM2B) 0.1mA idle current
JP6 Auxiliary	AUX	8A 250VAC or 5A 30VDC rated SPDT relay (18.3mA 12VDC coil) 3.5mm pitch 3-way Terminal Block (NO NC COM)
JP7 Inputs	VCC ALARM GND TEST CANCEL	0.1” pitch pin header for Inputs as JP3
CON1	ANT	Right-angled SMA socket for Antenna

A40 control chip	
A40 Controller	PIC16F883-I/SP
Clock	10MHz (ceramic resonator)
Timer 1	32.768kHz watch crystal
Data rate	2.8kbps Bi-phase coded burst
S1	0 – F Site Address selected using Hex switch
S2 S3	0 – 39 Unit ID High selected using BCD switch 0 – 39 Unit ID Low selected using BCD switch
Response time	<4s to 60s (worst case for whole network)
Size	
	83 x 66 x 16mm (excluding connectors)
	Four 3.3mm diameter mounting holes
Temperature	
Operating	-20ºC to +70ºC (some radios may be limited to -10ºC to +55ºC)
Storage	-30ºC to +70ºC
Radio modules	
	Compatible BiM pinout transceiver or transmitter/receiver pair 10mW NiM1BT-173.225-10 (UK) CVR1-173.225-10 (UK) 10mW BiM1-173.225-10 (UK) 20mW NiM1B-154.570-5-20mW 100mW BiM1-151.300-10 (Australia) 10mW NiM2B-434.650-10 (EU) 25mW NiM2B-458.700-10-25mW (UK) 5mW BiM3G-869.85-10 (EU)
	Not compatible with RDL2 or 500mW BiM3H or BiM1H due to 10ms preamble transmission and regulator current limitations

LED Indications

D1	Relay activated
Red/Green alternate flashing	Initial power up sequence (about 0.25 seconds)
Solid **Green**	second stage master-only power up sequence
Green rapid blinking	out of lock / out of range
Red rapid blinking	out of lock / out of range and low battery
'Dirty white' flashing	ALARM (siren and auxiliary outputs also live)
Solid **Blue**	Test Mode
Solid **Red**	Cancel Mode in progress
occasional blue blink every 32s	Master unit in Normal State
occasional green blink every 32s	Slave, in synchronisation/lock with Master
bursts of red blinking	any unit, low battery

Note: *When changing switch settings, it is recommended to physically reset (power cycle) the unit afterwards to ENSURE correct operation.*

All units must have the same Site address (group code) set up on the Hex switch
Each unit must have a different ID code (set on the two BCD switches).
Valid ID codes are 00-39
There must be a unit 00.
Unit 00 is the master, and generates the synchronisation "heartbeat" for the system

Operational Description

A40 uses 4-hops "synchronise and reply" basic setup. A specific "master" unit provides network synchronisation (but it is just an ordinary node with its ID code set to 00). Current consumption is lower (<1.8mA: 6 months on a pack of alkaline C cells) when using 10mW NiM1BT-173.225-10 transmitter and CVR1-173.225-10 receiver, but whole network response time is 60 seconds.

Each burst occupies an 89ms long slot (19ms timing slack around the 70ms burst)
45 consecutive slots make up a 4 second long frame
8 frames make up a 32 second long group

Each slot is rigidly allocated to the ID number of a specific unit (1 through 39: slot 0 is reserved for the master sync transmission). The extra slots at the end of a group are used for local zone Slot 41 triggering, communication to the display adaptor, general administration and housekeeping tasks and overall timing slack.

In each group, there are four outgoing synchronisation frames (numbered 0 through 3) and four returning reply frames (4 to 7).

Alarm will always over-ride Test, and Cancel will over-ride everything.
Alarm ON occurs whenever a sync or reply burst with the network status code set to ALARM is received. This means, any given unit could receive a relevant burst from an adjacent zone in less than one frame.

In the worst case situation, a system setup has units spread to maximum range, resulting in the Activating Unit being in zone 3 on one side of the site, and the worst case receiving unit in a different zone 3, on the other side of the master. So the very worst possible case for the whole network to reach alarm state is 60 seconds

To speed up the apparent response time of the system to the users, it has provision for all units in an activating zone to trigger almost immediately (rather than having to wait for the next sync burst from the master). This is implemented by assigning an end-of-burst slot. In this Slot 41, all units listen. A transmission is made by any unit that has had an input taken active in the previous 4 seconds. This transmission is only made once for any given activation.

Obviously, if multiple activations occur in the same zone, a collision will occur and the local zone signalling will fail. However, in this case the conventional reply/sync system will still carry the activation, albeit considerably more slowly (32 seconds max)

Pushing the cancel button turns off the local outputs and causes the next burst to be sent with the "cancel" status bit set. Receiving one of these cancels the alarm state in any unit receiving it, including any units with their button inputs active. Once the "cancel" message reaches the master, it is propagated back out through the network in the status frames as well, turning off units on the other side of the network. Otherwise, a unit receiving an alarm or a test burst will lock into that mode until it receives either a higher priority message (or a cancel). This ensures that the network remain in "alarm" condition even if the initiating unit has ceased to function

Satellite and Drone nodes

In order for more than 40 input devices to be used on the system, a secondary operating mode (selected by jumper link on Display connector GND pin 2 to SAT pin 5) is available. When set to this "satellite" mode, a unit is set to have the same ID number as an adjacent "normal" node and transmits only to it (via the slot 41 local zone mechanism). Activation of the satellite unit shows up in the network reporting data as an activation of the normal unit is pared to. This allows a small constellation of units in a given physical location to all activate the same primary node. A typical use of this would be in a fire alarm where smoke detectors around a node 'report in' an alarm to the network. There is no limitation as to how many satellite units are installed on a system, but if more than 10 are located in close proximity then slot 41 congestion may become a problem, although satellite units re-transmit their activation states using a pseudorandom dithered rule to ameliorate this issue.

Drones are receive only units with ID set to 40, and are used as sounders or perhaps displays attached. The display can be attached to any of the above to enable it to display status

Battery consumption

Unit transmits once in every frame.
Idle current is approximately 0.1mA

NiM1BT TX current of 22mA for 70ms burst
7 times in every 32 second group 0.337mA

CVR1 RX current of 9mA during
3.56s per group (main listen) 1.002mA
100ms once per frame (special) 0.225mA
100ms once per group (sync) 28uA

1.7 mA average (to take up the sleep mode current and leakages)

1.7mA at 7800mAh equals 190 days (which is over the 6-months)
(It's also worth noting that a complete out-of-sync state, drawing probably around 11mA with everything active, still lasts for a month)

Other radio options:

1. NiM1B-169.4125-10 or NiM2B-434.650-10.
Receive current increases to 18mA
Average current consumption increases to 3.1mA
(3-months on C cells, eight months on D cells)

2. NiM1B-154.570-5-20mW or NiM2B-434.650-10-25mW
Average current consumption increases to 3.4mA
(seven and a half months on D cells)

Status output

9600 baud 8 data bits, no parity, 1 stop bit, 3.3V inverted RS232 (UART) output which can be connected to a PC/Laptop via 3.3V TTL serial to USB cable (e.g. FTDI TTL-232RG-VSW3V3-WE).

The datastream reports network and local unit status. The same data is outputted from all units on system (that are in sync) at the same time (slot 42, frame 3), every 32 seconds. 16-byte burst is preceded by a 1ms interrupt pulse on the INT pin 5 to wakeup display processor 1-5ms before the start-bit of the first status byte. Unformatted binary Status bytes are separated by less than 1 bit period.

Byte	Value	Description
1	0 -15	System Address
2	0-39 255	Normal Unit ID Drone
3 Bit 7 Bit 6 Bit 5 Bit 4 Bit 3 Bit 2 Bit 1 Bit 0	 1 = Low 1 = Low 0 0 0	Network status record byte Local low battery Network low battery Cancel mode (note: cancel over-rides alarm, which over-rides test) Alarm mode (if bit 2 is high, bits 1,0 have no meaning) Test mode (if bit 1 is high, bit 0 has no meaning)
4-13		Burst payload bytes. Bit-level coded exactly as the radio link burst format
14		Current sync slot
15		Current sync frame (low 4 bits) and Zone (high 4 bits)
16		Heartbeat number (cycles 0-255, incrementing on each burst sent)

Decoding the network data will make available useful data such as "if an activation has occurred (and which unit has initiated it)", "which units are currently on-system" and "low battery states".
Limitations are obvious (in that an activation over-writes low battery information, and there is no way to tell the unit that initiated an alarm from the unit that initiates cancel: both show up as "active") but intelligent decoding, monitoring not only the current burst but also the states of the preceding bursts,

will be able to add more discrimination.

The display interface connector includes an LED drive line to indicate system low battery, which flashes for 100ms every 4 seconds (Use a TruOpto OSHR5111P 5mm Red LED 20000mcd or similar LED)

Diagnostic Modes

Unit ID / Mode	LED	Function
90	None	RF transceiver off, A40 controller current measurement
91	Solid Red	Red LED Test
92	Solid Blue	Blue LED Test
93	Solid Green	Green LED Test
94	None	Receiver ON but no decoding
95	None	Unmodulated Carrier Transmission
96	None	500Hz tone modulated Transmission
97	Flashing Blue	Dynamic Test mode Transmitter ON for 70ms (synchronisation type burst) Receiver ON for 100ms
98	Flashing Blue	Range Test Receive mode Decodes the stream of sync bursts from a mode 97 transmission and flashes blue for valid decode.
99	None	Reserved. Do not use.

Applications

Temporary fire alarm – this is ideal for building sites or showground alarms or anywhere a temporary alarm system is required.

Multi- building alarms- the unit can be mains powered and battery backed form an alarm system to offer a permanent solution for multi- building alarm systems.

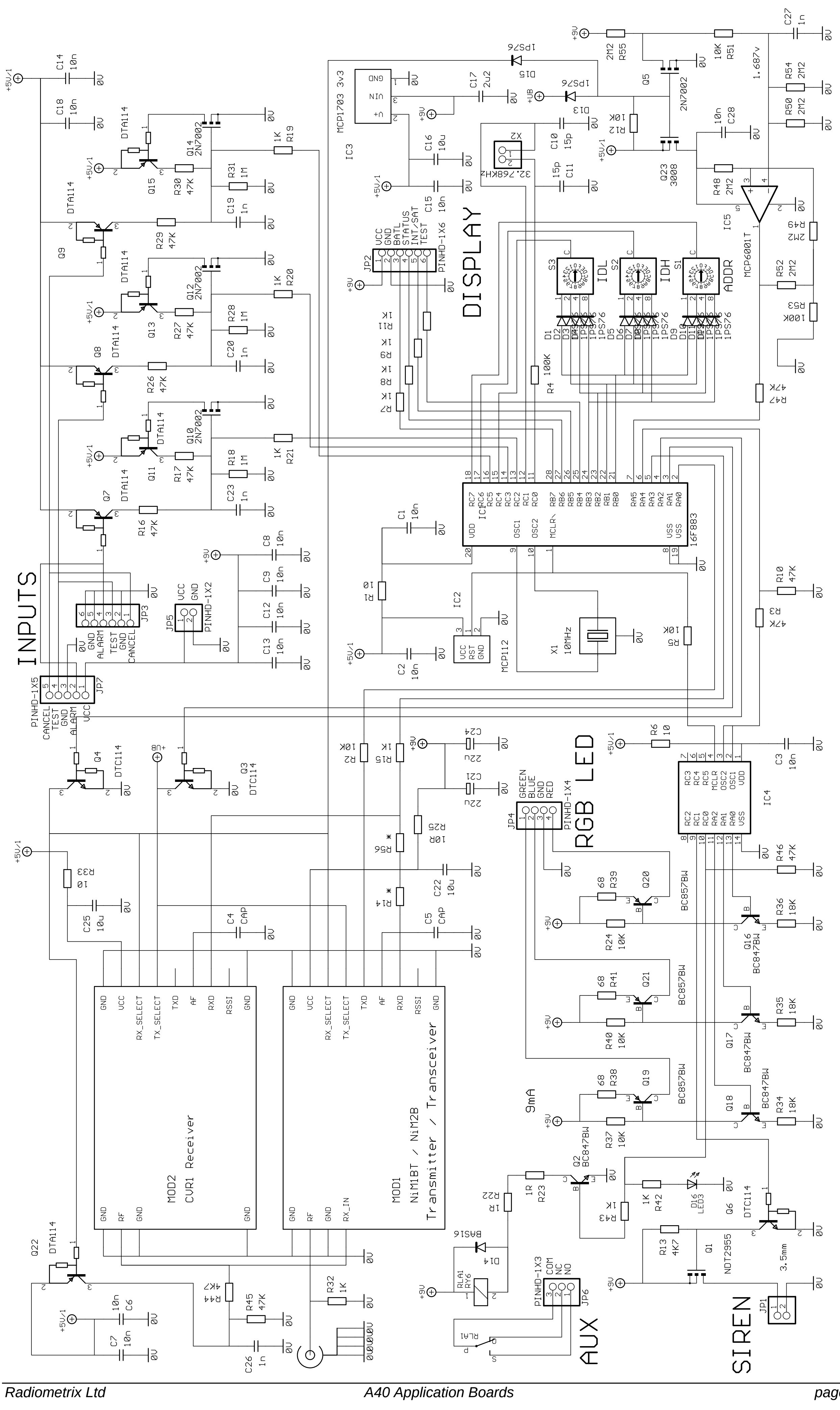
Door alarms in buildings – exit doors which need to be alarmed can transmit back to a central display unit with the door ' number' being displayed.

Fence alarms – with the use of gain antennas the system could be used for border or perimeter guarding and ranges of several kilometres could be achieved to guard areas along with ' fill in' units along the fence to give precise location of intrusion.

Medical alarm in hospitals/ care home – units could be attached to 'out of bed' alarms for elderly patients. With display units positioned on walls to show which bed had been vacated to nursing staff.

Classroom emergency alarm- Could be used in schools with a display on each node so that teachers in trouble could be alerted if a fellow teacher was being attacked. Each node would give location of alarm.

Light switching – could be used to turn all lights on in a carpark if movement was detected and a simple circuit used to turn off again after a period. Using expanded mode up to 400 lights could be controlled and turned on / off.


INPUTS
DISPLAY
RGB LED
AUX
SIREN
MOD1
NiM1BT / NiM2B
Transmitter / Transceiver
MOD2
CVR1 Receiver
16F883
IC4
IC5
MCP6001T
MCP1703 3v3
MCP112
10MHz
32.768KHz
ADDR
IDH
IDL
NDT2955
DTC114
3.5mm
9mA
1.687v

Ordering Information

Part No.	RF Power (mW)	Frequency (MHz)	Country
A40-151.300-BiM1	100	151.300	Australia LIPD
A40-154.570-NiM1B-20mW	20	154.570	US MURS
A40-173.225-NiM1BT-CVR1	10	173.225	UK, South Africa Fixed Alarm, Telecommand
A40-434.650-NiM2B		434.650	EU SRD
A40-458.700-NiM2B-25mW	25mW	458.700	UK Telecommand

Frequencies and options

The A40 application board can take any of the Radiometrix 10mW-100mW VHF/UHF transceiver units which have a BiM footprint and switching and settling time of less than 10ms, thereby offering a number of frequency and power options.

Call sales on +44 20 8909 9595 to see what frequencies and power levels are available in your country.

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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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