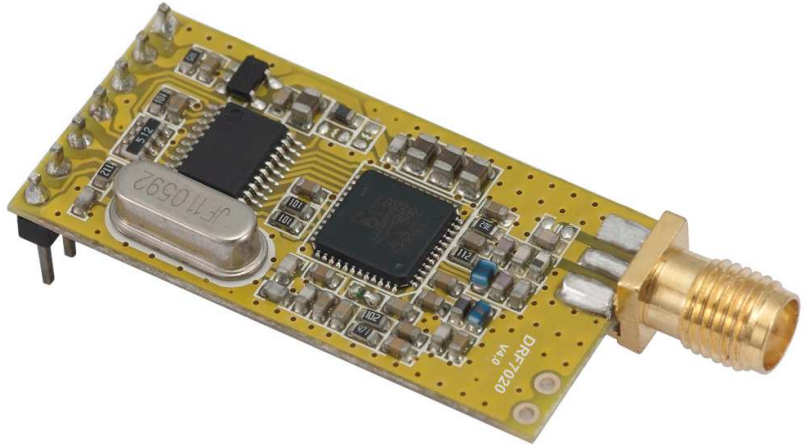


First impressions – Dorji DRF7020D13-043A 433 MHz wireless data modules

via stan.swan@gmail.com Oct 28^h 2011 (Draft #6). "Copy left", but credit appreciated)

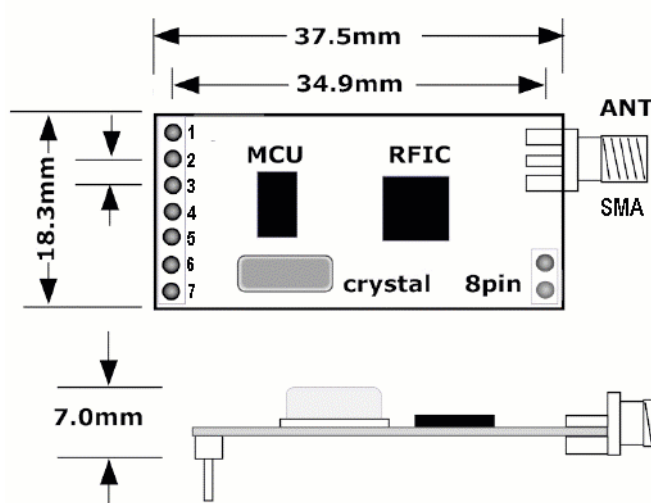
Asian sourced 434 MHz ISM data modules just keep getting better and better!

Although restricted to just mere 10s of milli-Watts transmit power, the licence free 433.92 MHz ("434") ISM (Industrial, Scientific and Medical) UHF band retains enduring appeal for both makers and end users. Originally reserved for non-commercial radio use, considerable innovative ISM band data handling has emerged in recent times, with the low data rates (1200 - 9600 bps) especially tempting for easy micro controller wireless applications.



Bluetooth, ZigBee and WiFi wireless offerings now of course abound, the latter with blisteringly rapid mega b.p.s. data rates, but these technologies are up at 2.4 GHz and best suit only very nearby links. Such higher microwave radio frequencies are blocked by almost anything in the way of course. In crowded Asian cities slow data speed 434 MHz devices are preferred for utility reading, as low UHF frequencies have better punch through obstructions.

Although surprising performers for what they are, most cheap 434 MHz data modules are generally very low powered (a mere few mW) & often the RX is "deaf". Jaycar's venerable ZW-3100 & ZW-3102 ASK (Amplitude Shift Keying) AM pair are typical offerings, with their continued popularity relating to ease of use and simple set ups. Superior FSK (Frequency Shift Keying) FM types are usually less susceptible to interference, although bandwidth will be greater. Enhanced performance however comes with GFSK (Gaussian Frequency Shift Keying) modulation, as the outgoing transmission is filtered and smoothed to a cleaner signal occupying a narrower bandwidth. Receiver sensitivity thereby also improves.



PIN FUNCTIONS

PIN	Name	Function	Description
1	GND	Ground	Ground (0V)
2	VCC	Power	Power supply
3	EN	Input	Enable pin (>1.6V);
4	RXD	Input	UART input, TTL level
5	TXD	Output	UART output, TTL level
6	AUX	Output	Data In/Out indication
7	SET	Input	Parameter setting pin

Pins have traditional 2.54mm (= 1/10th ") spacing

DORJI
Applied Technologies
=> www.dorji.com

Dorji DRF7020D13 434 MHz data transceiver - mechanical dimensions

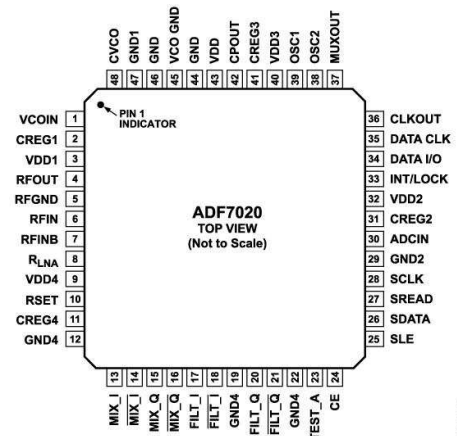
MicroZed's Dorji DRF7020D13: Australian PICAXE agents Microzed now pleasingly retail Chinese made Dorji 433 MHz GFSK transceivers, selling a tempting DRF7020D13-043A at just ~Aust \$23 each (antenna extra). These stamp-sized modules are powerful (but still a legal 25 mW), sensitive (~-118 dBi at low data rates), versatile and easy to use. Inbuilt buffers and error correction give reliable "wireless serial port" action –essentially what's sent out at the TX (transmitter) of one module is transparently seen at the RX (receiver) of the other. The modules handle all the hard work! 434 MHz offerings of just a few years back, although considered smart at the time, increasingly look quite tame in comparison. Note- Dorji offer diverse adapters & about a dozen other UHF modules,, but many have transmitter powers that exceed the 10 dBm (10mW) or 13dBm (25mW) 434 MHz legal limit that's permitted in most Western countries.

DRF 7020 D 13 — 043 A

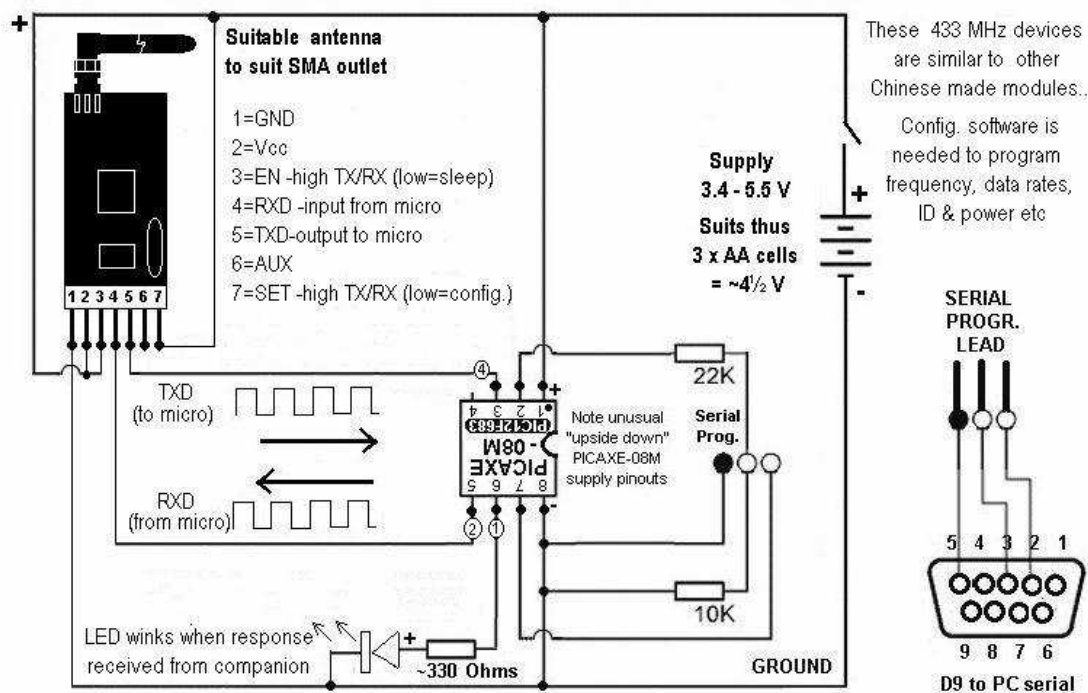
Num	Symbol	Meaning
①	RF module	RF GFSK module
②	IC Type	ADF7020
③	Module Function	Data transmission
④	Power	13dBm output power
⑤	Freq. Band	043: 433MHz
⑥	Package	DIP package with SMA connector

Part Name	RF IC	MCU	Freq.	Voltage	SEN	Rx current	PWR	Tx current	STB current
DRF4431F13-043	SI4431	No	434Mhz	1.8~3.6V	-121dBm	≤18.5mA	13dBm	≤36mA	≤1uA
DRF4431F13-086	SI4431	No	869Mhz	1.8~3.6V	-121dBm	≤18.5mA	13dBm	≤36mA	≤1uA
DRF4432F20-043	SI4432	No	434Mhz	1.8~3.6V	-121dBm	≤18.1mA	20dBm	≤95mA	≤1uA
DRF4432F20-086	SI4432	No	869Mhz	1.8~3.6V	-121dBm	≤18.1mA	20dBm	≤95mA	≤1uA
DRF4431F27-043	SI4431	No	434Mhz	3.3~6.0V	-122dBm	≤20.5mA	27dBm	≤320mA	≤3uA
DRF4431F27-086	SI4431	No	869Mhz	3.3~6.0V	-122dBm	≤20.5mA	27dBm	≤320mA	≤3uA
DRF1212D10-043	SX1212	Yes	434Mhz	2.1~3.6V	-113dBm	≤3.2mA	10dBm	≤35mA	≤1.5uA
DRF7020D13-043	ADF7020	Yes	434Mhz	3.4~5.5V	-118dBm	≤28mA	13dBm	≤35mA	≤5uA
DRF7020D20-043	ADF7020	Yes	434Mhz	3.4~5.5V	-117dBm	≤32mA	20dBm	≤100mA	≤5uA
DRF4432D20-043	SI4432	Yes	434Mhz	3.4~5.5V	-121dBm	≤20mA	20dBm	≤100mA	≤3uA
DRF4432D20-086	SI4432	Yes	869Mhz	3.4~5.5V	-115dBm	≤20mA	20dBm	≤100mA	≤3uA
DRF4432D20-091	SI4432	Yes	915Mhz	3.4~5.5V	-115dBm	≤20mA	20dBm	≤100mA	≤3uA
DRF7020D27-043	ADF7020	Yes	434Mhz	4.7~8.0V	-117dBm	≤35mA	27dBm	≤400mA	≤5uA

Dorji modules -the name arises from a Tibetan word meaning “a reliable and trustworthy guardian of peace and justice” – are noticeably similar to other Chinese offerings. Close inspection reveals a common use of the high performance Analog Devices ADF-7020-BCPZ (=> www.analog.com/en/rfif-components/rfif-transceivers/adf7020-1/products/product.html) transceiver IC , although a "1BCPZ" was noted on the Dorji. Their controlling micros. may also differ, being Atmel on one & “0C002” on the Dorji. As they've a different on board micro-controller and RF IC hardware, the likes of Appcon's “RF Magic” configuration software probably hence won't work with the Dorji transceivers.



PICAXE coding: The Dori modules 1/10th inch SIP connections suit breadboard trials, and almost trivial PICAXE test coding can put them through their paces. The infamous PICAXE-08M serial hang up was got round here by using PULSIN, as this command does "move on" if no data is received! Of course no sooner had the approach been organised than the local Postman Pat delivered a swag of the new fire breathing 08M2s. These thankfully now respond to SERIN timeouts and could be used instead - call it "Dorji's Law" maybe ? As most constructors will still be using 08M's the PULSIN approach has however been initially retained. Note: The 08M2 now requires it's pins to be known as C.0, C.1, C.2, C.3, C.4, C.5 - the 08M simply used the pin number without the "C." in front. The latest PICAXE programming editor however automatically converts pins to the new b.# style, and 08M2 users can further retain 08M compatibility by adding "let dirsb = \$FF" as an initial code line.



DORJI™ model "DRF7020D13-043A" UHF data transceiver - 1/2 duplex testing

Use with "ping-pong" code => www.picaxe.orcon.net.nz/dorjitrjal.bas , under breadboard layout .../dorjitrjal.jpg

Stan. SWAN
July 2011

Here's the simple trial "ping-pong" driving code Note- the "t" before the baud rate. These modules use a non-inverted "true" data mode ("t") rather than inverted ("n"). True uses a high idle state, with low start & high stop comms. bits surrounding the "10101010" style 8 data bits.

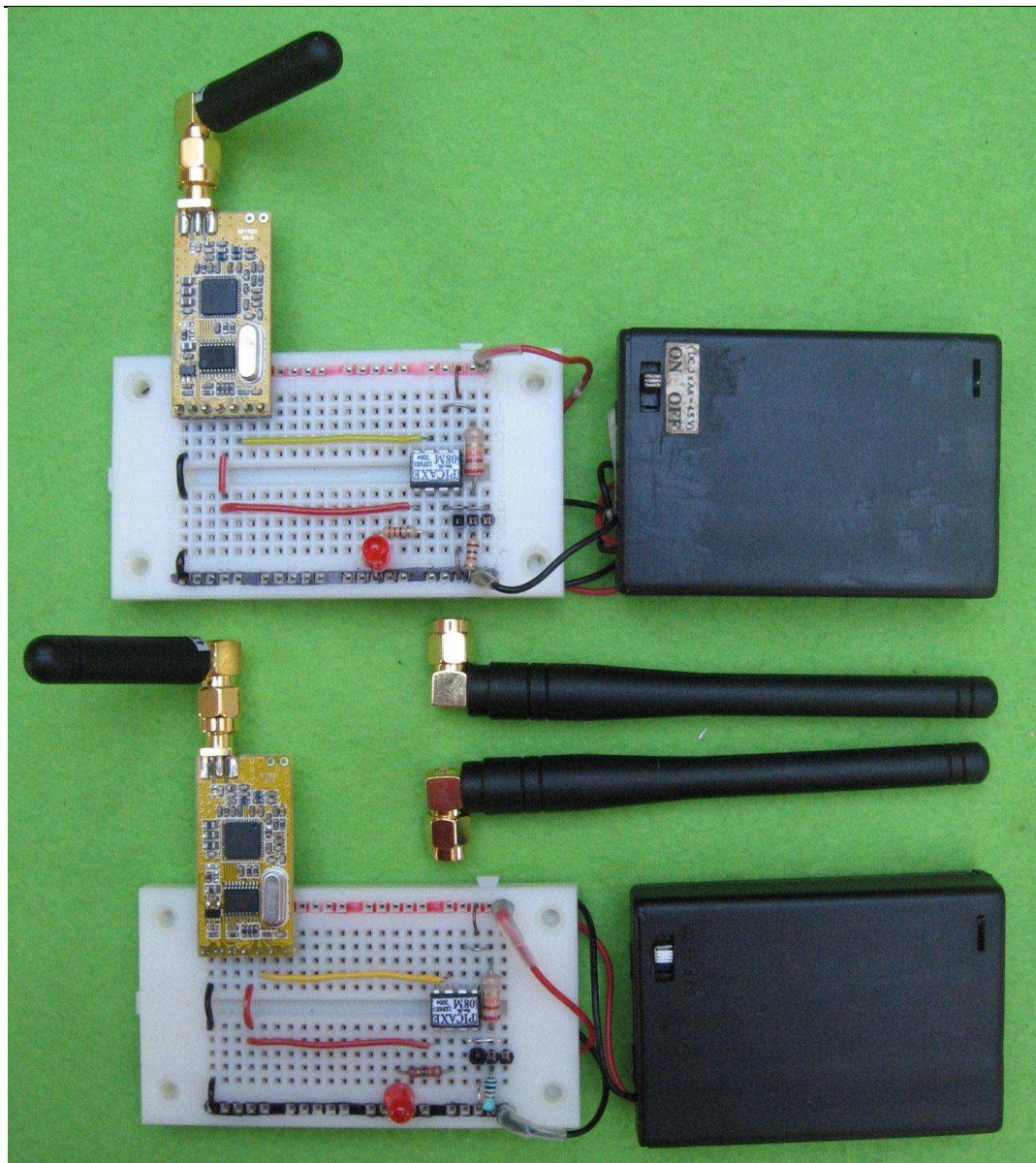
'DORJI DRF DRF7020D13 433 MHz transceiver trial setup July 2011. Stan. SWAN
'makes use of the slight reading "wait" of PULSIN to prevent 08M serial hangup !
dorji:

```
serout 2,t1200,(b0) ' PING. b0 just a handy "placeholder"- can be anything
pulsin 4,0,b1 ' listens pin 4 - reads & briefly awaits any reply
if b1=0 then dorji ' if nothing heard then "ping" again & await reply
```

```
serin 4,t1200,b0 ' routine when a response heard after pinging
pulsout 1,200 ' LED flash indicating data received
goto dorji
```

The resulting action is perhaps akin to a "Hello 1 this is 2 can you hear me? Over" style radio check, with a "Hello 2 this is 1. I heard you - please confirm that you've received my report back to you" response. Voice radio operators naturally would soon go crazy

continually ping-ponging mindless signal reports like this, even though it verifies each end IS actively sending and receiving. At a data level however it conveniently allows one man testing of the modules range – when the local LED stops winking the far end is no longer linked. Enlisting a non-technical buddy to help with such coverage tests may otherwise soon become an exercise in boredom for them! The aux output on Pin 6 (& supposedly indicating TX / RX activity) remains at a constant low on transmit, but it briefly goes high on receive, for a period related to the length of the data packet. Simple tests confirm this is long enough to blip an LED and/or trigger an PICAXE interrupt. The DRF7020D13i module has no RSSI (received signal strength) or WOR/W (wake on radio/wireless) tap points to awaken a snoozing system if signals arrive. However PICAXE driven “SLEEP” & pin3 (EN) control can greatly help, although a scheme is then needed to match to the signal transmission rate.



Field testing: Quick trials with a matching pair of Dorji DRF7020D13,organised to run half duplex controlled by PICAXE-08Ms to hand, readily managed 300 metres range through typical NZ light timber frame buildings & assorted sheds & vegetation. Both set ups were identically coded and wired, with Dorji pins 2(Vcc), 3(EN) & 7(SET) run to the +ve supply-

refer layout. (These 3 links are wired under the module and thus obscured on the diagram). No initial module configuration was required, as they pleasingly worked 'out of the box' on 433.920 MHz & at full 25mW transmit power. This may be all many users need of course. Even when placed right beside each other the units worked OK, with no sign of overloading. The supply needs range from 3.4- 5.5 V, & conveniently thus suit 3 x AA (~4½ V). Active current drains were about 30mA, but could be lowered with PICAXE 'SLEEP' commands.

Several supplied antenna were used, with even the stubby ~45 mm long one performing well. (Although deceptively short, it's indeed labelled 433 MHz!) Past experiences indicate several km LOS (line of sight) should be possible with the longer antenna. To put such performance in perspective, even at the default "9" (=13dBm or a mere 20 mW) the TX power is only about that of an LED. In daylight a LED would be hard to see at 10 metres!



Antenna: The module features a quality gold plated SMA socket, which suits the matching stubby antenna. Aside from such classic options as a ¼ wave whip (~170mm long at 433 MHz), Yagi or Slim JIM, the best range boosts at UHF come by elevating the RX/TX. Tests once made with ~470 MHz UHF CB sets, progressively elevating outdoors from ground level to rooftop, showed ranges were boosted a near order of magnitude this way. For demanding links hence mount these 434 MHz modules as high as possible (perhaps within a plastic container) and run the low speed data and DC supply up to them from below. Note: Power boosting is usually illegal - Australian/NZ 433.92MHz LIPD ISM regulations (revised Jan. 2009) say the transmitter should not exceed 25mW EIRP (Effective Isotropic Radiated Power), but some countries limit the transmitter power to only 10mW, & allow a gain antenna only at the RX. An alternative could be to organise a simple data repeater-see later ideas.

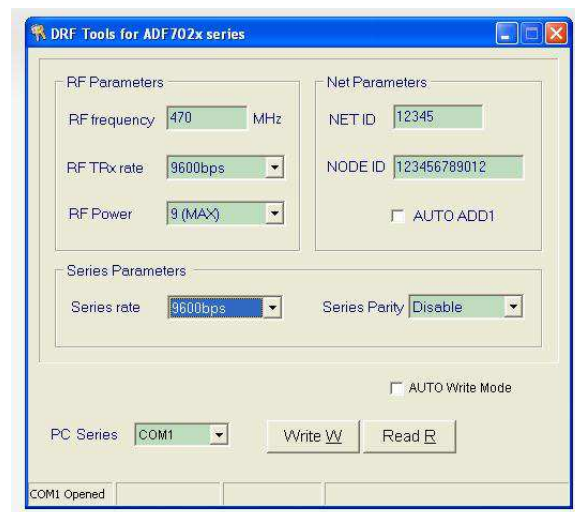
Set up configuration: The modules work well without configuring, but comprehensive “DRF Tools” setup software (“7020series.exe” ~820k) is available from Dorji’s web site => www.dorji.com . This tool allows tweaking of frequency (~418 - 455 MHz), power and data rates, but a USB or serial TTL-to-RS232 level shifter is needed - Dorji’s small USB-TTL adapter (~\$12) seems ideal for this task & is likely to be preferred.



As with similar USB/serial configurations, getting serial adapter modules talking to ones USB fitted PC may be a driver and hardware trial. However the Dorji adapter (detected as a SiLabs “CP2102 USB to UART bridge controller”) worked seamlessly once it’s drivers were sourced via => www.dorji.com/info/download.html

Although they work “out of the box” it’s probably worth configuring modules to your own needs, especially if local interference arises. The 434 MHz ISM band covers a ~1.7 MHz spectrum slice from 433.05 to 434.79 MHz, so quiet slots and multiple channels, well removed from the usual 433.92 MHz “RF soup”, may be utilised. Tweaking power settings & data rates (both “on air” and serial) can also give worthwhile performance boosts and/or battery life extensions. The PICAXE-Dorji interface rate can go as low as 1200 bps, but 2400 bps will probably be most suitable. This UART (Universal Async. Receiver Transmitter) rate is normally slower than the modules usual “on air” 9600 bps, but slower RF transmission rates often perform better, as signals occupy narrower bandwidth. Hence try also setting the “RF TRx rate” to 2400 bps.

N.B. Net & Node ID configuration parameters seem meaningless in the “DRF Tools” utility. Providing the frequency and data rates match, the modules communicated no matter what these are set to! These 2 options are apparently intended to suit mesh networking, but such capabilities remain under development & are presently disabled. Of course a simple network can still be created with a protocol provided with PICAXE serin “ABC” style qualifiers for station ID and data handling.



Transceiver configuration is also possible directly (at 9600 bps) via the driving micro-controller- the setup mode is entered simply by setting the Dorji module SET pin (7) to low. Configuration syntax follows the write command style **WR_Freq_DRFSK_POUT_DRIN_Parity**

Hence to set the module to work at Freq (433.92MHz), DRFSK (9.6k bps), POUT (13dBm), DRIN (1.2K bps) & Parity (no parity), enter the 10 byte command- **WR_433920_3_9_0_0**
The module will promptly respond back this string to confirm parameter acceptance. Once SET is adjusted back to high the new settings can be utilized. Here’s the settings summary -

Parameter	Unit	Length(Bytes)	Explanation
Freq.	KHz	6	433.92MHz = 433920
DRFSK	Kbps	1	2400, 4800, 9600, 19200 bps equal to 1, 2, 3, 4
POUT	dB	1	0~9; 0 refers to -1dBm and 9 for 13dBm
DRIN	Kbps	1	1.2, 2.4, 4.8, 9.6, 19.2, 38.4, 57.6 =0,1,2,3,4,5,6
Parity		1	0: No parity; 1: Even parity; 2: Odd parity

Simple Repeater: As a simple circuit extension, a proof of concept 434 MHz & PICAXE-08M(2) based simplex 'store & forward' data repeater ("digi-peater") was trialled. Decades of ham radio 144 MHz voice repeater experience had given familiarity with probable benefits, and this quest was largely intended as a check on DORJI based data repeater potential. A typical use may arise with wireless temperature monitoring deep inside a building, with the weak acquired data signal then rebroadcast by a rooftop repeater to a more distant receiver. The set up below gave ~100m range in such circumstances, but pleasingly >1km via an elevated repeater! Data is sent transparently under EDAC (Error Detection and Coding), via an inbuilt 256 byte buffer that kicks in if the 'on air' rate is less than the UART data rate.

The test circuitry was still based around the earlier layout for all 3 modules (transmitter, repeater and receiver), although the PICAXE micro-controller on each required individual programming - a near trivial task thanks to Rev. Ed's user-friendly editor. The new PICAXE-08M2 'serin' timeout and redirect options were used to redirect the program sequence if the uplink transmission was lost for more than 2000 ms (2 seconds). Past PICAXE serial "hang-ups" (often requiring cussed code workarounds) are thus now thankfully avoided. Elevating this repeater above obstacles worked wonders for improving coverage in difficult UHF environments (trees/buildings/terrain), showing impressive LOS range boosts to many km.

Simple 433 MHz 9600bps data repeater (DORJI DRF7020D13 based & PICAXE 08M2 driven) - suits non LOS ranges >~1km !

Transmitter	Repeater	Receiver
'DORJI 'DRF7020D13' 433 MHz transceiver - TX 'Data must be "T" to work - "n" gives corruption 'Use with companion rxdorji & maybe repeater ? dorji: for b0=1 to 100 'Counts 0-100 = easy check! serout 2,t1200,("ABC",b0) pulsout 1,200 pause 1000 next b0 goto dorji	'Dorji 433 MHz simplex data REPEATER rptdorji: serin [2000,lost],4,t1200,("ABC",b0) serout 2,t1200,("ABC",b0) goto rptdorji lost: pulsout 1,100 'uplink lost- LED alert goto rptdorji	'Dorji 433 receiver-use with companion txdorji RX 'Exploits new PICAXE 08M2 serin timeout features rxdorji: serin [2000,lost],4,t1200,("ABC",b0) serxd (#0,CR,LF) 'N.B.- 'doubled' data display pulsout 1,200 'is shown if both TX & goto rxdorji 'repeater are in range! lost: serxd ("Data link lost...") goto rxdorji

via Stan. SWAN Oct. 2011

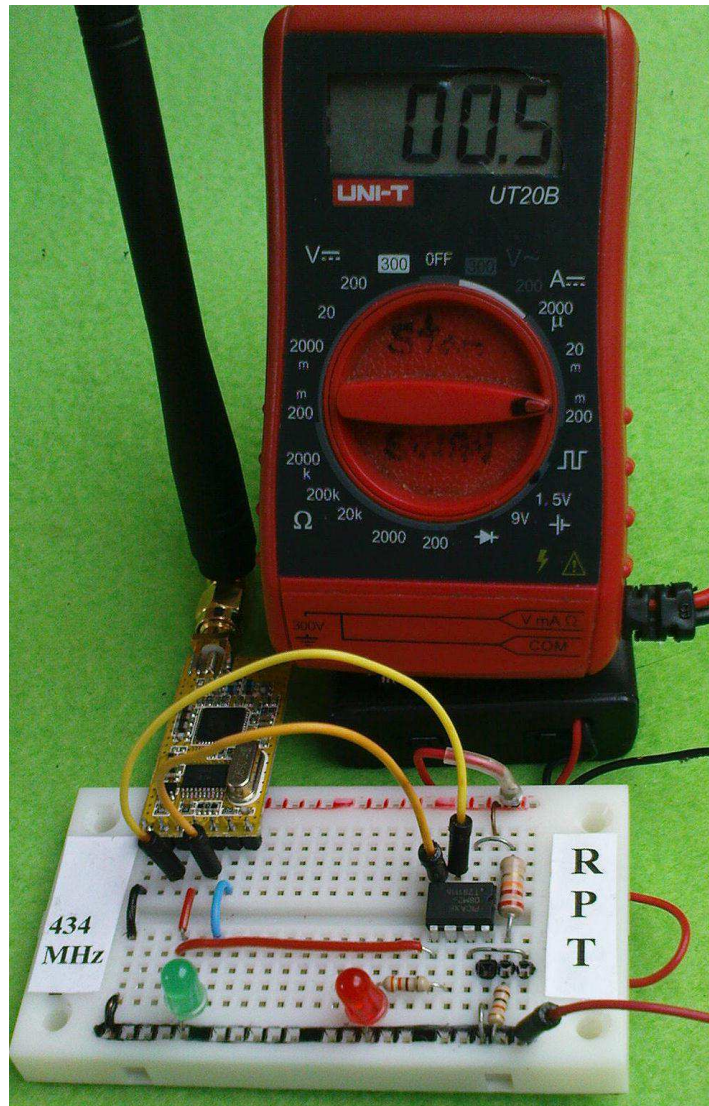
Although programmed differently, all 3 modules are laid out essentially the same, except for an extra LED (green) on the repeater's pin 6 to show uplink data received. If both the transmitter & repeater are received then a distinctive doubled data display shows - VERY handy for field trials (by noting RX LED double wink). Set all 3 modules initially (via the Dorji USB adapter?) to 434.000 MHz, with 9600 bps on air & 1200bps data rate.

Such a very basic data repeater can be greatly enhanced & tweaked of course. At the very least the repeater (which could be hauled up a tree/sited on an elevated pole/rooftop & powered by battery or solar PV) can employ some current reducing snoozing 'down time'. It's presently drawing a rather high ~30mA & if powered by 3 x AA cells, the drain could flatten batteries within a week. Although a PV solar panel (~2 - 5 watts?) and rechargeable cells could ease this drain, battery replacement may soon become irksome and costly.

Enhanced repeater: When monitoring the likes of (say) ambient temperature or water levels, the very nature of such slowly changing values may justify only occasional data sending of course. As time critical data would probably go via cellular now anyway, it's hence wasteful to leave the repeater fully powered for infrequent signals, especially since PICAXE controlled snoozing can be easily employed. Naturally consideration of the overall system, particularly the consequences of missing/awaiting key data signals, may dictate approaches.

A simple technique just involves the repeater awakening (via a PICAXE sourced "high" to the Dorji's 'EN' pin3) every minute for a few seconds, and then listening for the data being continually fired from the transmitter. Upon detection, data is organised for normal repeating to the distant RX, then the EN pin3 is made "low" for snoozing again. If nothing is heard the repeater's "lost" LED can be activated before the program loops. Only small wiring changes are needed in the original circuit – Dorji pins 3(EN) and 5(TXD) now run to PICAXE pins 3(data in) and 4 (sleep/wake control). Refer=> www.picaxe.orcon.net.nz/dorji-enh-rpt.bas

This crude "machine gun" approach requires multiple sends of the data in the hope that the snoozing repeater may waken for a reception 'window', but was shown to be reliable and effective. Current drains of under 1mA were noted during PICAXE & Dorji snoozing. Depending on the 'SLEEP' duration (which very usefully can be determined at the transmitter) drains may now average just a few mA overall, & repeater battery life may extend by ~an order of magnitude- maybe to months. A smaller solar PV & 4 x AA NiCd/ NiMH cells could now handle this load.



A more tempting scheme could be to "ping" the repeater regularly, telling it to sleep unless fresh data was available. Timing drifts may arise of course (as accurate time keeping is not available on a simple system), but a degree of synchronisation could develop if the repeater acknowledges TX commands before hibernating. The Dorji's are transceivers after all, so a reply signal can confirm repeater compliance. Enjoy-article feedback comments appreciated!

References: Code, circuitry, field trial findings, pictures and regulations etc are conveniently hosted at => www.picaxe.orcon.net.nz/dorji434.htm Acknowledgement of assorted data sheets and diagrams from Dori Applied Technologies (Shenzhen-China) is hereby made. All other pictures and circuits are by the author => stan.swan@gmail.com (Wellington,NZ)