Remote Link

Revisions	
Date	**Description**
3 Feb 2014	preliminary
7 March 2014	release

For full details and software follow this link:

http://doc.byvac.com/index.php5?title=Product_RL01

Introduction

The remote link is an interface to the low cost TX / RX modules available. The on board microcontroller will take care of reading the attached transducer, constructing and assembling the packets and presenting them to the hosts system. This considerably frees up system resources.

They are designed to use the low cost 'keyd' 315 to 433MHz TX/RX pairs. The system is designed for sending small packets (4bytes) of data as far and reliably as possible. This is ideal for sending telemetry data from a remote location, e.g. the outside temperature.

Two PCB's are available for self assembly. RL01 is a PCB that will do both TX and RX depending on which components are fitted and the RL02 Transmitter PCB that has an on board voltage doubler for increased range. Both circuits work from 4 x AA or AAA cells giving 6 Volts.

The hardware and software are both open source and so can easily be modified. The link can sand data from a variety of sources, the firmware that comes with the micro controller can send from the following devices:

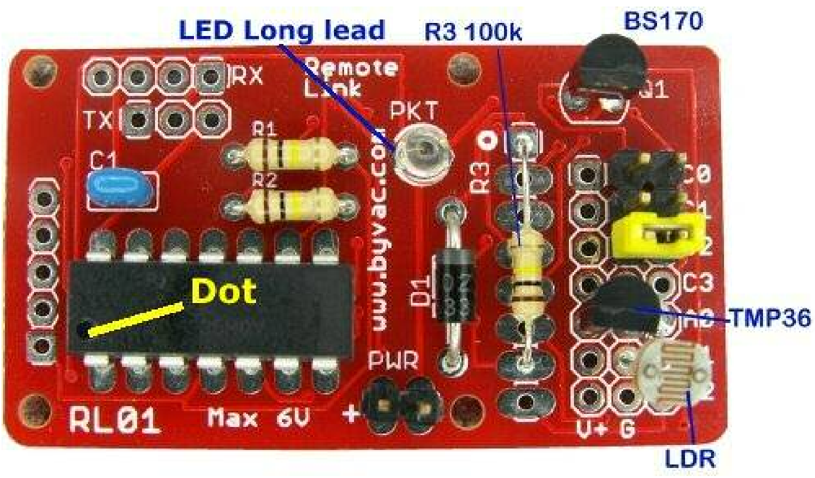
- DS18B20 1 wire Temperature sensor -55 to +125 Deg. C
- LM35 Analogue temperature sensor 2 to +150 Deg. C
- TMP36 Analogue temperature sensor -40 to +125 Deg. C **
- LDR for measuring ambient light **

** The current Firmware V2.4x uses these devices for the packet information.

Transmitter RL01

The PCB for the transmitter and receiver are exactly the same, however different components are used. There is also an RL02 board for increased range. See "Transmitter RL02".

Special Note: The range of the RL01 as a transmitter is poor and only practically good for a few metres using the 433MHz frequency but is much better with the 315MHz frequency. It is recommended for outdoor use that the RL02 is used.



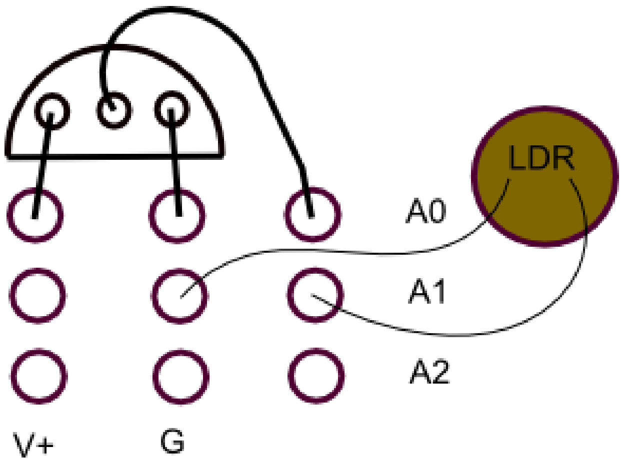
Completed Board - without the TX module

The board shows the components used in the transmitter. Firmware version 2.4x will send alternately two packets of information one for the LDR and the other for the TEMP36. Above the TMP36 sensor are three jumpers that can set the length of time between packet transmission. The greater the length of time the longer the battery will last.

Construction

Construction is straight forward, whilst it does not matter which components are placed first, some components MUST be placed the correct way round and these are detailed here:

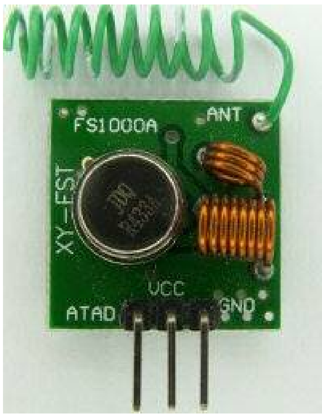
- PIC16F1824 IC This must be soldered with the dot to the left as shown, as this is a low cost system there is no socket so be sure that it is the right way round. The device is sensitive to static and so use a static wrist band or simply discharge yourself (touch a large metal object) before handling the part.
- Diode D1 The white stripe goes upwards
- LED This will have a longer lead at one side. The longer lead goes to the left.
- TMP36 temperature sensor. The centre pin of this device goes to the right and so care must be taken not to short this out on anything, ideally use some heat shrink or insulating sheath on the centre pin.



This is the arrangement on the PCB. The components are a quite close together so a bit of care is needed to make sure the wires do not touch.

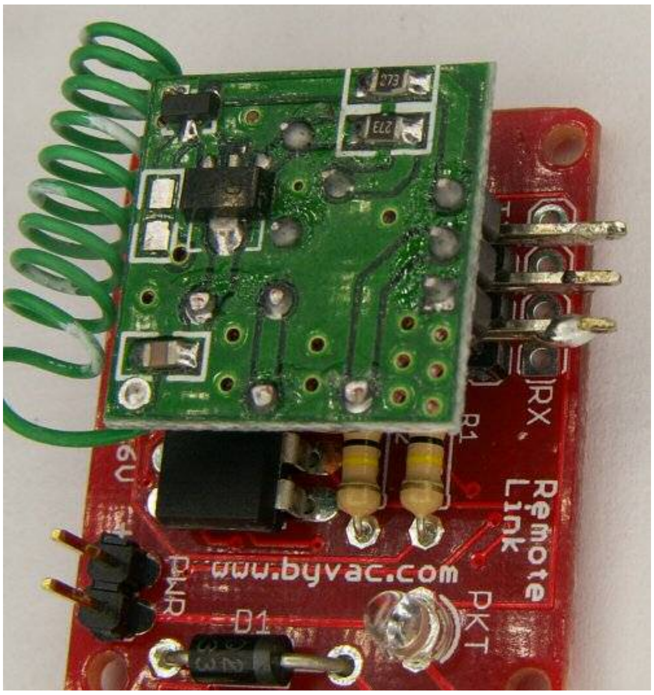
The other components can be placed any way round. Provided is an 8 way pinhead this is cut into 2 x 3 pins and 1 x 2 pins to use for the jumpers and power connector.

Installing the TX Module

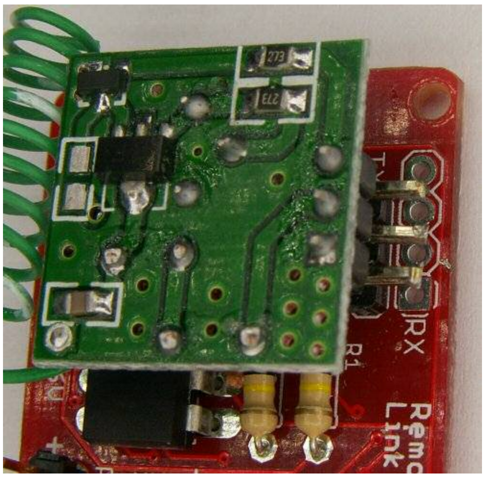


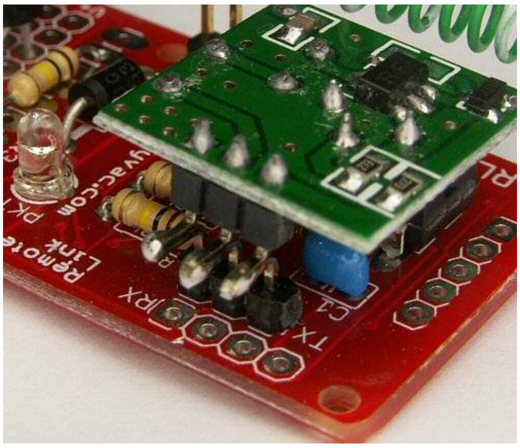
TX module with antenna attached

The TX module can be installed into the PCB holes in an upright position if required. But to save space a 90 degree pinhead is used.



The 3 way 90 degree pinhead is mounted on the PCB first and the TX module is soldered to that as shown. The pins can then be cut off, this makes the TX module including the antenna just as wide as the PCB so it is much more compact.





Component List TX

- PIC16F1824
- C1 0.1uF capacitor
- R1 to R3 100k Resistors
- LED 3mm
- Diode 1N400x or similar
- Q1 BS170 MOSFET
- TMP36 Temperature sensor
- LDR 50k dark resistance
- 8 way pin head cut to size
- 3 way 90 degree pins
- 3 shorting jumpers
- RL01 PCB

Operation

It is assumed that 4 x AAA cells will be used to power the device producing 6V. The main purpose of the diode is to reduce the voltage from a 6V battery to 5V or so for the PIC.

The firmware will send out an alternative packet every so often and then go to sleep to conserve power. As an extra power saving method the BS170 will turn off when in sleep mode, this means that any sensor attached to the device is also switched off.

Sleep is controlled by a timer and this can be adjusted using jumper pins.

Packet Transmission Time

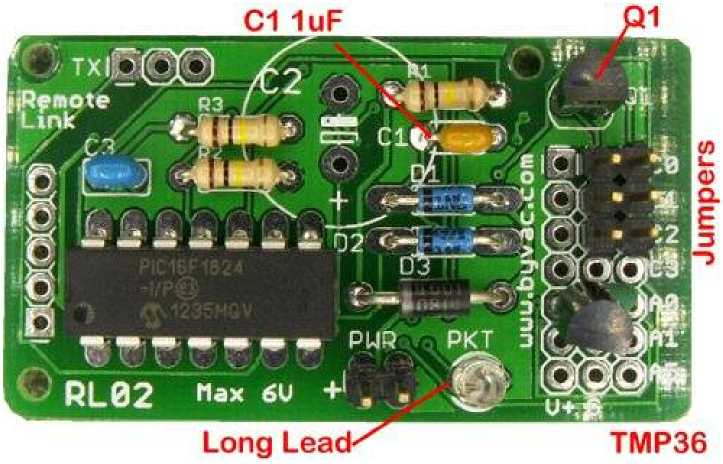
The table shows the packet transmission frequency when the selected jumpers are closed. Note the jumpers are only checked on power up, so should only be changed when the device is off.

	2s	4s	8s	16s	32s	64s	128s	256s
C0		x		x		x		x
C1			x	x			x	x
C2					x	x	x	x

Jumper configuration x means the jumper is connected.

Transmitter RL02

The RL02 transmitter board has an on board voltage doubler that will drive the TX module with about 10V. This **greatly improves** the range but there is a battery life cost. Each time a packet is sent there is a 1.5 second switch on to pump up the capacitor to the higher voltage. As the packet is more likely to be received this can of course be offset by not sending the packet so often.



This is the transmitter board without the large capacitor fitted, the jumpers are used in the same way as RL01 and shown is a TMP26 fitted.

Care must be taken to get the correct components in the correct place. The blue diodes D1 and D2 are schottky types but D3 is just a normal type.

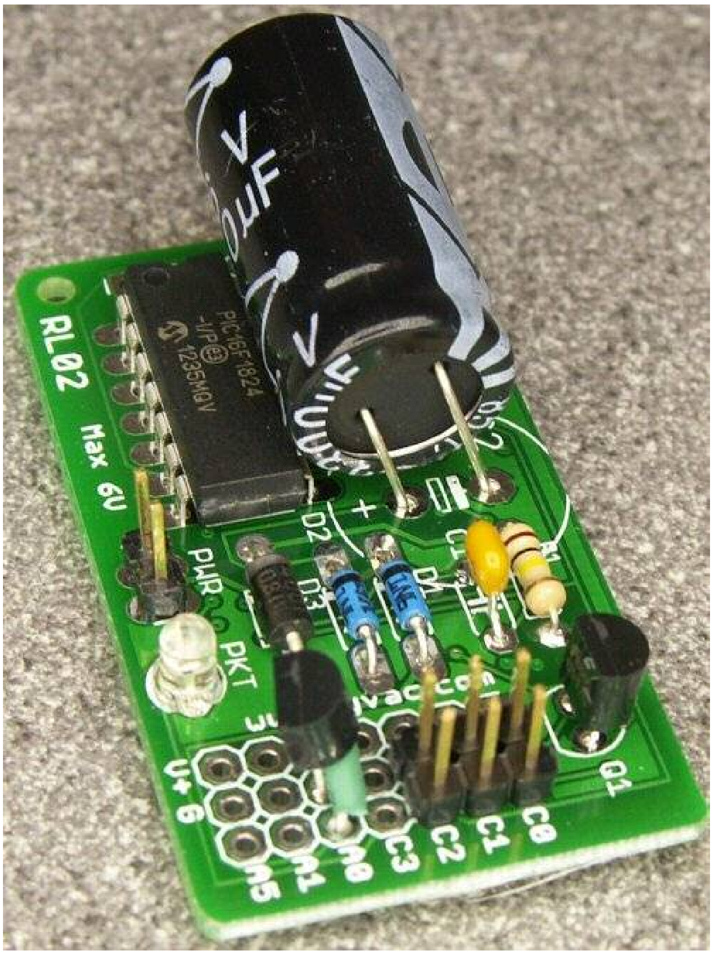
Component List TX

- PIC16F1824
- C1 1uF capacitor
- C2 3300uF capacitor
- C3 0.1uF capacitor
- R1 to R3 100k Resistors
- LED 3mm
- D1, D2 Schottky 1N6263 or similar
- D3 1N400x or similar
- Q1 BS170 MOSFET
- TMP36 Temperature sensor
- LDR 50k dark resistance (if supplied)
- 8 way pin head needs cutting
- 3 shorting jumpers
- RL02 PCB

Construction

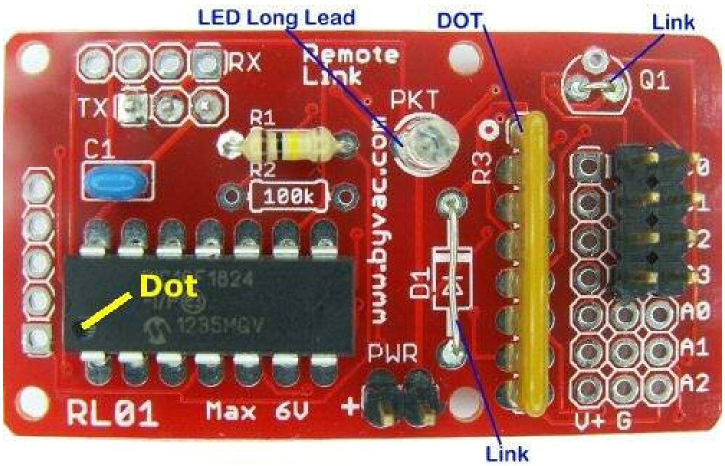
Construction is the same as for the Rl01 taking care to get the components the correct way round.

The capacitor can go either up, left or right. When it is laid down like shown it des save some space. The leads need to be soldered so this can happen:



Receiver

The receiver uses less components than the transmitter but it uses the same PCB. Output from the receiver to the host is taken from underside of the board.



Construction

Observe from the picture that not all components are fitted, this is because the same board is used for the transmitter as well as the receiver. The construction is straight forward but care must be taken with the following parts:

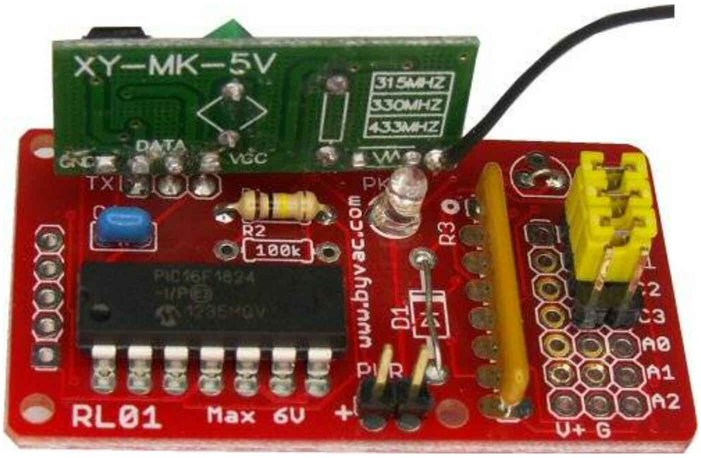
- PIC16F1824 IC This must be soldered with the dot to the left as shown, as this is a low cost system there is no socket so be sure that it is the right way round. The device is sensitive to static and so use a static wrist band or simply discharge yourself (touch a large metal object) before handling the part.
- LED This will have a longer lead at one side. The longer lead goes to the left.

- R3 must go in the correct way round, there is a dot on one end, make sure this goes to the top.

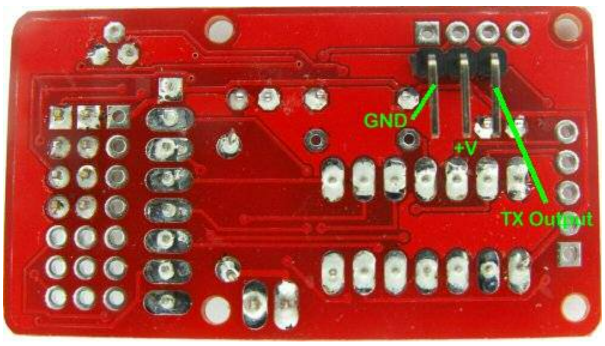
Make sure both wire links are put in place. The receiver must be powered by a regulated 5V supply.

The receiver module is fitted on top of the board but there is a 3 pin 90 degree angle connector fitted to the bottom of the board.

This is the receiver (TX) module. The antenna is soldered to a hole next to the coil on the left hand side, it can just be seen; the black wire.



The RX module can be soldered in as shown, it does contact the LED slightly.



The 3 pin 90 degree right angle pinhead is soldered to the underside of the board, the actual soldering is of course done at the top side of the board. This is used to optionally power the board and connect to the host.

Component List RX

- PIC16F1824
- C1 0.1uF capacitor
- R1 100k Resistor
- R3 100k DIL resistor

- LED 3mm
- 10 way pin head cut to size
- 3 way 90 degree pins
- 3 shorting jumpers
- RL01 PCB

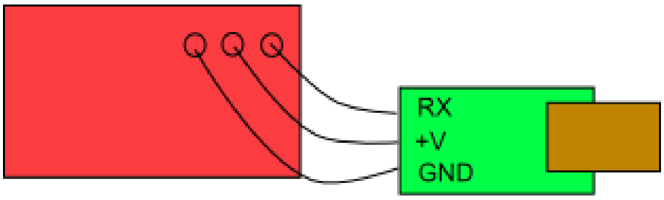
Operation

Operation is dependent on the firmware used, it is assumed for this text Version 2.4x is in place.

There are several modes of operation selected by the jumpers in the table below.

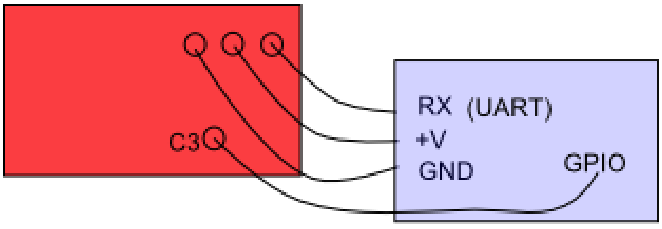
Connecting to the Host

The host (whatever the RX is connected to, e.g. Arduino, PC) will be connected to the TX Output pin on the underside of the board. For convenience power can also be supplied here.



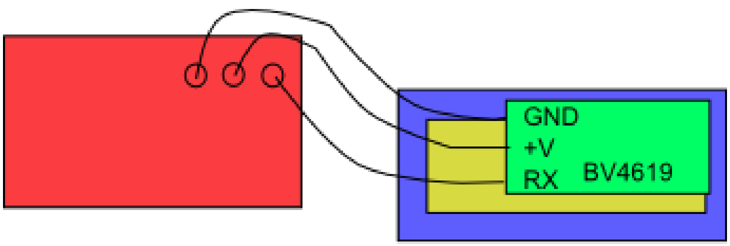
USB to Serial

Connection option for connection to a PC. Very useful for debugging.



Microcontroller

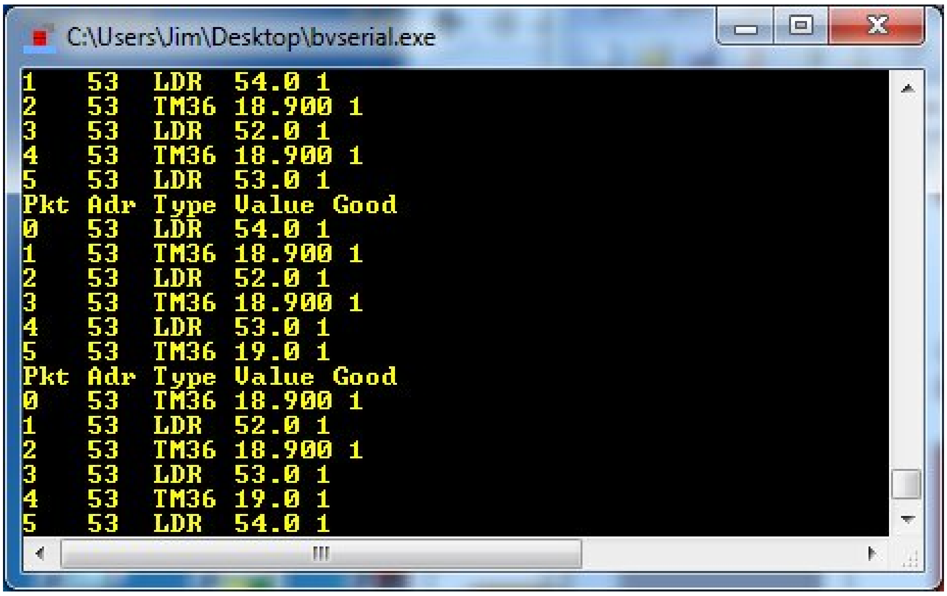
Connection to a micro controller, only the RX pin is needed. This could be an Arduino, ByPic or Raspberry Pi



20x4 LCD

Connection to a BV4619 LCD controller. This will give direct output to a 20x4 display that can be useful for checking range.

The normal output from the TX pin is a list of the last 10 packets of information. The jumpers control when this information is sent, how it is presented (format) and to what device.



This is typical output to a terminal running at 9600 Baud. Jumpers C1 and C2 are closed.

When the information is sent it is controlled by jumper C0 and pin C3. When jumper C0 is closed the information is presented each time a new packet is received. This is useful for debugging and testing for range. In a more practical situation, this would normally be open. The information is then only sent when pin C3 is taken low. This pin would be connected to a GPIO output pin of the host micro controller and when the micro controller needs to see the information this pin can be pulsed.

It is important that this pin be kept high until the information is needed otherwise it will halt the operation of the receiver. In other words the micro controller should pulse the pin low to request the information and then set it high again.

C2 controls how the information is presented.

Raw Data Format (C2 closed)

The information consists of a number packets in a table with the information presented as below. When A packet is received it is placed at the end of the table and the rest of the table is pushed down. This way there is a history of the last x number of packets. The actual number of packets may vary depending on which firmware version.

:Packet Number, TX address, Type, Data A, Data B, Data C, Checksum, Checksum result, CR

Packet Number: This is a number from 0 to 9. The latest packet received is packet 9, this is output last, with packet 0 being output first. The packet number is preceded by a ':' this is so that a microcontroller can easily detect and select the required packet.

TX Address: A transmitter has a single byte address this is so that more than one transmitter can be used with the same receiver. This address will effectively identify the location of the transmitter.

Type: This refers to the sensor type, as an example the TMP36 is type 22 and the LDR is type 10

Data A,B and C: This is the data from the sensor and varies depending on the type of sensor. As a general rule any sensor will send a number, this will be a 16 bit number with the high byte sent first.

	Type	**Data A**	**Data B**	**Data C**
LDR	10	0	High	Low
LM35 [1]	20	0	High	Low
DS18B20 [1]	15	Sign	High	Low

TMP36 [1]	22	Sign	High	Low

NOTE: [1] Values are sent multiplied by 1000, so 23.764 degrees will be 23764

Checksum: A checksum is generated by the transmitter from the combination of all of the bytes sent. In the current firmware this is 6 bytes for each packet which consists of the transmitter address, 4 bytes of information and the checksum itself.

If the receiver adds these 6 bytes together, using an 8 bit variable, the result should be 0, if not one or more of the bytes are incorrect.

Checksum Result: This is a calculation carried out by the receiver and it will present a 1 if the checksum was okay and 0 if not.

Converted Format (C2 open)

The receiver will determine the type of sensor from the type byte and convert the data into a readable format. All numbers are presented as floating point. The data is presented as 10 packets (or records) in the following format.

Adr, Type, Value, Good CR

Address is the transmitter address and type is the type of device, both described above. Good will be 1 if the checksum is okay and 0 otherwise.

Value: This is a floating point value calculated form the raw data, devices such as the LDR that does not have a floating point value are still presented that way but the decimal part will always be 0.

Output to Device C1

In firmware 2.4x there is an option to send data directly to a 20x4 LCD fitted with a BV4619 LCD controller. With C1 open extra text is sent that will format to the LCD display. This is intended for finding range and experimentation.

	Open	**Closed**
C0	Only send packets when C3 is low	Send data packets each time a new a packet is received.
C1	Send information for LCD BV4619 format	Send information formatted for terminal
C2	Send information as raw data	Send information converted to a number depending on device type
C3	A transition from high to low will send out the information. This must be kept high when not needed	

Jumper configuration for firmware 2.4x

Packet Format

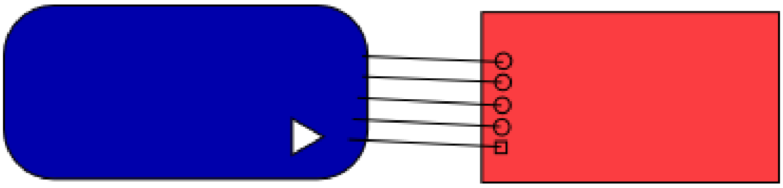
The packet format has been previously described but is presented here for reference. A packet is the data bytes that are sent by the transmitter at intervals. It consists of 6 bytes.

1. Address of the transmitter. This is so that more than one transmitter can be used, it effectively describes the location of the transmitter.
2. Four bytes of information. This can be any information pertinent to the sensor device.
3. Checksum. The check sum is calculated such that if the receiver sums all 6 bytes together using an 8 bit variable the result will be 0

In addition to the above a 40mS preamble is sent to synchronise the transmitter and receiver. The complete length of the packet including the preamble is approximately 100mS.

Programming & Firmware

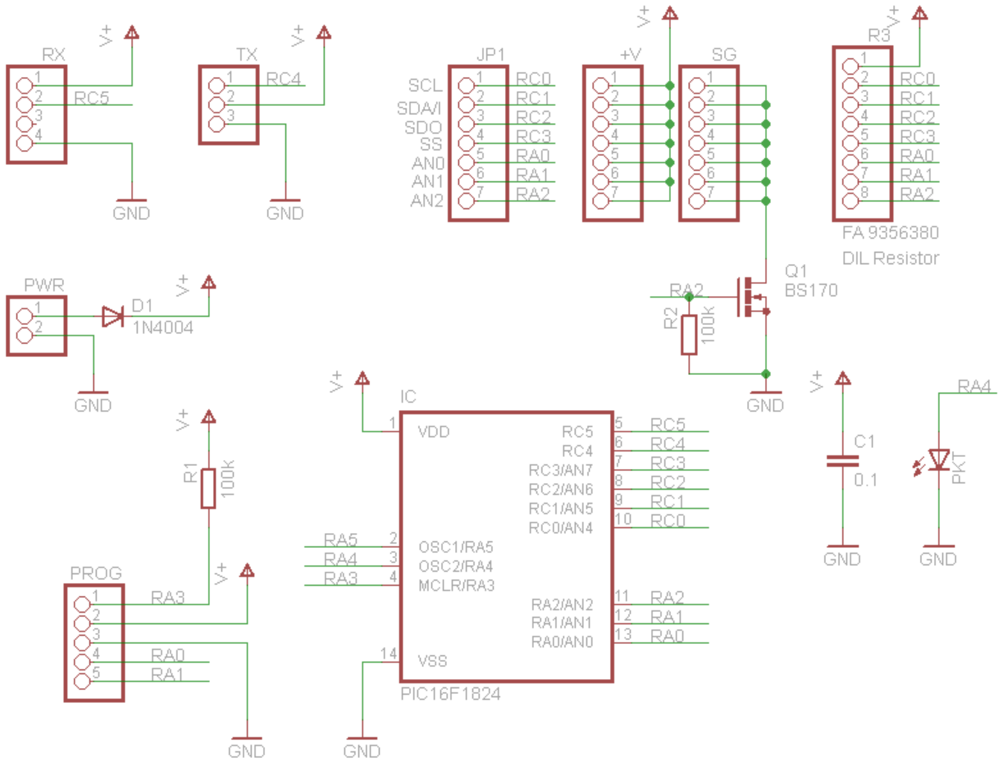
The PIC's come loaded with the current firmware but can be re-programmed. For convenience the PCB has programming pads that correspond 1:1 with either a PICkit 2 or PICkit 3



Pin 1 on the PICkit, marked with a white triangle goes to the square pad on the PCB. It is possible to simply use a 5 way pinhead and wedge them into the holes whilst programming.

Hardware

RL01 Circuit



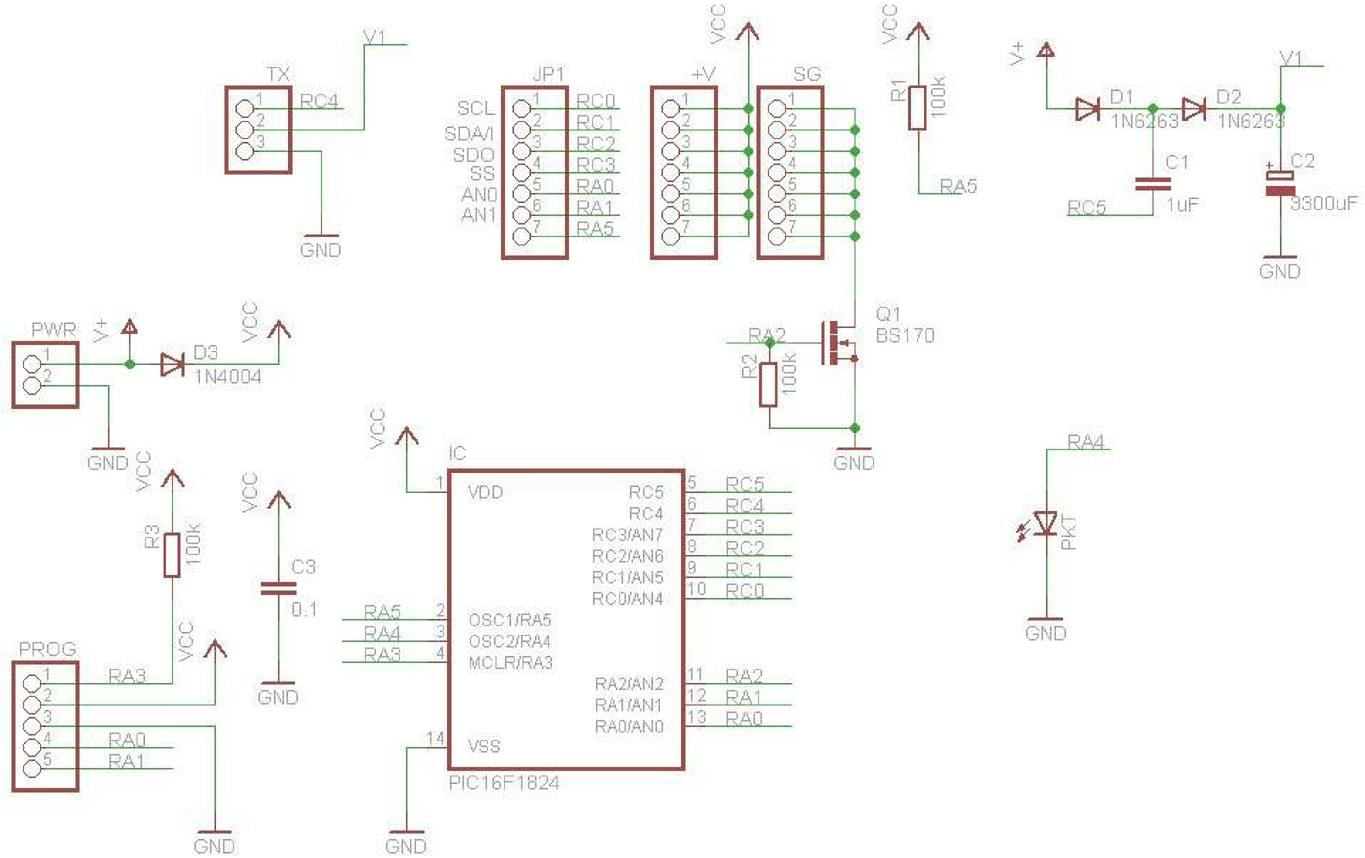
The circuit is designed to be as general purpose as possible, to this end it could in fact be used for other purposes. Most of the ports have been brought out to the connector and there is an optional SIL resistor to provide pull up to all pins.

A feature useful for low power operation is the ability to switch the sensors off for the relatively long periods of sleep. This is done by Q1, A low on the gate of Q1 will remove the ground connection to the sensor thus effectively switching it off. A sensor should therefore be connected to the +V and SG pads to provide power.

The output of the sensor is connected to any convenient GPIO pin, but they have been arranged so that an I2C or SPI device can be connected to the upper pins as indicated on the diagram. The PIC used has a register that can redirect the pins for other uses if required.

The TX and RX modules will in fact work by simply connecting them to the UART, however the range is limited, to this end RC5 is by default connected to the UART RX and RC 4 is connected to the UART TX. These as mentioned previously can be redirected to other pins if required.

RL02 Circuit

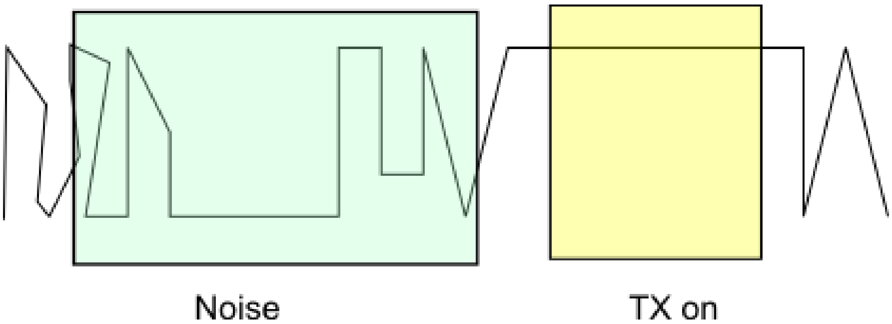


This has the diode pump circuit formed by a 1uF, 3300uF capacitor and two schottky diodes, D1 and D2 otherwise the circuit is very similar to the RL01. It does nor have any space for a pull up resistor so if this is required, for an LDR for example it must be fitted separately.

Range & Background

The TX and RX modules used are very cheap in every sense of the word. They work by 'keying'. That is the transmitter is either switched on or off. One good aspect of the transmitter is that the ADAT pin is a switch, threfore the transmitter can be powered permanently but only consume power when the ADAT pin is high, greatly simplifying the power conservation circuitry.

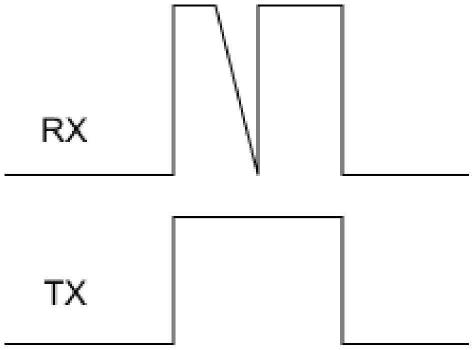
The receiver output will go high when it receives a signal from the transmitter, however when it is not receiving a signal it may be high or low in a seemingly random fashion due to noise.



When the receiver receives a signal and goes high there is a small period of low when not receiving a signal before reverting back to noise. To take advantage of this a preamble is used that simply consists of high and low pulses. This stabilises the receiver and provided there is a good signal an almost 1:1 correspondence with the transmitter is achieved.

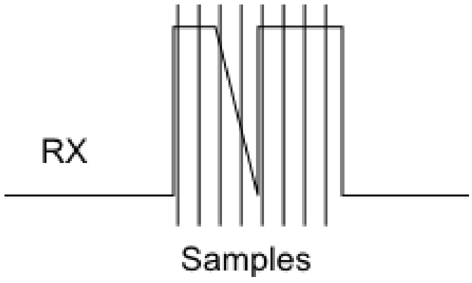
By experimentation is has been found that a reasonable period of preamble is required to achieve acceptable pulse widths. That is they start very narrow and eventually achieve stabilisation.

It is also important to keep the data pin changing state. A long period of low signal will result in noise and a long period of high will destabilise the receiver. This is common for all systems of this type and various methods are used. Look up Manchester encoding for further information.



When the signal strength is low (which is often the case) glitches have been observed, this behaviour rules out edge detection as a method of decoding the signal. Also when there is no signal, there are more glitches are observed during the off period than the on period.

The method therefore chosen to decode the signal is to only sample during the on periods and then to take an average length of the on period. This will determine if the signal is 1 or 0. By sampling the time period, should a glitch does occur then it will not necessarily result in the loss of any information.



Expectations and Improvements

The TX and RX modules are very low cost and so don't perform that well. As always there are exaggerated claims about range. In any radio link the range in free air line of site will be drastically reduced by objects.

The Antenna

There are various methods that can be used for the antenna and choosing the correct one will make a considerable difference in performance. However a simple 1/4 wave coiled out of telephone wire is quite effective. The following lengths are used depending on the TX/RX frequency:

315MHz	283mm
330MHz	227mm
433MHz	173mm

In practice the length can be slightly shorter but the above lengths have proved to work satisfactorily.

Extra Voltage

The range is proportional (kind of) to the voltage supplied to the transmitter, up to 12V can be used and it does have quite an effect.

The first possible improvement is to power the TX module directly from the power source rather than through the diode, this is simple enough to do but does mean cutting a PCB track on the RL01.

Voltage Doubler

This is done in the RL02 design, it improves the range considerably, 3 or more times better range.

Enclosure

The RL01 and RL02 will fit snugly into a Maplin FT32 type box, including a 4 way battery AAA holder:

The hole is for the LDR.