LightwaveRF 433MHz Protocol Notes

Intro

This document gathers together notes on the RF protocol used to communicate by 433MHz to the devices like dimmers and switches from control units like the remote controls and Wifi link. It does not cover the UDP protocol into the wifi link a this is well documented elsewhere.

The notes come from material previously produced by GeekGrandad http://geekgrandad.wordpress.com/2013/01/03/lightwaverf-arduino-library/, Benjie http://www.benjiegillam.com/2013/02/lightwaverf-rf-protocol/, and SoMakeIt https://wiki.somakeit.org.uk/wiki/LightwaveRF_RF_Protocol

I have also done my own experimentation and produced Arduino type libraries for TX and RX using 433MHz modules which can be found on Ebay very cheaply. The libraries can be found on github at https://github.com/roberttidey/LightwaveRF

The notes here are organised in a bottom up approach, rf modulation and bit encoding, message encoding, message transmission, commands and parameters. There is then a section describing the libraries.

RF modulation and bit encoding

Modulation

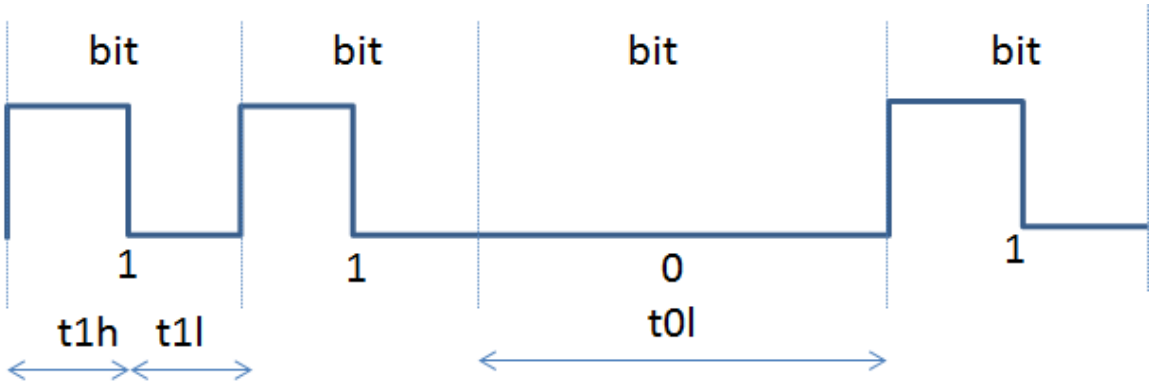
The transmissions take place at 433.29MHz and the basic modulation is simple AM modulation or OOK (on-off keying). A high turns the transmitter fully on and a low turns the transmitter fully off.

There are two common types of RX module. The more common is a simple super-regenerative receiver where an oscillator at 433MHz is regularly ‘quenched’ and allowed to build up again. A received signal changes the rate at which oscillations build up and effectively gives a high gain. A second type is a more classical superhet receiver using a built to purpose receiver ic. This is potentially more stable but also tend to be made available with controlled bandwidth which can affect the received timings a little bit.

Bit encoding

There are several ways of interpreting the bit encoding mechanism. The way I choose here seems to be the easiest to understand. A binary 1 is represented by a burst of RF followed by a short burst of silence. A binary 0 is represented by an extended burst of silence. To ensure that the data can be recovered reliably there must be a decent number of transitions in the data and the method used here is to do message encoding to ensure there is never more than a single 0 in a sequence.

The timing is illustrated here.



The timings I have measured are a good match with previous results.

Using the super-regen receiver to capture the timings and averaging over about 1000 transitions I get

t1h = 293uSec, t1l = 280 uSec, and t0l= 990 uSec

The superhet receiver gives slightly different results of

t1h = 328uSec, t1l = 251 uSec, and t0l= 982 uSec

The difference is probably due to a smaller bandwidth on the superhet making it slower to transition from on to off and therefore stretching the high periods a bit.

Transmitting bit encoding

This is fairly straightforward as a 1 bit can be encoded as a on period followed by an off period, and a 0 bit can be encoded as a longer off period.

Receiving bit decoding

This is little bit more complicated as there is no obvious transition between a 1 bit and a 0 bit. However, there is never more than one 0 bit in the sequence so the decoding can be done just by looking at the duration of the low periods. A short low (t1l) represents a 1 bit, an extended low (t1l + t0l) represents a 10 sequence.

Message encoding

The message encoding is nicely described by the SoMakeIt reference. A message packet consists of 40 bits of data which is organised into 10 nibbles of data. Each nibble is represented by a start bit (1), followed by 8 tx bits. These tx bits are chosen to obey the rule that there is never more than one 0 bit in the sequence. The byte encoding of these nibbles is also chosen so there are always two 0's in each byte. This keeps the transmission time of each nibble the same.

Nibble	Byte	Hex
0x0	11110110	F6
0x1	11101110	EE
0x2	11101101	ED
0x3	11101011	EB
0x4	11011110	DE
0x5	11011101	DD
0x6	11011011	DB
0x7	10111110	BE
0x8	10111101	BD
0x9	10111011	BB
0xA	10110111	B7
0xB	01111110	7E
0xC	01111101	7D
0xD	01111011	7B
0xE	01110111	77
0xF	01101111	6F

This translation table can be used to both format data for transmission and to decode the real message content on reception.

The overall message has an additional start bit (1) and an additional end bit (1).

So, in summary, the 40 bits or 10 nibbles are transmitted as

MsgStart 1

10 times

    Nibble start bit 1

    4 bit nibble -> 8 bit encoding

MsgEnd 1

This gives a total of 92 bits of low level 1's and 0's encoded into actual transmission bits.

{Comment}

Although the chosen scheme here is simplistic, it is not as good as it could be. A more efficient self clocking encoding scheme could have either slowed the timing down making it more robust or have encoded more tx bits in the same type of packet. The latter could have given a more expandable message and could also have included error correction capability.

Message transmission

Each message packet of 92 bits consists of 72 1's and 20 0's (Each of the 10 translated nibbles has 2 0's). This means it takes 72 * (t1h + t1l) + 20 * t0l time to transmit. This is about 61msec.

The transmitting device repeats this a number of times with a gap of about 10mSec in between each message. The repetition is intended to increase the chance of a message being received correctly

even if several get interfered with or lost. Devices also seem to need at least 2 repetitions to obey the message. This is to decrease the chance that a received corrupted message is acted upon.

The number of repetitions varies with the transmitting device. The simple remotes I have tested repeat the message 6 times taking about 400msec overall. The wifi link repeats the message 25 times taking about 1.7 seconds. I guess the reason for the difference is that a remote is likely to be used in fairly close proximity to the device whereas the wifi link has to work over a larger area.

Commands and parameters

As has been said the basic message consists of 10 4 bit nibbles of data. These are structured as

- 2 Nibbles – 1 byte parameter value (0-255)
- 1 Nibble device (0-15). 15 reserved for mood control.
- 1 Nibble - Command (0-15)
- 5 Nibbles of Transmitter ID
- 1 Nibble of Transmitter Sub ID (0-15)

The device, Transmitter ID and Sub ID are what are used to pair a controller with a device. This is an important aspect of the one way nature of the communication. The Controller / transmitters have no intrinsic way of directly addressing devices. Similarly a device does not have the concept of a device number or address. Instead during a pairing operation the device remembers the device number, Transmitter ID, and sub ID. It will then respond act on messages containing this information and ignore all others. Most devices seem to have the capability of remembering up to 6 ‘addresses’ and therefore responding to messages coming from 6 different sources. Note that a wifi link or equivalent master controller is regarded as a single ID combination in this respect. All UDP messages going into the Wifi link for a particular device will appear on the RF protocol to be coming from the same (wifi link) source irrespective of the phone, computer, etc sending commands to the wifi link.

The second interesting part of the ID combination is the Sub ID. This is used by the Wifi Link to effectively form a Room ID. The end devices themselves have no concept of rooms but commands into a wifi link are organised by rooms each with a number of devices. The device number becomes the device nibble (0-15) and the room number becomes the Sub ID (0-15). So, theoretically you can arrange devices in up to 16 rooms each with 16 devices for a total of 256 end devices. Other parts in the chain may limit this further, e.g. the smartphone app.

It is possible that other parts of the Transmitter ID could be used for further expansion in this direction but I have always seen the same 5 nibbles coming out of a particular wifi link.

That then leaves the Command in the message and the 8 bit parameter.

This seems to be the greyest area at the moment and although there is enough for basic control I am continuing to do some work on this and will edit this section.

Command	Value	Parameter	meaning
Off	0	0-127	Switch a device off param usually 64
Off	0	128-159	Set a device level 0-31 (param–128)
Off	0	160-191	Decrease Brightness
Off	0	192-255	All off param usually 192
On	1	0-31	Switch a device On to last level
On	1	32-63	Set a device level 0-31 (param–32)
On	1	64-95	Set a device level 0-31 (param–64) Same effect as 0-31
On	1	96-127	Set a device level 0-31 (param–96) Same effect as 0-31
On	1	128-159	Set a device level 0-31 (param–128) Same effect as 0-31
On	1	160-191	Increase brightness
On	1	192-223	Set all to level 0-31 (param–192)
On	1	224-255	Set all to level 0-31 (param–224)
Mood	2	130-	Start mood n (param–129). (130=Mood1) Device = 15
Mood	2	2-	Define mood n (param–1). (2=Mood1) Device = 15

The commands have been labelled as Off and On as that is what the controllers tend to send. This certainly applies to switches but for dimmers the distinction is less and in practice a lot of the behaviour is determined by the parameter. For example one can set the level of a dimmer using the same parameter setting using either an off or on command.

Libraries and test programs

I have written two libraries for Arduino type processors (e.g. ATMega328) to control the RX and TX modules used for 433MHz transmitting and receiving. They are split into the two parts as often one only wants Tx or Rx. Of course if an application has both reception and transmission then both libraries can be included. The code for these is on the Github mentioned together with some test sketch programs.

The functionality of the libraries is to provide the lower levels of message transmission and reception. They also support the basic addressing mechanisms. The Rx library supports filtering and pairing operations to reduce the messaging reported back to the application. It is up to the applications to decide what messages to send and how to interpret and act upon the messages received.

TX library (LwTx)

The Tx library is based around a tick based interrupt service routine running a state machine going through the various phases of message transmission (start of message, start of nibble (byte), nibble byte, bits, message end, inter message gap and repeats. The interrupt is only active once a message has been posted to be sent and once the message has been sent the interrupt is turned off until the next message.

This technique means that the foreground application of the Arduino can post a message and then get on with other tasks and no low level timing has to be done in the foreground.

When the interrupt is active then it operates with a standard tick of 140uSec as this gives a good match to the bit timing requirements. Everything therefore happens at this rate or a multiple of it. So for example a TX high consists of two ticks (280uSec).

The routine has been written to be tunable. The basic tick rate can be adjusted and also the number of ticks associated with particular states. These tuning parameters can be set from the application.

The interface to the library consists of

- void lwtx_setup(int pin, byte repeats, byte invert, int uSec); Should be called at least once to initialise the library. Set the TX pin to be used to control the transmitter, the number of message repeats to use, whether a high or low controls the transmitter on, and the basic tick rate (140)
- void lwtx_setTickCounts(byte lowCount, byte highCount, byte trailCount, byte gapCount); Tunes the number of ticks to be used for the various timing periods. Defaults are set internally so only needs to be called if tuning needed.
- void lwtx_setGapMultiplier(byte gapMultiplier); Normally gap is restricted to 255 * 140usec (35.7mSec). This call allows long gaps to be set for experimentation. The gap delay set by tick counts is multiplied by this amount allowing up to 9.1secs
- void lwtx_settranslate(boolean txtranslate); Sets whether nibble to byte translation of message data is used. This defaults to 1 (on) and the application should then send in message data. If set to 0 (off) then translation is skipped and the app should feed in raw byte values. Only needed if playing with the encoding scheme.
- boolean lwtx_free(); Used to detect if a message transmission is in progress. Should be checked for true before sending any message. If false then the app should postpone sending the message until it becomes free.
- void lwtx_send(byte* msg); Message sending interface. Normally a message consists of a 10 byte buffer.
- void lwtx_setaddr(byte* addr); Set address as 5 digit address to allow sending short commands
- void lwtx_cmd(byte command, byte parameter, byte room, byte device); Short commands, lwtx_setaddress should be called first.
- void lwtx_setEEPROMaddr(int addr); Sets the EEPROM base address to store info

This library can also save the basic device address in EEPROM. This is enabled by configuring the EEPROM_EN in the library; 0 is no EEPROM support, 1 is EEPROM support using an EEPROM.h library and 2 is EEPROM support using native functions. EEPROM_ADDR_DEFAULT defines the base address in the EEPROM to store the 5 byte device address but this may also be set using the lwrx_setEEPROMaddr function.

Example programs

Two example sketches are on the GitHub.

The LwTXTest is a simple sketch that simply sends a fixed message repeatedly. You can change the message by editing the sketch.

The LwTxTestEx is a larger sketch which allows for controlling the transmissions sent using commands received on the serial port. Type 9 to get help. Commands allow setting the basic 5 digit address, for sending command messages (cmd+parameter+room+device), for setting the basic send characteristics (repeats, clock period), and for adjusting pulse widths and gaps. If less than the number of values are used with a command then the previous values apply. So, for example, sending command messages can consist of just command + parameter and they will then address the last device used.

RX library (LwTx)

The Rx library is based around a pin change interrupt service routine running a state machine going through the various phases of message reception (start of message, start of nibble (byte), nibble byte, bits, and message end.

This technique means that the foreground application of the Arduino can get on with other tasks and no low level timing has to be done in the foreground. Message reception happens asynchronously and the foreground just has to occasionally check for and handle new messages.

The pin change interrupt basically measures the interval from the last change and splits this interval into groups of delay for the different types of interval of interest. This is combined with the level of the pin to form a state machine 'event'. The event is then handled by the main message state machine.

The routine is not directly tunable but the delay interval categories can be easily changed in the code if required.

Filtering of messages can also take place in the library. A repeat count allows for only reporting messages that occur at least this number of times in quick succession and they will only be reported once. A timeout also controls the repeat window.

Pairing is also supported. The library can accept pairing info in the form of room, device and 5 digit base address. It can also be put into an auto-pairing mode and will then add the address data from the next received message into its pairing information if the command is on (cmd=1). If the command is an off (cmd=1) then it will try to remove the pair. It will then only report messages that match one of its paired address. Multiple pairs up to a maximum of 10 are supported. There are two additional controls associated with pairing. PairEnforce controls what happens if no pairs are present. If false then any message received is reported. If true then messages are not reported until a pair is defined. PairBaseOnly controls how a pair is defined. If false then a pair is the transmit address + room + device associated with the message. This would be normal if using the library to make a single end point device. If true then only the 5 nibble transmit address is used and messages will be reported for any room and device. This can be useful if making intermediate devices like a repeater.

Moods and All Off are supported. If pairing has been defined then a message is reported if a Mood or All Off message is received irrespective of the device number in the message. It is up to the application to further interpret these messages and remember mood settings when a mood definition message is returned and then act when a start mood arrives.

The routine can also gather stats on the timing of the pulses giving average and min, max values for the durations of interest.

The interface to the library consists of

- void lwrx_setup(int pin); Must be called at least once to set the pin used for reception which must be pin 2 or 3 as these are supported by change detect interrupts.
- void lwrx_settranslate(boolean translate); Sets whether nibble to byte translation is used. Defaults to translate on.
- boolean lwrx_message(); Returns whether a message has been received or not. Should be called periodically to determine whether to handle a message.
- boolean lwrx_getmessage(byte* buf, byte len); Returns the message into a buffer of a t least len bytes. Len controls what information is reported. It can take values of 2, 4 or 10. If 10 then the full message packet is returned. 4 returns command, parameter, room and device. 2 returns just command and parameter. 2 and 4 are intended to be used primarily when pairing is used. translate determines whether the returned message is raw data or translated nibbles but this only applies to 10 byte returns.
- void lwrx_setfilter(byte repeats, byte timeout); This sets the number of repeats for a message to be regarded as valid. It can also set the timeout for these repeats. Use a repeat count of 0 to get all packets reported.
- byte lwrx_addpair(byte* pairdata); This adds pairing data. This is a 8 byte buffer containing device, dummy, 5 base address, room. It returns the number of active pairs defined.
- byte lwrx_getpair(byte* pairdata, pairnumber); This puts the pairing data for one pair into the buffer in the same format as addpair. It also returns the current paircount. If the pairnumber exceeds the paircount then the buffer is not updated and just the paircount is returned. So this may be called with a high pairnumber to get just the paircount.
- void lwrx_setPairMode(boolean pairEnforce, boolean pairBaseOnly); This sets the two pairing mode controls. pairEnforce true means that messages only get reported once pairing is established. pairEnForce false will report all messages if no pairing is defined. pairbaseOnly defines what constitutes a pair. If true then only the basic Tx address is used, If false then it uses the Tx address plus the device and room number associated with the pair.
- void lwrx_makepair(byte timeout); This puts the receiver into pairing mode for timeout in 100ms units. The first valid message received has the pair data added to the pairing pool. After the timeout period it reverts to normal mode.
- void lwrx_clearpairing(byte* pairdata); This clears out any previously added pair data.
- void lwrx_packetinterval(); This returns the number of milliseconds since the last packet was received. It may be used to determine when the reception is quiet as repeat packets may be being received after a message is reported due to the repeat filtering.

- boolean lwrx_getstats(unsigned int* stats); Returns an array of 9 values of stats consisting of average, max and min values of high times, short low times and long low times. The average values are multiplied by 16. Min and max are directly uSecs.

- void lwrx_setstatsenable(boolean rx_stats_enable); Controls whether stats are collected. Disabling also resets the stats counters.
- void lwrx_setEEPROMaddr(int addr); Sets the EEPROM base address to store info

This library can also save the basic device address in EEPROM. This is enabled by configuring the EEPROM_EN in the library; 0 is no EEPROM support, 1 is EEPROM support using an EEPROM.h library and 2 is EEPROM support using native functions. EEPROM_ADDR_DEFAULT defines the base address in the EEPROM the paircount (1 byte) followed by 8 byte entries for each pair. The pair information is held in translated raw tx byte form to make comparisons quicker.

Example programs

One example sketch is on the GitHub.

The LwRXTest is a sketch that sends any message it receives down the serial line. It shows the elapsed time and the message nibbles.

It can respond to a number of commands received on the serial line. 9 will give a little help menu. Commands allow for controlling the message reporting format, adding and clearing pair data and controlling repeat filtering. Commands also allow displaying the stats and resetting and disabling the gathering of stats.

Compile time macros allow for the log messages responding to serial commands to be controlled. Turning these off by commenting out the #define feedback means the sketch is smaller and the output will be primarily message traffic.

Using Libraries on other processors

The libraries were originally written to be used on AVR328 type processors. They have now (June 2014) been restructured slightly to make it easier to port to other processor / environments. This is controlled by #defines in the LWtx and LWRx header files.

The LwRX library primarily relies on configuring a pin to be tied into an interrupt routine. This is done by an attachInterrupt call which configures the interrupt number to be used. Previously as on a 328 processor only two pins were available (2,3) and these were mapped to interrupt numbers 0,1. Leonardo and Mega2560 have a wider range of pins that can be used and Due / Spark Core type processors have no restriction. A #define (PIN_NUMBERS) in LwRx.h sets up the list of pins that can be used in order of interrupt number. If there is no limitation then don't define PIN_NUMBERS and the pin number will be passed through direct to the attachInterrupt. The LwRx.h also has a #define section to define the board used which is primarily used to determine what header files are loaded. Similarly an EEPROM_EN can be defined or not to determine whether EEPROM support is available and will be used.

The LwTX library relies primarily on configuring a timer interrupt and being able to start and stop it. This was previously set up to use Timer2 on a 328. The set up and functions have now been separated in the code to make it easier to use different timer interrupt support. In particular there

are now 3 timer routines; one sets up a timer with a fixed period and attaches an interrupt service routine, the other two stop and start the interrupts. #defines are used to control which 3 routines are compiled into the code. The routines for the 328 and other basic AVR 8 bit controllers are coded directly. Two other sets are provided; one for the Spark Core and one for the Due. Both of these rely on external libraries. The Spark Core needs the SparkIntervalTimer library available from https://github.com/pkourany/Spark-Interval-Timer. The Due relies on DueTimer available from https://github.com/ivanseidel/DueTimer. Again EEPROM support can be turned on and off.

Note that as of the date of this document only the AVR 328 has been confirmed as compilable and working. The library was separately ported to the Spark Core using effectively the same code but the re-organised code has not been proven yet.

The AVR328 timer routines in the tx part were originally just for 16MHZ clock units. If a #define in LWTx.h is uncommented then they may be used for 8MHz units.

ESP-12 (esp8266) modules

The LwRx library has also been proven on ESP-12F (ESP8266) modules without significant change using the Arduino environment for these modules. A small change to the declaration of the stats function was needed as the compiler seems to more tightly distinguish between int and uint16_t. This compatibility opens up these very low cost units as LightwaveRF targets. The wifi capability on these modules means that they give lots of other possibilities as LightwaveRF devices.

The LwTx library use on these devices is under investigation.

Raspberry Libraries

I have also written 3 versions of libraries for the Raspberry Pi to support LightwaveRF RX and TX. All these libraries use the excellent pigpio library which utilises the DMA to give microsecond access to the GPIO. The first version is written in python which works but has some performance issues. The second is written in c++ linked directly, but can be relatively simply used within other language environments. It does, however, exclusively use pigpio for its own purposes. The third c version uses the recently introduced custom extensions for pigpio. This means that the lwrf routines are extensions of pigpio and are be accessed via the pigpio daemon. This makes them very easy to use from other languages including python without the performance issues. An example python program is given.

It is highly recommended to use the third c custom extension version. This has easy access and very low CPU usage (~7%) when running in background.

Pigpio documentation and downloads is at

http://abyz.co.uk/rpi/pigpio/index.html

Python Lwrf.py library

I have written a python library (lwrf.py) for the Raspberry Pi to support LightwaveRF RX and TX.

This uses the python interface calls supplied with pigpio and this in turn relies on the pigpiod daemon running in the background.

The RX side uses this to provide call backs on RX pin changes with a tick count. The protocol handler is then similar to the Arduino libraries. The TX side uses the waveform generator part of pigpio to set up a packet definition of transitions which are then put out by pigpio.

In order to use this library, the PIGPIO library must be installed, the pigpiod daemon must be running and the pigpio.py library interface to the daemon must be in the same directory as lwrf.py.

To start pigpiod manually just run sudo pigpiod from a console window. It can also be arranged to start automatically on raspberry pi start up.

Although this solution works it is very CPU intensive even with no message traffic. This is caused by the RX background activity. The python callback is exercised every time there is an RX transition which is happening all the time (typically 7000 times a second) due to the receiver agc and background noise. The pigpio to python interface time per call uses pretty much all the CPU even with minimal protocol handling

A rx class provides simple access to the rx functions and a tx class similarly for the tx functions. Normally a separate python app will create instances of these and use the class functions to check for and receive messages, and to transmit messages. To test the main function of lwrf.py will transmit one tx message 10 times and also print out any messages received for a 30 second period. If both a TX and RX module are attached to the Raspberry then the test will show the tx messages being received and it will then pick up any transmissions from other LightwaveRF devices like remotes or the wifi link.

See the main code at the bottom of the file to see how to set up and use the classes.

The rx class can be set up with a repeat parameter and also defines the GPIO pin to be used to connect to a RX 433MHz data pin. If repeat is 0 then all received packets are reported. If >0 then a packet is only reported after 'repeat' identical packets have been received and this will only be reported once until either a different packet is received or there is a gap of at least 1 second. This means that the normally repeated messages in a transmission will just report once.

The tx class defines the GPIO pin to use. The tx.put command contains a repeat parameter which controls how many times a tx packet is transmitted.

Both rx and tx messages are structured as a 10 element python list containing integers of the10 nibbles in a LightwaveRF packet.

C++ Lwrf.cpp library

I have written a C++ library (lwrf.py) for the Raspberry Pi to support LightwaveRF RX and TX.

This uses the pigpio library directly and does NOT use the pigpiod daemon. If the daemon has been started before then it should be killed first.

The RX side uses this to provide call backs on RX pin changes with a tick count. The protocol handler is then similar to the Arduino libraries. The TX side uses the waveform generator part of pigpio to set up a packet definition of transitions which are then put out by pigpio.

The library consists of two files (lwrf.cpp and lwrf.cpp) . A test program test_lwrf.cpp is supplied to show usage.

The rx class can be set up with a repeat parameter and also defines the GPIO pin to be used to connect to a RX 433MHz data pin. If repeat is 0 then all received packets will get reported. If >0 then a packet is only reported after 'repeat' identical packets have been received and this will only be reported once until either a different packet is received or there is a gap of at least 1 second. This means that the normally repeated messages in a transmission will just report once. The rx.Ready() call returns the number of pending messages or 0 if none. The rx.Get() call will return the oldest message and delete it from the message queue.

The tx class defines the GPIO pin to use. The tx.Put command contains a repeat parameter which controls how many times a tx packet is transmitted.

Both rx and tx messages are structured as a 10 character string containing the nibbles in Ascii Hex of a LightwaveRF packet.

The test program can most easily be built by placing all 3 files in the PIGPIO folder and then issuing the build command in a console window set to the PIGPIO folder.

g++ -o test_lwrf test_lwrf.cpp lwrf.cpp -L. -lpigpio -lpthread -lrt

To run the test use

sudo ./test_lwrf

This will send out a test message 10 times, print out any received packets for up to 30 seconds.

The RX and TX GPIO pins used are defined in the test program as also is the message and timeouts.

Using with other apps

To use the c++ version with other apps, the libraries could be included directly within other c++ applications. The other approach is to modify the test program so that it reads and writes the lwrf messages to FIFO pipes and runs forever as a daemon. However, it is easier to use the c custome extension for this.

C custom Lwrf library

This is written in custom.cext which is automatically compiled into pigpio as an extension to pigpio and accessible via pigpiod to support LightwaveRF RX and TX. Pigpio must be version 26 or higher.

This method will typically be used with the pigpiod daemon. The daemon must be started before using an application (sudo pigpiod).

The RX side uses this to provide call backs on RX pin changes with a tick count. The protocol handler is then similar to the Arduino libraries. The TX side uses the waveform generator part of pigpio to set up a packet definition of transitions which are then put out by pigpio.

The library is built into custom.cext and should replace the default file supplied with pigpio . A header file is also needed custom_lwrf.h. A python test program lwrfCustom.py is supplied to show usage.

The TX and RX methods are accessed via the standard pigpio custom_2 interface. This has a numeric argument, a char array, and can return a count and a char array. The numeric argument is used to distinguish the call as a LWRF library call making it simpler to add in other custom handlers into this file. The input char array contains a function number and further parameters and or tx message data. The return data is either in the count for simple numeric responses or in the char array for received data.

The rx routines are initialised with a repeat parameter and also define the GPIO pin to be used to connect to a RX 433MHz data pin. If repeat is 0 then all received packets will get reported. If >0 then a packet is only reported after 'repeat' identical packets have been received and this will only be reported once until either a different packet is received or there is a gap of at least 1 second. This means that the normally repeated messages in a transmission will just report once. The rx Ready() call returns the number of pending messages or 0 if none. The rx Get() call will return the oldest message and delete it from the message queue.

The tx routines defines the GPIO pin to use. The tx Put command contains a repeat parameter which controls how many times a tx packet is transmitted.

The top of the example lwrfCustom.py shows the custom command extensions and then the defined rx and tx classes access these routines in a python friendly fashion.

Both rx and tx messages are structured as a 10 character string containing the nibbles in Ascii Hex of a LightwaveRF packet.

The pigpio extension is built by copying the replacement custom.cext and custom_lwrf.h in the PIGPIO folder and then issuing the following commands in a console window set to the PIGPIO folder.

sudo killall pigpiod (if the daemon is running)

make

sudo make install

To run the test make sure pigpio.py is in your python apps directory and copy in lwrfCustom.py

sudo pigpiod (in a console window if not already running)

Python lwrfCustom.py

This will send out a test message 10 times, print out any received packets for up to 20 seconds.

The RX and TX GPIO pins used are defined in the test program as also is the message and timeouts.

You can use the python program as either an external library or change the functionality of the main routine.