Infrared Remote Controller Knowledge Base

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1. Infrared Remote Control Theory

Infrared control is one of the lowest cost solutions for remote control within the indoor visible range. As the required components are relatively low cost and readily available, almost all video devices, stereos, air conditioners, fans, set top boxes and other related devices adopt an infrared control method.

This document will be mainly used to explain the theory of infrared remote controller and analyse the standard protocol details. With this information, users can develop the most suitable infrared remote controller by using the Infrared Remote Controller Wizard.

1.1 Infrared Light

Infrared light is an electromagnetic wave, whose wavelength is between microwaves and visible light and ranges from 760nm to 1mm, an invisible light which is longer than red light. As infrared light is invisible, it meets with the requirements of short distance control, that is, we want to use it but we do not want to see it. Common infrared remote controllers generally use the invisible light with a wavelength of 940nm.

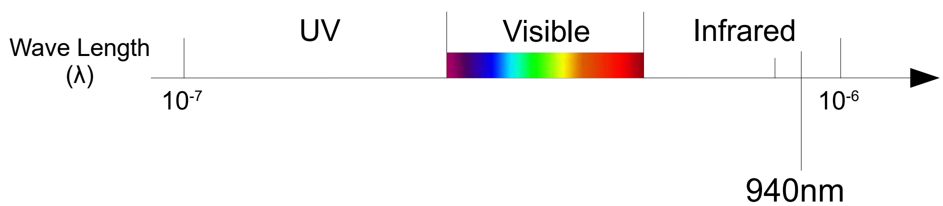


Fig.1-1 Infrared Spectrum

Although infrared light is invisible, it can still be seen using electronic imaging devices, such as cellphone cameras or digital cameras. By simply pointing the infrared remote controller device into a cellphone camera and pressing any button, the flickering light emitted from the LED can be observed.

However, all objects with a temperature above absolute zero of -273.15°C will emit infrared light. As a result, there are many different and natural infrared light emission sources in the environment. This can be from the farthest light source such as the sun or from surrounding lighting, heating and cooling devices. Therefore, when using infrared remote controllers, which use infrared light as a communication carrier, certain measures should be taken to ensure that the infrared message can be transmitted to the receiver correctly.

1.2 Modulation and Demodulation

Modulation of the signal on a carrier frequency is the solution to effectively transfer signals in a noisy environment. With modulation, the infrared light source can be made to flicker with a specific frequency, the infrared receiver will then be tuned to that frequency accordingly for demodulation, which allows the receiver to ignore environment noise and restore the original signals correctly.

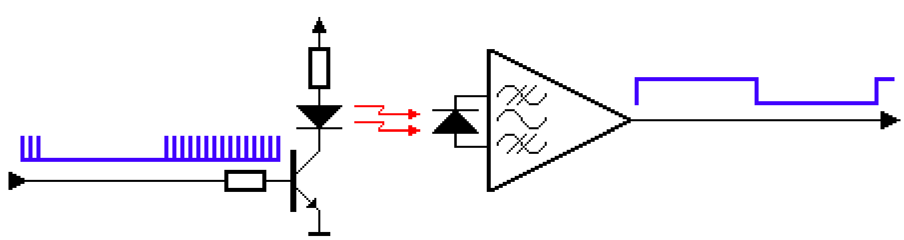


Fig.1-2 Infrared Signal Transmission and Reception

As the above figure shows, the transmitter at the left side uses a continuous pulse train to force the IR LED to switch on and off, which will then generate modulated signals. The detected signal is output from the receiver at the other side and then processed.

In such communication, it is general to use "MARK" and "SPACE" to represent the communication content. The "SPACE" is a default signal, which generally indicates an IR LED off state of the transmitter. However, in some infrared remote controller ICs, the drive chip drives the IR LED with 100% duty cycle (full light) during the "SPACE" state, and switch off the IR LED after data transmission is completed. It should be noted that there is no carrier signal in the "SPACE" in both methods. During the "MARK" state, the remote controller forces the IR LED to switch on and off using pulses at a specific frequency and duty cycle. Remote controllers usually use a carrier frequency ranging from 30kHz to 60kHz, within which the most commonly used duty cycle together with frequency is 1/3 duty @ 38kHz.

1.3 Devices

The usual modulation and demodulation devices are transmitters and receivers. The transmitter is generally a battery-powered handheld remote controller. During the design of transmitter, the power consumption should be reduced to as little as possible, and the infrared signal should also be as powerful as possible to achieve the required transmission control distance. A shock-proof function is also necessary.

As the infrared remote controller is a battery-powered handheld device, a control chip with an ultra-low static power consumption is the best choice for remote controllers to prolong the battery life. When no button is pressed, the remote controller will be in a sleep mode which will only consume a minimal current. When any button is pressed, the chip will be woken up to transmit the appropriate IR command.

In the IR LED transmitting state, the current flowing through the LED may vary from 100mA to 1A. To greatly increase the control distance, the current has to be as high as possible. However, this conflicts with the demands of battery-powered handheld device characteristics. Therefore, a trade-off should be made between the control distance and battery lifetime for dynamic power consumption control. Usually the duty cycle of the carrier pulse signals should be modulated to 1/3 or 1/4, which can effectively reduce power consumption and component heating, the influence on remote control distance can be reduced as well.

Generally, the IR LED voltage drop is about 1.1V. The transmitting current can be adjusted by modifying the resistance which is in series with the IR LED. Remote controllers often use an IR LED with a light-emitting wavelength of 940nm.

There are many different receivers in the electronics market. The most important selection criterion is the demodulation carrier frequency.

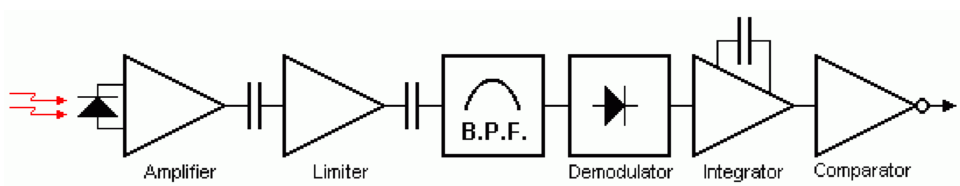


Fig.1-3 Receiver Structure Block Diagram

A typical block diagram of a common infrared receiver is shown in the Fig.1-3. The received infrared signal will be amplified and limited by an operational amplifier and limiter after which the signal will pass through a band-pass filter (BPF) which is tuned to the modulation frequency. The signal is then sourced to a detector, an integrator and finally output to a comparator. From the standpoint of a signal input and output result, a low level on the comparator output indicates that a carrier has been detected while a high level indicates that there is no carrier.

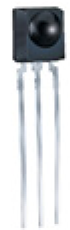


Fig.1-4 Receiver Module

These operation modules are fully integrated within a single electronic device as shown in the above figure. It is not necessary to debug each module in practice, users only need to power the device and check for a high/low level on the output pin. The common carrier frequencies for infrared remote controls include 36kHz, 38kHz and 40kHz, etc. As a result, infrared receiver manufacturers often tune their receivers according to these widely used carrier frequencies. The optimal carrier frequency will be marked in the product names, such as VS1838, HS0038, IRM-3640T, etc. Therefore, users can choose their desired device according to the product operating frequency when developing and purchasing receivers.

2. Remote Controller Protocols

Infrared remote controller is mainly used in consumer electronics. Although information security is not important in such control products, in order to eliminate interference between different devices, the remote controller should issue dedicated commands to the product to be controlled according to a specific transmission protocol. The protocols developed by some manufacturers such as NEC, Sharp and Philips have been directly used, imitated and modified by various electronic product manufacturers due to the advantages of ease of use, high reliability and low power consumption. As there are various types of modified protocols, this document will exclude such modified protocols and focus on discussing original protocols.

2.1 Protocol Composition

Most protocols can be subdivided into several parts: header, fixed/inverted code, data code and repetition code.

2.1.1 Headers

Header (aka. preamble) is used to generate a signal for the receiver wakeup and calibration, it is generally divided into two types, namely carrier type and digital type.

The carrier type is an AGC pulse train composed of "MARK" and "SPACE" which are both longer than the bit time. The typical protocols contain NEC and Philips RC-6. The long pulse train of the header can be used to initialise the infrared receiver gain.

Fig.2-1 Carrier Type Header

During phase code transmission, in order to distinguish between "1" and "0", it is necessary to transmit some fixed digits for calibration before the actual data is transmitted. These calibration digits are so-called digital type headers. A typical protocol contains the Philips RC-5 protocol.

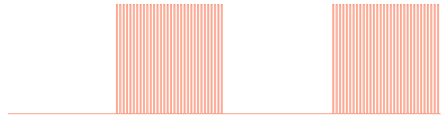


Fig.2-2 Phase Code Digital Type Header

There are also protocols that transmit messages directly without a header such as the Sharp protocol.

2.1.2 Fixed/Inverted Codes

In addition to normal data codes, some protocols will insert one or two extra fixed or variable digits. The fixed digital code(s) in the Manchester encoding method can be used as the receiver calibration time reference. Typical protocols contain Nokia NRC17 and Philips RC-6.

The inverted code is mainly used in the continuous code transmission state to determine if the current transmission is caused by a held down button or if the button action is one of continuous pressing and releasing. Typical protocols contain Philips RC-5 and Philips RC-6.

2.1.3 Data Codes

There are generally two data modulation methods, namely variable length encoding (PWM/PDM) and phase/Manchester encoding.

Variable length encoding (PWM/PDM): This modulation method uses a fixed time length for “MARK” together with two different time lengths for “SPACE”s to modulate “0” and “1” codes (PDM). It can also use different time lengths for “MARK”s together with a fixed time length for “SPACE” to modulate “0” and “1” codes (PWM).

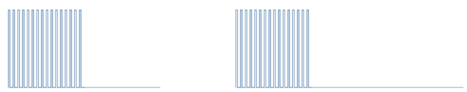


Fig.2-3 Variable Length Code Modulation

Manchester encoding: The Manchester modulation is a phase encoding method which uses the same time length for “MARK” and “SPACE”. Code “0” and “1” is then composed by placing the “MARK” in the first half with “SPACE” in the second half or placing the “SPACE” in the first half with “MARK” in the second half.

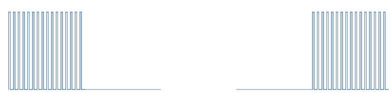


Fig.2-4 Phase Code Modulation

Energy saving is an important consideration for battery-powered electronic devices such as remote controllers. However, in some remote control ICs, the “SPACE” state is generated by turning off the IR LED, while in others the state is generated by driving the IR LED with a 100% duty cycle (fully illuminated). Therefore, for the previously described remote controllers, PDM and Manchester encoding methods are less power hungry than PWM, while for the latter type, Manchester encoding is the optimal choice for power saving.

The “0” and “1” codes in the Manchester encoding method is composed of “MARK” and “SPACE” with the same time length, therefore, the phase code transmission power consumption is constant, while the power consumption for variable length codes varies according to different codes.

Address code and command code: for users who use a large number of consumer electronic products, there may be different products of the same brand located in the same room. Therefore, it is necessary to permit a remote controller to control a single product without causing misidentification of other products. In these cases, distinction between the contents of the transmitted codes is indispensable. However, to modify a protocol for each individual product is certainly too heavy a workload for engineers reducing their development efficiency. As a result, in order to ensure maximum development efficiency and eliminate interference between different products, the address code and command code are generated within the protocol. The address code is mainly used to distinguish different devices while the command code is used by remote controllers to identify the different button commands of different device functions.

Positive code and inverted code: In order to increase the reliability of code transmission, it is sometimes necessary to add some data verification. As infrared remote controllers do not need to consider information security, and as data verification can increase the reliability of code transmission and reception, the processing of such methods is a relatively simple affair. Some engineers may choose to add both transmission and inverted codes for the address or command during the design phase.

2.1.4 Repetition Codes

In some consumer electronic devices, the receiver needs to determine if the button on the remote controller is in a held down state or not, therefore many remote control protocols have developed repetition code protocols. In the application of repetition codes and taking TV sets as an example, the requirements for continuous volume and channel increment and decrement should be taken into account. However, it should also ensure that the TV channel view will not be affected when the channel control button is held down. Therefore, it is necessary to distinguish between if the button is being held down for a longer period or if it is being pressed and released continuously. The NEC type protocol has a higher power-saving solution which only sends a 9ms “MARK” and a 2.5ms “SPACE” during repeat transmissions. This method can ensure that the receiver will correctly recognise the repetition code and also reduce the power consumption when transmitting a complete code frame.

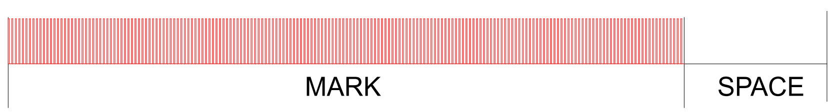


Fig.2-5 AGC type Repetition Code

For protocols such as NEC, the remote control message is in the first frame code. If the receiver misses the message or recognises it wrong, the pressed button will fail to be recognised even if it is held down. For such cases, some engineers may consider transmitting the complete code in the repetition code stage. However, when the receiver have received several groups of the same transmitting code continuously, it will fail to distinguish whether the button is held down or whether it is being pressed and released continuously. Therefore, in the case of transmitting the complete code in the repetition code stage, a toggle bit can be utilised, such as used in the Philips RC-5 code, to recognise the button action.

2.1.5 Connection Code - Interval Code

The connection code is usually applied for use in LCD type remote controllers. The common modulation method of an LCD type remote controller is to modulate the display and control status information into the transmitting code, the details of which are described in chapter 2.3.1.

Generally, an LCD type remote controller contains many bits in its transmitting code. The remote controller can transmit dozens to hundreds of codes at a time. However this will result in the voltage sharply dropping if the battery capacity is low, which could cause a low voltage reset in the master controller device. Using a connection code will insert a “SPACE” with a period range of between 10ms ~ 30ms to pause the remote controller IR LED driving output, thus allowing a short recovery time for the battery voltage.

2.2 Standard Protocols and Parameters

With the popularity of infrared remote controller brought about by the booming consumer electronics industry in 1990s, some well-known manufacturers have designed various protocol standards for infrared remote controllers, which subsequently have been directly used or modified by various household electric appliance companies. The following contents will show some classical and special protocol applications as a protocol introduction.

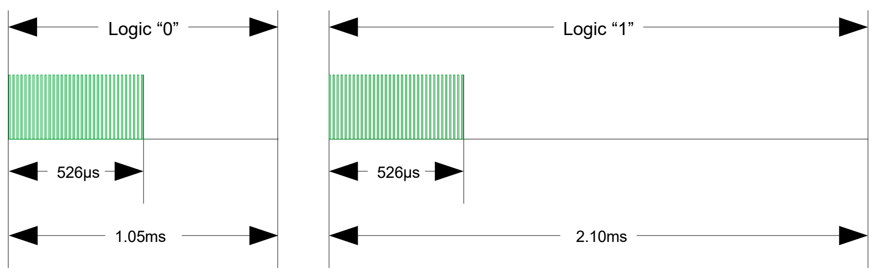
2.2.1 JVC Protocol

JVC products use many different protocols, the following contents will describe the commonly used control protocol for most JVC devices.

Features:

- 8-bit address, 8-bit command
- Pulse distance modulation - PDM
- Carrier frequency of 38kHz
- Bit time: 1.05ms for logic "0"; 2.10ms for logic "1"
- Duty cycle: 1/3 or 1/4

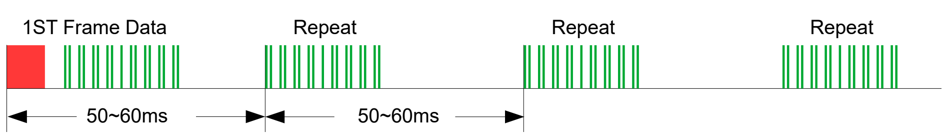
Modulation:



The JVC protocol uses the pulse distance encoding method (PDM). Each pulse is a 38kHz carrier with a time length of 526μs. A logic "0" transmission time takes 1.05ms, while a logic "1" takes 2.10ms.

Protocol:

The above figure shows a transmitting pulse train for the JVC protocol. The LSB is transmitted first in this protocol. In this case, the address is 0AAH and the command is 055H. A message is started by an 8.4ms AGC burst (MARK) followed by a 4.2ms "SPACE", then the address and command are transmitted. The total transmission time of the data frame is variable.



The message will be repeatedly transmitted every 50~60ms if the button on the remote controller is held down. The JVC protocol only sends the 8.4ms AGC pulse and its accompanying 2.1ms "SPACE" in the first frame, while the repeatedly transmitted message only contains address and command codes. Using this method the receiver can determine whether the button is held down or not.

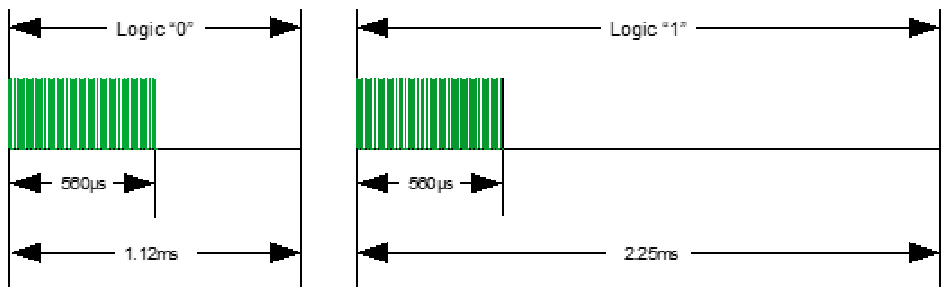
2.2.2 NEC Protocol

The protocol developed by NEC (now called Renesas Electronics) is the most commonly used remote controller protocol in consumer electronics. In the Chinese electronic manufacturing industry, most remote controllers use the NEC protocol or other derivative versions based on it.

Features:

- 8-bit address, 8-bit command
- Extended address mode doubles the address size
- Pulse distance modulation - PDM
- Carrier frequency of 38kHz
- Bit time: 1.12ms for logic "0"; 2.25ms for logic "1"
- Duty cycle: 1/3 or 1/4

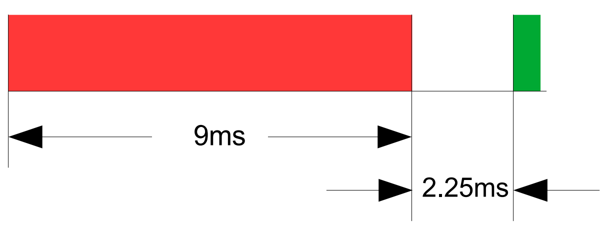
Modulation:



The NEC protocol uses the pulse distance encoding method (PDM). Each pulse is a 38kHz carrier with a time length of 560µs. A logic "0" transmission time takes 1.12ms, while a logic "1" takes 2.25ms.

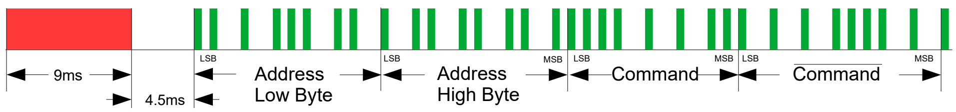
Protocol:

The above figure shows a transmission pulse train for the NEC protocol. The LSB is transmitted first in this protocol. In this case, the address is 0AAH and the command is 038H. A message is started by a 9ms AGC burst (MARK) followed by a 4.5ms "SPACE", then the address and command are transmitted twice respectively. Note that codes in the second address and command are all inverted. As every code has its corresponding inverted code, the total transmission time of the data frame is constant.



For the NEC protocol transmission, the address and command are only transmitted once in the first frame even if the remote controller button is held down. The remote controller will transmit a repetition code every 108ms, which consists of a 9ms AGC burst followed by a 2.25ms “SPACE” and a 560μs “MARK”.

Extended NEC Protocol



The NEC protocol was so widely used that very quickly all of the 256 device addresses were used up. To avoid interference caused by users using same addresses, the address range was extended from 8 bits to 16 bits, resulting in the available addresses increasing to more than 60 thousand. In the extended NEC protocol, the total quantity of logic “0”’s and logic “1”’s is no longer equal, therefore the transmission time with an extended address is variable.

When the address high byte and low byte are complementary to each other, this protocol will be classified as a standard NEC protocol rather than the extended protocol. Attention should be paid to the address range limitation when using the extended protocol.

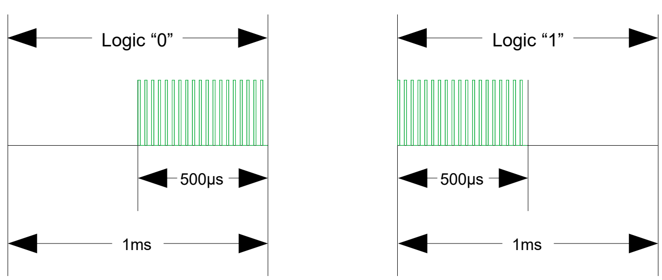
2.2.3 Nokia NRC17 Protocol

The Nokia NRC17 protocol was designed for Nokia consumer electronics and used to be applied in TV sets and VCRs. Afterwards the protocol was mainly used in Nokia satellite receivers and set top boxes until Nokia stopped production of these products.

Features:

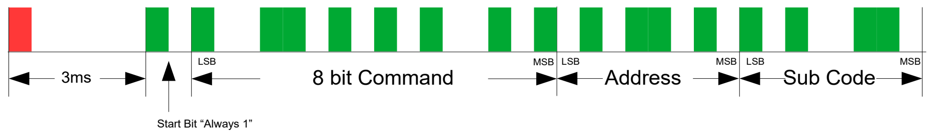
- 8-bit command, 4-bit address and 4-bit sub-code
- Phase modulation
- Carrier frequency of 38kHz
- Constant bit time of 1ms
- Low battery voltage indication
- Duty cycle: 1/3 or 1/4

Modulation:



The NRC17 protocol uses phase encoding modulation. The carrier frequency is 38kHz and the bit times are both 1ms. In this protocol, “MARK” and “SPACE” each accounts for 50% of the time length in "0" and "1" codes. For a logic "1", "MARK" is in the first half and "SPACE" is in the second half, while for a logic "0", "SPACE" is in the first half and "MARK" is in the second half.

Protocol:



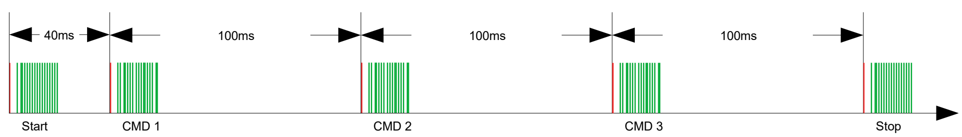
The above figure shows a transmitting pulse train for the NRC17 protocol. The LSB is transmitted first in this protocol. In this case, the address is 0CH, the command is 03DH and the sub-code is 0BH.

The first burst of the NRC17 transmitting code is a pre-pulse which consists of a 500μs "MARK" and a 2.5ms "SPACE", the pre-pulse takes 3 bit times.

After the pre-pulse, the Start Bit is transmitted, which is always a "1". As in the logic "1", the burst is exactly half a bit time. It is suitable for bit time calibration of the receiver.

The next codes are 8-bit command, 4-bit address and 4-bit sub-code, in which the LSB is transmitted first. The sub-code can be used as an extended address.

An NRC17 code frame takes exactly 20ms.



When a button on an NRC17 protocol remote controller is pressed, the remote controller will transmit a Start message containing a 0FEH command and a 0FFH code composed of address and sub-code. After 40ms, the correct button message is transmitted and the command will be repeated every 100ms until the pressed button is released. When it happens, the remote controller will send a Stop message before the next repetition message is sent. The Stop message also contains a 0FEH command and a 0FFH code composed of address and sub-code. Every transmitting sequence contains Start and Stop messages, which can be used to determine if the button is pressed repeatedly or just if it has just bounced. Therefore, the 0FEH command and the 0FFH code (address + sub-code) should not be used in the remote controller design to avoid receiver misjudgment.

Low Battery Voltage Indication

In the NRC17 protocol transmission, the receiver will be informed that the battery capacity is low. If the receiver is a television, it can display a message on the screen informing users that the remote controller's batteries need to be replaced. A normal pre-pulse takes 3ms, however, when the battery power is low, the pre-pulse of the Start and Stop messages will be lengthened to 4ms.

Note that to implement a low battery power indication function a battery voltage detection circuit is required in the remote controller IC. Nowadays, remote controller ICs are excelling in their power control capabilities and two AAA batteries can provide a lifetime of more than several months. As a result, a low battery indication function is rarely used. However, as there are no safety issues with this function it is dispensable.

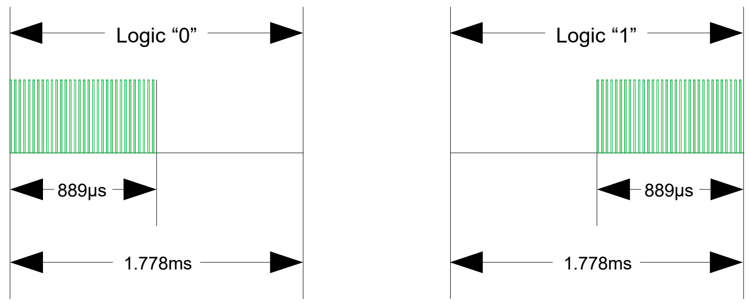
2.2.4 Philips RC-5 Protocol

As the Philips RC-5 protocol is easy to develop it is used in many remote controller applications.

Features:

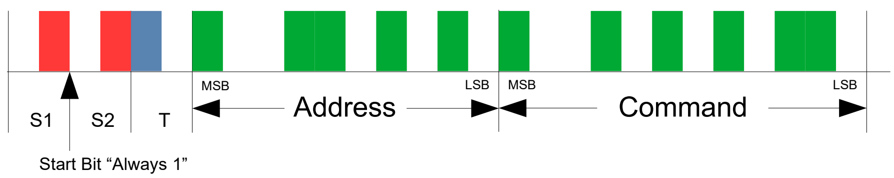
- 5-bit address, 6-bit command
- Phase modulation (aka. Manchester encoding)
- Carrier frequency of 36kHz
- Constant bit time of 1.778ms
- Duty cycle: 1/3 or 1/4

Modulation:



The RC-5 protocol uses Manchester encoding modulation. The carrier frequency is 36kHz and the bit times are both 1.778ms. In this protocol, “MARK” and “SPACE” each account for 50% of the time length for the “0” and “1” codes. For the logic “0”, “MARK” this is in the first half and “SPACE” is in the second half. For the logic “1”, “SPACE” is in the first half and “MARK” is in the second half.

Protocol:



The above figure shows a transmitting pulse train for the Philips RC-5 protocol. The MSB is transmitted first in this protocol. In this case, the address is 08H and the command is 01EH.

In the Philips RC-5 protocol, the Start pulse is composed of two logic “1” codes. In the logic “1” code, “SPACE” is in the first half and “MARK” is in the second half, which means that a half bit time has already elapsed when the receiver receives the first pulse for signal decoding.

In the RC-5 protocol code transfer, the remote controller will transmit a repetition code every 114ms even if the button is held down. The third bit toggle can be used to determine if the button on the remote controller is being held down or if it is being pressed and released continuously.

2.2.5 Philips RC-6 Protocol

Philips RC-6 protocol is the successor for the RC-5 protocol and is based around it. The RC-6 is a reliable protocol and is widely used in remote controller applications.

Features:

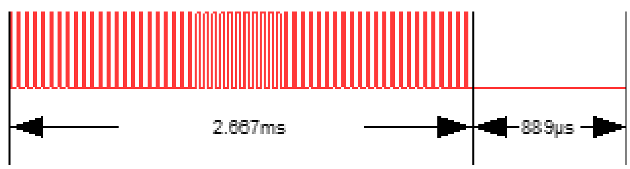
- Provides codes for different operation modes
- 8-bit address, 8-bit command
- Phase modulation (aka. Manchester encoding)
- Carrier frequency of 36kHz
- Constant bit time of 889μs
- Duty cycle: 1/3 or 1/4

Modulation:

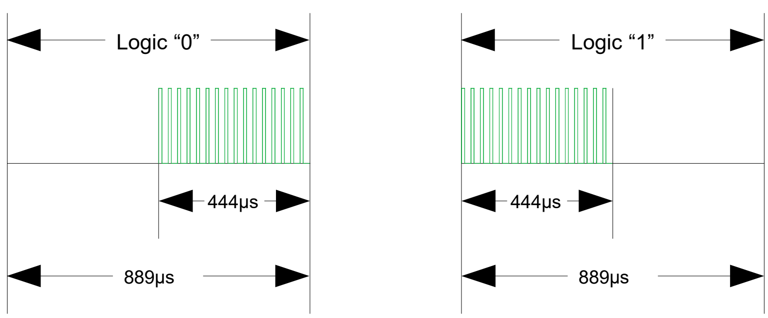
The RC-6 protocol generally uses a 36kHz infrared carrier in which the duty cycle ranges from 25% to 50%. Data is modulated using the Manchester encoding method, which means each bit, regardless of "1" or "0", contains a "MARK" and a "SPACE". For a logic "1", "MARK" is in the first half and "SPACE" is in the second half, while for logic "0", "SPACE" is in the first half and "MARK" is in the second half. Therefore, the bit modulation method for the RC-6 protocol is opposite to the RC-5 protocol.

In the RC-6 protocol, a total time length of 16 carrier periods is regarded as a time unit, labelled as 1t (1/36K×16=444μs).

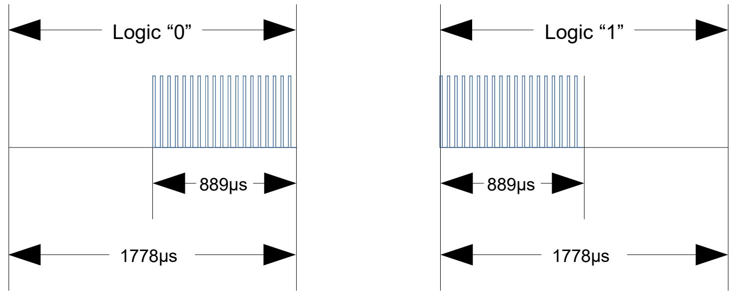
- Preamble
  In the RC-6 protocol, the preamble contains a 6t (2666μs) "MARK" and a 2t (889μs) "SPACE". The preamble is mainly used for receiver gain initialisation.



- Normal Bits
  For the normal bits, a logic "0" is composed of a 1t "SPACE" and a 1t "MARK" while a logic "1" is composed of a 1t "MARK" and a 1t "SPACE".



- Trailer Bit
  For the trailer bit, a logic "0" is composed of a 2t "SPACE" and a 2t "MARK", while a logic "1" is composed of a 2t "MARK" and a 2t "SPACE".



In the RC-6 protocol, codes including the preamble and trailer bit belong to the header field.

The common operation mode code used in the RC-6 protocol remote controllers for consumer electronics is Mode 0.

A complete signal frame for the RC-6 protocol is shown below:

- Header
  The header field consists of three parts. The first part is a Leader Symbol (LS), which is used for receiver gain adjustment. It is then followed by a Start Bit (SB), which is a constant logic "1" used for receiver timing calibration. The second part is a mode code, which consists of three bits. The currently known remote controller mode code is "000". The third part is the Trailer bit (TR), whose bit time is twice as long as a normal bit. This bit serves as the toggle bit which will be inverted once a button is released. This allows the receiver to determine if the button has just been pressed or if it is being pressed repeatedly.
- Control Field
  The control field contains an 8-bit address and an 8-bit command, the MSB is transmitted first in this protocol.
- Signal Free Time
  The signal free time is a time period in which no data may be transmitted. The receiver detects this time period at the end of a message to avoid incorrect reception. The signal free time is set to 6t, namely 2.666ms.
  In the RC-6 protocol code transfer, the remote controller will transmit repetition code every 108ms even if the button is held down.

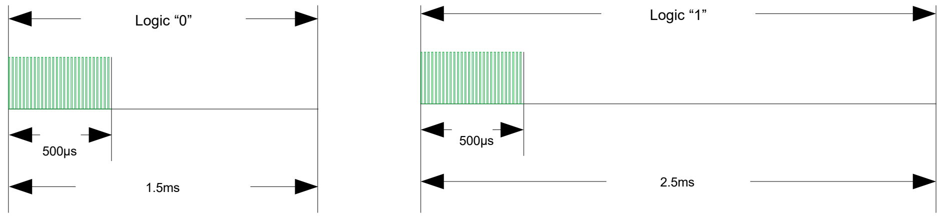
2.2.6 RCA Protocol

The RCA protocol is a remote controller protocol which is widely used in televisions, VCRs, power amplifiers and TV sets.

Features:

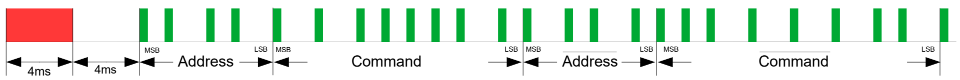
- 4-bit address and 8-bit command
- PDM modulation
- 56kHz Carrier frequency
- Bit time: 1.5ms for logic "0"; 2.5ms for logic "1"
- Duty cycle: 1/3 or 1/4

Modulation:



The RCA protocol uses a pulse distance encoding method – PDM. Each pulse is a 56kHz carrier of 28 cycles in total with a time length of 500µs. A logic "0" transmission time takes 1.5ms, while a logic "1" takes 2.5ms.

Protocol:



The above figure shows a transmission pulse train for the RCA protocol. The MSB is transmitted first in this protocol. In this case, the address is 05H and the command is 0C2H. A message is started by a 4ms AGC burst MARK followed by a 4ms SPACE. After this the address and command are transmitted twice. Note that the codes in the second address and command are all inverted. As every code has its corresponding inverted code, the total data frame transmission time is constant. The inverted code can improve data transfer reliability.

The message will be repeatedly transmitted every 64ms if the button on the remote controller is held down.

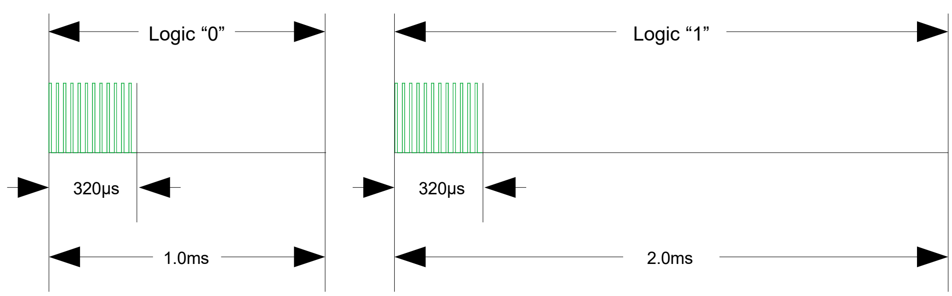
2.2.7 Sharp Protocol

Sharp protocol is mainly used in Sharp TVs and VCR products.

Features:

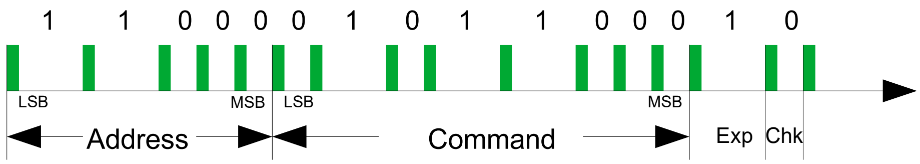
- 5-bit address, 8-bit command
- Pulse distance modulation - PDM
- Carrier frequency of 38kHz
- Bit time: 2ms for logic "1"; 1ms for logic "0"
- Duty cycle: 1/3 or 1/4

Modulation:

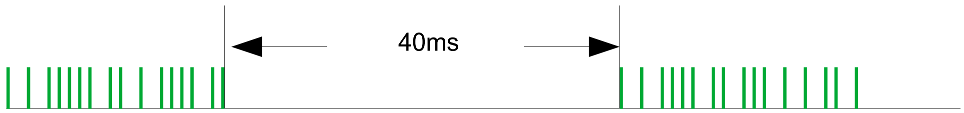


The Sharp protocol uses pulse distance modulation. Each pulse is a 38kHz carrier with a time length of 320µs. A logic "1" transmitting time takes 2ms, while a logic "0" takes 1ms. The recommended carrier duty cycle is 1/4 or 1/3.

Protocol:



The above figure shows a transmission pulse train for the Sharp protocol in which the address is 03H and the command is 1AH. Note that the address is transmitted before the command and the LSB is transmitted first. The final two bits are fixed as a logic "1" and a logic "0".



A complete command sequence contains two messages. The first transmission is exactly as described above. The second transmission will be executed after a delay of 40ms. In the second sequence, all digits, except the address code, are inverted. By this way the receiver can verify if the received message is reliable or not.

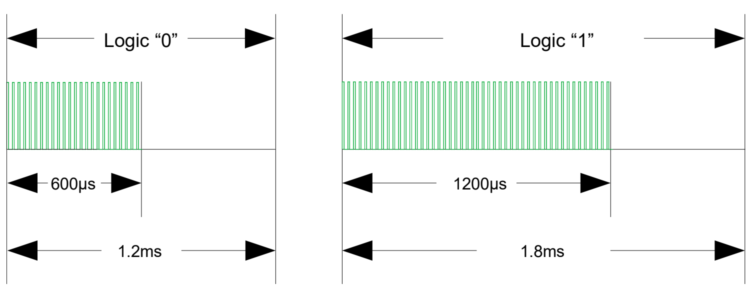
2.2.8 Sony SIRC Protocol

According to information founded on the internet about the Sony SIRC protocol, there are three versions in existence: 12-bit, 15-bit and 20-bit versions. All versions have 7 bits reserved for commands. The 12-bit version contains a 7-bit command and a 5-bit address. The 15-bit version contains a 7-bit command and an 8-bit address. The 20-bit version contains a 7-bit command, a 5-bit address and an extra 8 extended bits.

Features:

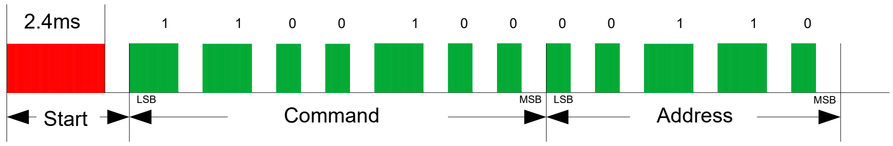
- 12-bit version format: 7-bit command, 5-bit address
- 15-bit version format: 7-bit command, 8-bit address
- 20-bit version format: 7-bit command, 5-bit address, 8 extended bits
- Pulse Width Modulation - PWM
- Carrier frequency of 40kHz
- Bit time: 1800μs for logic "1"; 1200μs for logic "0"
- Duty cycle: 1/3 or 1/4

Modulation:



The SIRC protocol uses the pulse width modulation method. A logic "1" consists of a 1.2ms "MARK" and a 0.6ms "SPACE", while a logic "0" consists of a 0.6ms "MARK" and a 0.6ms "SPACE".

Protocol:



The above figure shows a pulse train for the 12-bit SIRC protocol. The LSB is transmitted first in this protocol. A message is started with a 2.4ms "MARK" followed by a 0.6ms "SPACE". Then the 7-bit command and 5-bit address are transmitted. In this case, the address is 0CH and the command is 13H. As the Sony SIRC protocol uses pulse width modulation, the "SPACE" duration is constant, therefore it is unnecessary to add an additional "MARK" after the last bit time.

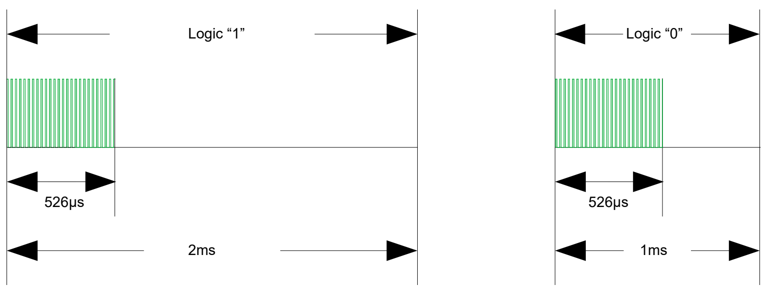
2.2.9 X-Sat / Mitsubishi Protocol

This protocol has been created by Mitsubishi, and is used in Mitsubishi devices. The protocol is also used in the X-Sat series of satellite receivers made by the French company Xcom. The differences between them is that the X-Sat uses a 38kHz carrier, while the Mitsubishi uses a 40kHz carrier.

Features:

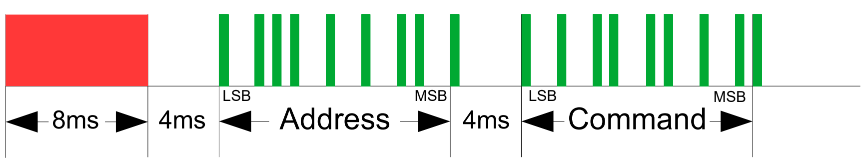
- 8-bit address, 8-bit command
- Pulse Distance Modulation - PDM
- Carrier frequency of 38kHz
- Bit time: 2ms for logic "1"; 1ms for logic "0"
- Duty cycle: 1/3 or 1/4

Modulation:

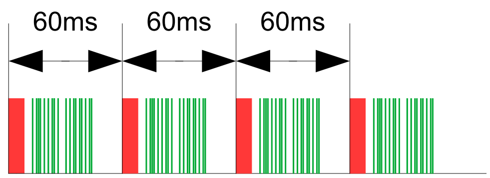


The X-Sat protocol uses a pulse distance modulation method. Each pulse is a 38kHz carrier with a time length of 526μs. A logic "1" transmission time takes 2ms, while a logic "0" takes 1ms. The recommended carrier duty cycle is 1/4 or 1/3.

Protocol:



The above figure shows a transmitting pulse train in which the address is 0B9H and the command is 6BH. Note that the address is transmitted before the command, and the LSB is transmitted first. A message is started with an 8ms AGC burst, which is used for infrared receiver gain initialisation. The AGC pulse is followed by a 4ms "SPACE", and the following codes are the address and the command codes. Note that there is a 4ms gap between the address and the command. The total transmission time of a frame is variable according to different codes.



The transmitted pulse sequence will be repeated every 60ms if the button on the remote controller is pressed continuously.

2.2.10 Protocol Summary

The integrated standard protocols in the software are listed in the following table:

Protocol Name	Freq.	Duty Cycle	Encoding Method	Preamble	Address	Command	Repetition Mode
JVC	38kHz	1/4, 1/3	PDM	AGC	8 bits	8 bits	Only Data
NEC	38kHz	1/4,1/3	PDM	AGC	8 bits	8 bits	AGC
NEC-16	38kHz	1/4,1/3	PDM	AGC	16 bits	8 bits	AGC
NRC17	38kHz	1/4	Manchester	AGC	4/8 bits	8 bits	ALL
RC-5	36kHz	1/4,1/3	Manchester	Data	5 bits	6 bits	ALL
RC-6	36kHz	1/4,1/3,1/2	Manchester	AGC	8 bits	8 bits	ALL
RECS-80	38kHz	1/3	PDM	Data	3 bits	6 bits	ALL
RCA	56kHz	1/4, 1/3	PDM	AGC	4 bits	8 bits	ALL
Sharp	38kHz	1/4, 1/3	PDM	None	5 bits	8 bits	Only Data
SIRC	40kHz	1/4, 1/3	PWM	AGC	5/8 bits	7 bits	ALL
X-Sat	38kHz	1/4, 1/3	PDM	AGC	8 bits	8 bits	ALL

2.3 LCD Type Remote Controller Protocol

Different electric appliance manufacturers provide specific protocol standards for their LCD type remote controllers. The major LCD type remote controller application products are for air conditioners. The following contents will take an air conditioner remote controller as an example to introduce the LCD type remote controller protocol design method.

2.3.1 LCD Type Remote Controller Protocol and Design

In consumer electronics, some products, such as wall-mounted air conditioners, ventilation systems, wall-mounted water heaters, etc., are not suitable to have a human-machine interface as the installation location is either too high or too far away. Therefore, designing an interactive interface on a remote controller is a low cost and easier solution.

Remote controllers have strict requirements with regard to power consumption. Therefore, in IR remote controller with LCD display solutions the interaction can be implemented on the user terminal, both the cost and power consumption can be optimized.

As the IR remote controller communicates with the host device using a simplex communication method, except for the transmission function, the synchronization between the remote controller information display and the host device operation should be guaranteed when designing an LCD type remote controller.

For example, when users press a button on the air conditioner remote controller to decrease the temperature by 1°C, if the code transmission is blocked resulting in the host device not receiving the control command, the actual host device operation will then be different with what displayed on the remote controller LCD. This is because the host device is unable to provide feedback to the remote controller to correct the LCD display. In such case, the most convenient way to correct this is by using the remote controller during the next code transmission to synchronize the remote controller LCD display content with the host device operation.

This is different from general remote controller protocols, whereby the button corresponds to a fixed code transmission. Most of the LCD type air conditioner remote controller protocols modulate the interactive information, namely the LCD display contents, onto the code for transmission. Once the host device correctly receives the interactive information transmitted by the LCD type remote controller, the synchronization between display content and the host device operation can be implemented.

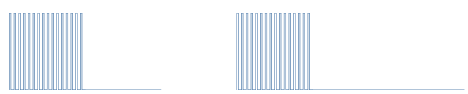
2.3.2 LCD Type Remote Controller Protocol and Parameters

In the present market, there have not yet been LCD type remote controllers supporting the Manchester modulation method. The following parameters provide the descriptions for air conditioner remote controllers which operate using the PDM modulation method.

Feature:

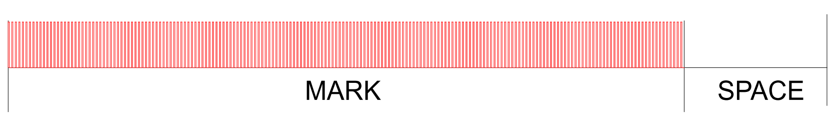
- Modulation information: on/off, mode, timing, fixed code, etc.
- No specific carrier frequency
- Variable length encoding – PDM
- No constant bit time
- Duty cycle: 1/2, 1/3 or 1/4

Modulation:



Preamble:

A preamble code is an AGC signal composed of MARK and SPACE which are both longer than the bit time of the protocol. The preamble code is mainly used to initialise the receiver gain.



- Connection Code
  A connection code is to insert a fixed period of delay time into the modulated data. The functions are shown below:
  a. To distinguish protocols, avoiding any interference caused by different remote controllers.
  b. When the battery capacity is low, a pause period in the carrier output can reduce the possibility of a remote controller device reset caused by a long continuous code transmission.
  Usually, the connection code does not contain a preamble code.
- Double-Group Code Transmission
  The double-group code transmission function is similar to the connection code. Note that in the double-group code transmission, the second group also contains preamble and connection code in the same way as the first group does.

In some protocols, the double-group code is reserved for specific functions due to the power consumption control requirement. For example, the double-group code transmission mode of the GREE air conditioner remote controller is only used when the timing booting/shutdown function is enabled, in which cases the timing setting information will be modulated onto the second group for transmission.

2.4 Other Protocols

There are many other dedicated protocols in the market which are defined by new manufactures. Although this document has not assembled all these existing protocols, the implementation methods are identical. A new transmission protocol can be formed by modifying the parameters of variable length encoding modulation (PDM/PWM) or Manchester/Bi-phase encoding modulation as well as the length of the address code and command code.

Reference Data Source:

https://www.sbprojects.net/

https://www.lirc.org/