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Infrared control – a second life

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Introduction

Infrared (IR) controlers are used on home appliances but all these controllers are not compatable with controlling a plane because there is no proportional control, and the response time is quite slow. Distance is limited with IR, but with room flying of ultralight constructions, this is not a problem. IR is attractive to modelers for its low cost, low weight, and no license. There is hope for light weight radio solutions without distance limitation like Plantraco's systems, and upcoming 2.4 Ghz frequencies bring new promises, but cost will stay high. On the other hand the The PicooZ heli brings back IR to the center of the scene. Let us take full benefit of this.

A little bit of history

The pionneer of IR control was Sergio Zigras in the US. The IR systems he developed since 1997 evolved from single-channel bang-bang to "galoping ghost" control and finally to fully proportional multichannel systems. His major problem was the transmitter box, but he found a surplus of PC joysticks, and populated them with a processor, a transistor and emitting IR diodes. See http://www.cloud9rc.com/va.asp?ID=118 november 2006 and http://www.didel.com/slow/mirted/MIRz.html for pictures and details. Sergio had to stop selling when he ran out of transmitter boxes. Didel proposed several solutions, designing new receivers when new processors were available, but not having a good solution for the transmitter. Koichi Tanaka promoted IR in Japan and the rest of the world, supplying PC boards and documenting on how to adapt to RF transmitters.

Sergio's first IR handle (1998)

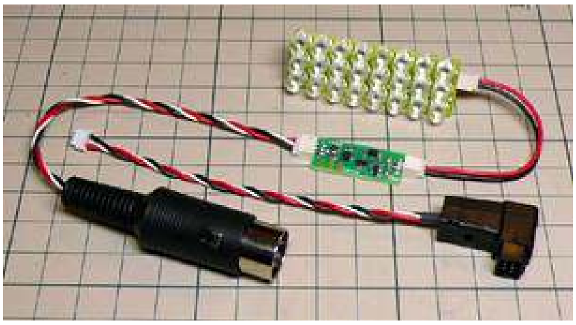
IR receivers one channel (1998)

The Celine (2002) and the 2nd generation of Sergio's IR transmitter

What is available

As mentioned above, the problem is the transmitter. Didel populated Plantraco boxes with a set of 8 IR diodes, but the product does not sell very well due to the excessive cost. Didel still proposes the Radir board that converts the PPM signal of a trainee's plug to an IR set of pulses. Indoor Airplane World (K.Tanaka) in Japan has a similar system pictured below.
The problem is the compatibility with the different radios on the market, and the frequent need to add an external battery.

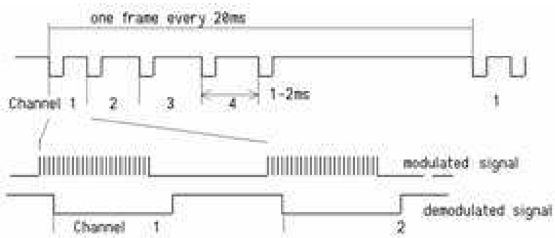
Didel Radir
http://www.didel.com/slow/mirted/Radir.doc



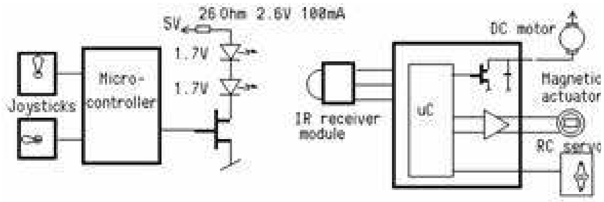
Indoor Airplane World set
http://www.cityfujisawa.ne.jp/~toko/

IR signals

RC modelers are familiar with the PPM signals which consists of. A set of 1 – 2ms pulses according to each channel's stick position. The set of pulses (frame), is repeated every 20ms, and this is adequate for realtime real time control. On radios, AM or FM frequencies modulate this signal. The receiver removes the modulation and separates the channels, providing 1-2ms pulses to the servos. Sergio just modulated the frame pulses with a 40 kHz signal and sent it to the set of IR diodes. The IR receiver circuits includes a filter and a demodulator, and generates a clean PPM pulse. A microcontroller switches the pulses, but since ultralight servos (below 1gram) do not exist, the microcontroller generates directly the needed PWM signals for the motor control and the BIRD (Build-In Rudder) actuators. Very light control solutions are reached this way.
IR receivers are available from many manufacturers: Vishay TSOP34838, JRC NLJ21H380A (more sensitive but does not filter certain Neon light stripes very well), Sharp GP1US30XP (SMD, 0.03g). The 0.36g NLJ is safely stripped down to 0.1g.
Didel used initially a safer encoding, but came back to Sergio's simple solution to be compatible with radio trainee's plugs. The only problem now was the detection of the throttle position on the channel sequences. Throttle is unidirectionnal (one transistor) while BIRDs are bidirectionnal (full bridge). The microprocessor must know if the throttle is in first or third position. Automatic selection was proposed (http://www.didel.com/slow/mip/Ira.doc) and used on certain Didel receivers.



PPM signals. IR modulation is usually at 38 kHz

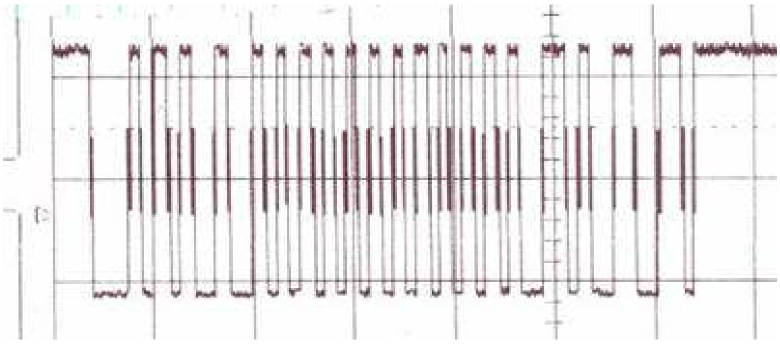


IR transmitter and receiver block diagram

Let us mention that remote controllers (TV clickers) use a wide variety of encoding schemes, where a string of bits is repeated at a lower frequency (every 100-200 ms) when a key is depressed. Sending 8bits with 0.5-1ms pulses takes less than 10ms, but synchronization preamble , addressing and redundancy check makes messages 30ms long. See http://www.sbprojects.com/knowledge/ir/ir.htm for a very didactic presentation of IR control.

The PicooZ
Millions of units of the PicooZ micro helicopter are invading the market. It is a wonderful design for its price, so why not use its IR transmitter to also control a plane or any kind of vehicle or gadget?
Existing IR receivers can be compatible if programmed with an appropriate software. An additional advantage of the transmitter is the built in Lipo charger for a 20-50 mAh Lipo. Why not fly our indoor models with the PicooZ transmitter?
Infrared receivers can be very light, and 3 to 6 grams planes are now easy to build.

PicooZ transmitter (if you never saw one, this paper is not for you!)



IR signals are received and filtered by the NLJ0038 IR circuit on the receiver

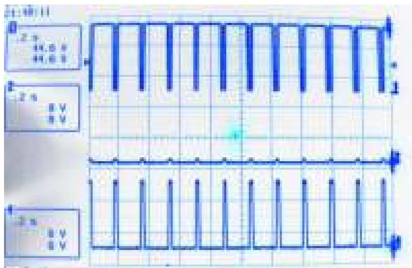
The PicooZ transmitter has two perpendicular sticks, one with a return spring, plus two buttons for trimming the tail propeller. Only simple 2-channels planes or gadgets can be controlled, three channels in some cases.

PicooZ signals
The PicooZ IR transmitter signals have the typical shape of the figure above. It is not like the standard RC5, but a special format with a preamble, data, checksum.

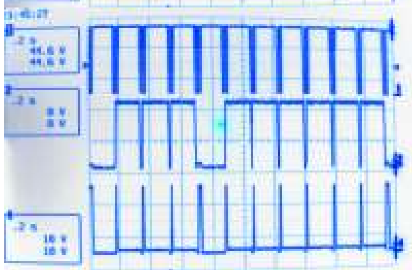
Details have been given by Andrew McCubbin , post 48 of
http://www.rcgroups.com/forums/showthread.php?t=662454&page=4#post7263007

The data consist of 15 bits:
2 bits for the address (switch position A B C on receiver)
4 bits for the throttle, values 0 to 14
4 bits for the trim, values 1 and -1
3 bits for the rotation, values -3 to +3
Please notice there is a good control of the trottle, but the rotation control is very coarse.

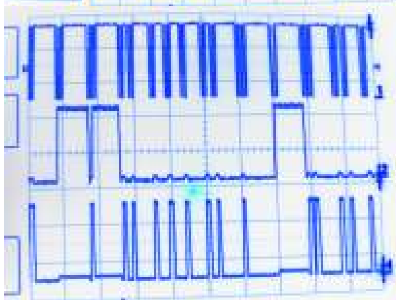
An interesting feature of the PicooZ is that three transmitters can operate simultaneously. However, the problem is these transmitters are not synchronized. They send their stream of pulses every 210 ms for address A, every 175 ms for address B and every 130 ms for address C.



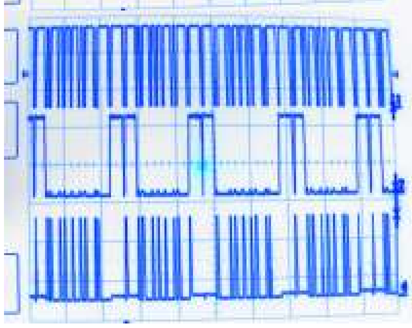
The upper track shows the signal of a single PicooZ transmitter. Canal B repeats the frame every 175 ms.
Lower track is set by the receiver when it reads a correct stream of 15 data bits.
Middle track is the error signal, always zero (with a little bit of noise)



If the distance is too high, received pulses get too short and irregular. The software recognizes it and stops decoding until next burst.
Here, only the first and fifth frame have been accepted.



Now a second transmitter is on.
The receiver reads all the incoming signals but from the address inside the data stream, it accepts only the data with the good address.
When there is a collision, incorrect pulse duration is detected, and the parity check will also signal if a single bit is corrupted.



The two transmitters have a regular rhythm, they overlap regularily, every 1.2 seconds since their period is respectively 175ms and 210ms (the PGCD, you remember?).

PicooZ clones, at least the ones we tested, have simpler IR signals and are not compatible.

Lipo charging
The PicooZ has strange circuitry on the Lipo itself. Our idea to charge “naked” Lipos was to use the circuitry of a dead PicooZ lipo and connect it with on one side the PiccoZ connector, and on the other side a Bahoma connector or your own preferred system. It does not seem to work as expected.

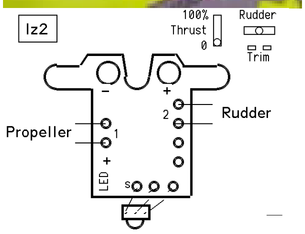
Taking out the PiccoZ Lipo circuit to build an adapter for any Lipo (uses a Bami-B)

Lipo adapter for a PiccoZ clone (uses a Bami-M)

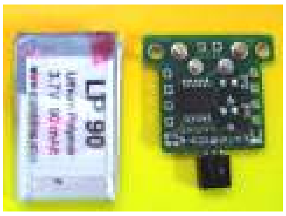
The two PiccoZ clone we had in hands have the charger inside the transmitter. Charging current seems to be in the 150mAh range, good and bad for a fast incomplete charge.

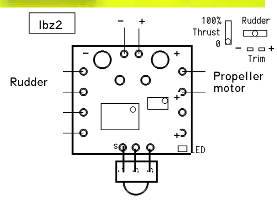
IR receiver modules
For many years, Didel developped IR receivers using the most recently available components. Now with the dual bridge amplifiers in a really small package (Allegro A3901), it is difficult to get lighter components. Several modules are available. Let us mention the 0.26 gram **Ir3** that uses 1.27mm connectors and the more easy to wire 0.8g Ib4 (2.54 mm pitch connectors).

Ir3 - 3 channels
0.26g without connector
1x 0.5A, 0.1Ohm transistor for propeller
2x 0.2A, 3 Ohm bridge for birds or high resistan-ce pager motor



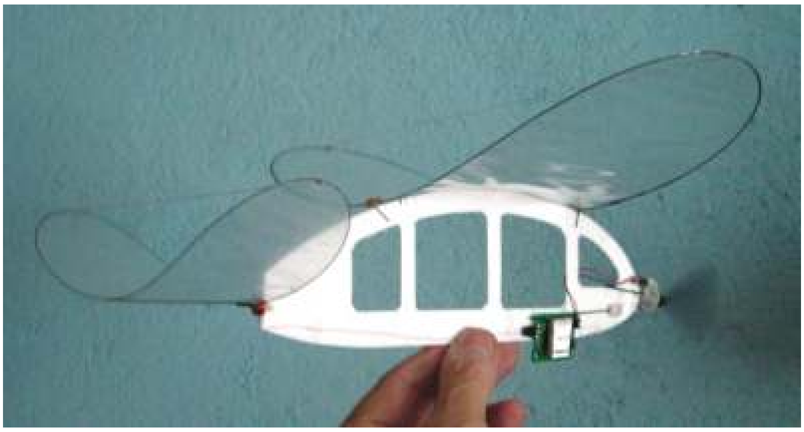
Ib4 - 4 channels
0.8g without connector
2x 0.5A, 0.1Ohm transistor for propellers or robot motor
2x 0.2A, 1 Ohm bridge for birds or motor





These Didel IR receivers are programmed in different way depending on the application, in order to take care of the limitations of the PicooZ transmitter.
First application is for an ultralight 2-channels plane. The thrust is positive and the direction is controlled by a magnetic actuator. The question is what do we do with the trim?
Like on the helico, we can modify the center with a trim up/down counter that

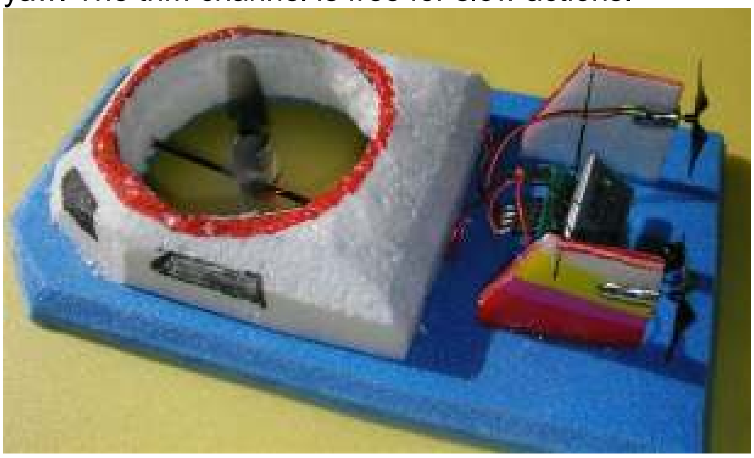
influence the direction value. We still have only 3 turning radius, but if the plane is not perfectly symetrical, the trim allows to adjust for a straight line. This give the first software versions **Iz2** and **Ibz2**.
But now you will argue, what sense to fly straight? With IR, my plane has to stay close, and the fun is to turn in the smallest possible space. The joystick will never stay quite in the center. I could use the trim buttons to control an additional proportional channel. This can be very useful for a blimp (the trim adjust the up/down propeller). On a plane, I can control lights, retract gear, bombing etc, and any thing else imaginable. This is why Didel propose the **Iz3** and **Ibz3** versions.



1 mm foam fuselage, 26 cm span, 5 grams complete with Lipo

Ibz2 IR controller (prototype)

If you dream about a twin motor, no low weight radio offers this. The Ib4 module has two transistors and two bidirectionnal amplifiers, so it can play more tricks than the Ir3. The **Ibztwin** version controls two propellers mixed fron thrust and yaw. The trim channel is free for slow actions.



Hoovercraft model, controlled by an IbzTwin circuit (built by Urs Szymanski, Switzerland)

The last proposed version is good for high manoeuvrability blimps and 2-wheel robots. The propellers or motors are controlled by the bidirectionnal channels, so the ship can go all directions and turn on itself. This is the **Ibzrobot** version.

It would be easy to program versions that control 1-2ms servos. We may do it for robotic applications. But servos are too heavy for a plane that must fly at IR distances, that is to be very light and fly very slowly.

Actuators
Low weight receivers needs low weight propulsion sets and actuators. They are offered by Plantraco, Bob Selman, Koichi Tanaka and others.
Pager motors in the 4 – 6 mm range with an as large as possible gear factor are good for 3-10 gram planes. There weight is 1.2 to 3 grams, and the associated Lipo weigts 0.7 to 3 grams.
Let us mention here the three technologies for the attitude control. Miniature servos weight is 1.5g or more, and there is little hope to develop a sub-gram servo without significant investment. Magnetic actuators (BIRDS) are low torque, that is they are very sensitive to hinge friction, but they are available in 0.2 to 1 grams and quite easy to control. SMA actuators are delicate and do not exist as ready to install units; they provide an acceptable proportionality only if well built.
For the time being, BIRDs proposed more than 10 years ago by Fritz Muller (name coined by John Worth for Built In Rudder) still have a good future for planes between 1 and 10 grams.