



RADIO CONTROL FOR GARDEN RAILWAYS

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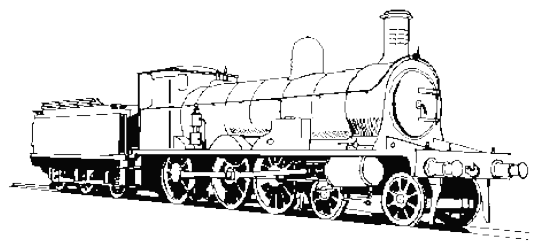
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THE FIRST STEP....

So you've decided to use radio controlled locomotives for your garden railway, or at least you're considering it. But like many people, you want to make sure you're going about things the right way. With this leaflet I hope to point you in the right direction and answer the questions which are no doubt in your mind.

The 'Power' Options

There are several ways you can go about running a radio controlled railway in the garden:-

- 1) Battery powered locomotives with 'on-board' power.
- 2) Electric locomotives that pick up power from the track with an R/C controller in each loco, or
- 3) R/C controller(s) controlling power to the track.
- 4) Live Steam radio controlled locomotives.

I chose options 1 and 4! My reasons for choosing battery powered radio controlled locomotives were threefold. To save having to wire up a layout, to eliminate track cleaning, and lastly - to allow realistic operation, with model locomotives just like real ones, having their power on-board. After all is said and done, real locomotives aren't 2-rail, don't have insulated wheels, and carry their 'fuel' on board, unless they're 25Kv or 3rd rail electrics! It does, however, mean that I have to roster locomotives properly, ensuring those 'on shed' are being charged for service. In general most of my locomotives will give 2 to 3 hours continuous running which is sufficient for most purposes.

There are also other advantages to using battery R/C locomotives. Track cleaning will limit how large a layout you can sensibly maintain, without extra help. If I need to do any electrical maintenance it's done indoors on the bench with everything in easy reach. When the weather's fine I'm out running trains; not messing about with track wiring.

I also operate live steam locomotives, some manual, some radio controlled, and they can play havoc on a 2-rail system! Once again the battery option for electric locomotives fits in well with live steam operation. Even if you have got an outdoor two rail layout, a battery R/C loco is still useful as 'Instant' motive power and it will polish up your track for your conventional 2-rail locomotives.

Radio Control - The Basics

Radio control systems are simply based on a transmitter, receiver, and then either servos to operate 'things' mechanical, or a speed controller to operate traction motors. The actual transmission system and frequency is immaterial, as the end result is the same. Control signals are produced by the receiver which cause the servos, or speed controller, to move in proportion to the movement of the transmitter controls - usually the joysticks. Hence the term 'Proportional Radio Control'.

The number of channels on an R/C set usually indicates how many things you can operate. The simplest systems available are normally two channel; they have two control sticks on the transmitter. Hence you could operate two mechanisms, via a servo on each channel, e.g. the regulator and gear lever on a steam loco, or two speed controllers, one on each channel.

The Equipment Available

There are three types of model radio control equipment available - AM, FM and now 2.4GHz digital. The control signals produced by AM, FM and 2.4GHz receivers are identical. This means that both servos and speed controllers are independent of the transmission system and can generally be used with either type of equipment. Most manufacturers have adopted the same standard for receiver control signals which allows a fair bit of compatibility from one make to another as far as servos and speed controllers are concerned. Also, at last, five of the major R/C manufacturers, Futaba, Hitec, JR, Acoms and Sanwa have servo 'plug' compatibility. Thus at the time of writing it is now possible to plug one make of servo, or speed controller, into the receiver made by another. It's only taken them 25 years to get here!

AM and FM transmissions in models are just like those in domestic radio receivers. Other than that you need not worry about these terms. AM equipment in the UK operates on a frequency of 27MHz (27 Megahertz) and has been around for some time now. Consequently, it is cheaper than the equivalent newer 40 MHz FM equipment, but its' limitations are now becoming apparent. As from 1st January 1999 AM equipment was made available on 40MHz too. However, it suffers from the same basic problems as 27MHz AM equipment - signal reflections (more of this later). 2.4GHz sets use digital transmission a bit like DAB digital domestic radio broadcasts. See the later section on page 6 for more details on 2.4GHz R/C.

As with most radio equipment only certain bands of frequencies are allocated to radio control. 27MHz only has six allocated frequency channels both AM and FM (Yes FM equipment has been produced on 27MHz in the past). These are identified by six colours which as pennants can be attached to the transmitter aerial for identification at meetings. The colours are :-

- 1 - Brown, 2 - Red, 3 - Orange, 4 - Yellow, 5 - Green, 6 - Blue.

Unfortunately, this is now interspersed with European standard Citizens Band radio frequencies, and the blue frequency is also the CB call up channel!

The 27MHz bands are open to all comers - model aircraft, boats, and cars, as well as trains. Add to this the split frequencies between the six main channels, and you have a recipe for confusion! The older AM equipment often spills over onto adjacent channels. I have one AM transmitter which will operate locomotives on the red channel when it has an orange crystal!

To sort out this mayhem the Department of Trade & Industry, who are responsible for the management and control of all radio channels in the UK, made other frequencies available to R/C modellers. Aircraft modellers were given the 35MHz band for their exclusive use, and 40MHz was given to ground based models (e.g. Cars, boats and trains). This segregation was done for safety reasons and is now backed by law. A model plane crashing out of control into a crowd at a meeting can cause serious injury. Anyone caught breaking these standards is open to prosecution.

On 40MHz, in the UK, there are 33 different frequencies, ranging from 40.665MHz to 40.985MHz, now both available on AM as well as FM. This gives less chance of bumping into someone on the same frequency. Not all 33 frequencies are standard throughout Europe, so beware if you go abroad! 40MHz FM equipment, is technically better than the equivalent 27MHz or 40MHz AM sets. Its' frequency alignment is more precise, with no hint of spill-over (crosstalk) on to adjacent channels. In FM the receiver 'locks on' to the transmitter by frequency, not by signal strength. Hence it is less easily knocked off tune. The 40MHz FM receivers I use have three or four channels. They are also physically smaller than equivalent AM receivers which are all plus points in railway applications.

For those only using speed controllers, it is possible to buy Combo outfits. These are sets sold without servos. It is also possible to buy receivers and crystals separately, for new locos you are building, to save having unused transmitters - you can only hold one at a time!

If you are just starting a radio controlled railway and can't decide which equipment to purchase, my advice would be to purchase a 2.4GHz system if you want a totally trouble free experience, especially if it's an expensive loco. If, however, it's a cheap loco to 'test the water' or 'something for the kids' then 40MHz FM is quite OK provided installation is done with the reference to the problems described in these pages.

The Problems - Reflected Signals and the Rusty Bolt Effect

In developing my speed controllers, I stumbled on a problem. This was caused by the radio signal being reflected and confusing the receiver. The reflected signal takes a longer path to the receiver, and therefore arrives a bit later. As the receiver works out what to do based on the timing of the incoming signal, not surprisingly it gets very confused. The end result is that servos don't maintain the correct position. Even worse, speed controllers in battery locos can instantly change speed, and direction, making it look as if the loco has gone berserk. For this reason ordinary speed controllers, as sold for boats and cars are generally unsuitable. I found this problem was already well know to radio engineers, and radio control aircraft enthusiasts. They referred to it as 'the Rusty Bolt effect' because rusted connections give a similar problem.

Signal reflections can be caused by structures and buildings, trees and wire fences, but the worst offender is usually the railway track and the locomotive itself. Any intermittent metal to metal contact will cause reflections, such as the wheels on the track, loose fishplates, or valve gear linkages. The metalwork picks up the radio signal and has a current induced in it. If the connection between one part and another is momentarily broken, by vibration as the train moves, it produces a spurious signal, like another transmitter working on the same frequency. You can hear the effect when you wear an FM personal stereo radio. A click can be heard when a metal screwdriver touches a screw fixed in a piece of wood lying on the ground. In some cases the Rusty Bolt effect can come and go which makes it annoying. It can also be OK on one model, and hopeless on another, even though apparently identical.

Motor Speed Control - 'Smart' Speed Control and the Mac•five

To solve these problems I developed a controller which would overcome these signal reflection problems, and give better slow speed control. I found that car and boat controllers gave too coarse a speed control for railway locomotives. I wanted to shunt rolling stock, and accelerate or decelerate gradually, not 0 to 90 in 5 seconds like a Formula One racing car.

The progress in electronics over the last 10 years has enabled much smaller controllers to be built. Using 'Smart' micro-chips the Mac•five is effectively a single chip computer. Apart from allowing the controller to be smaller, it also puts a certain amount of 'intelligence' inside the loco. This takes the form of a computer software program loaded during construction of the controller. To the operator, the computer isn't evident. No flashing lights, or panels of buttons, this is an 'easy to use' piece of technology.

The program enables the chip to determine between good and bad signals caused by reflections, and at what speed and direction the loco is travelling. This information is used to auto-drive the engine if required; i.e. run the loco in the required direction and switch off the transmitter. The computer chip then seamlessly maintains the same speed and direction until the transmitter is switched back on. To continue at the same speed, the joystick is moved to its' prior position and the transmitter switched back on, whereupon normal control is restored. For emergency stopping, the transmitter can be turned back on with the joystick in the centre-stop position. Self setting is another feature made possible by the use of a 'smart' computer chip. Every time the loco is switched on, the first thing the controller software does is to look for a valid transmitter signal. Once this is accepted, it takes a record of the signal as a reference for the stop position. Hence, there is no need for a 'pot' adjuster on the controller to align it to a particular transmitter, the chip's program does it all. This takes place in the first tenth of a second. So, it is unlikely to get it wrong, unless the joystick is moved whilst turning on the loco power. To ensure it locks on to a transmitter, I always switch on the transmitter first.

Self setting also enables transmitter swapping. Should the batteries fail on one transmitter, all that needs to be done is to transfer the crystal to another transmitter with good batteries, switch off the loco power, and on again after 10 seconds. Control is now realigned to the replacement transmitter, without disassembling the loco and manually re-adjusting it. Other advantages of this 'artificial intelligence' mean that the chip can produce traction control to reduce wheel-slip - not exclusive to Formula 1 motor racing you see! The term 'intelligence' is relative, by comparison the average house fly is Einstein! If anyone produces a computer with 'house fly' intelligence it will be something to shout about. As for me, my maths teacher had the best definition for a computer which still holds good today - a high speed moron. Still, a useful moron none the less.

A typical loco wiring diagram is shown in figure 1 for a battery powered locomotive. This shows how the Mac•five controller fits in the system with the receiver. Note that the controller provides power to the receiver. No separate battery pack is required. Whilst it was mainly designed for battery powered locomotives, the Mac•five could be used as an 'on-board' track powered controller too.

Live Steam Loco Servo Jitters - The Ripmax Servo Slow

Signal reflections also affect live steam locos causing their servos to jump out of position. Several live steam people asked me for the equivalent of the 'smart' Mac-five controller, for their steam locos - a servo smoother. One in particular had a problem where his Gauge 1 loco when notched up would go into mid-gear, or even reverse! With some thought a modified program was compiled, plus a new circuit board, and the SAM-2 was born (Servo Assisted by Microcomputer) in 1994. However, developments occur over the years and today, 2.4Ghz digital R/C has largely rendered the SAM-2 unnecessary. For those that don't want the expense of buying a 2.4Ghz set then there is the Ripmax Servo Slow. Designed to slow up servos used on retractable aircraft undercarriages, it also has the effect of slugging the jitters caused by servo glitches.

Aerials and General Reception Problems

Receiver aerials can be the cause of many problems, especially reduced range. Despite instructions to the contrary in most R/C equipment manuals, many people shorten the aerial lead on a 27 or 40MHz receiver in order to fit it in a particular locomotive.

This is just about the worst thing they could do, as it is likely to de-tune the receiver, drastically reducing its range at ground level. Whilst the shortened lead picks up less signal, of more significance, is the fact that an impedance mismatch occurs between the aerial and its receiver. This causes signal loss between the aerial and the receiver, as if it were two hundred feet away when it was only 20 feet away. It also increases the chance of another transmitter on a different frequency interfering.

Plastic bodied locomotives generally aren't a problem. The aerial lead can be stuck to the underside of the roof, or the boiler, in the form of a wide loop or an L shape along and across the loco. Sometimes a problem can arise with locomotives running 'end-on' towards, or away from, the transmitter. In this case only the diameter of the aerial wire is 'visible' to the radio signal. This can be overcome by sticking a brass shim to the underside of the roof. About 2" square will do, soldered to the end of the aerial lead. Do not make it too big, say 3" x 4" maximum, otherwise it can de-tune the receiver. Locomotives I have converted using this technique, give perfect operation 200 feet away with the house and garage in between.

Metal bodied locos bring their own problems, this of course applies equally to live steam or battery electric. Using the whole body of a metal loco as the aerial, especially diesels, doesn't work. Too much metal loads the receiver input and diverts the signal to 'earth'. This effectively reduces the signal reaching the receiver and thus its range. It can also be too effective as an aerial and pick up electrical noise coming from motors or servos. An effective solution is to cut out a section of cab roof, say 2" x 1" and fit a removable plasticard roof. This can be shaped, if necessary, by heating it between shaped metal plates, with a hot air gun. A thin brass shim can be stuck to the underside of the plastic roof, 6mm smaller all round, so that it breaks down any inductive or capacitive link to the body. The end of the aerial lead can then be soldered to the shim. Excess aerial lead can be bunched to save space. I used this

method on my Gauge 1 BR Class 37 and a controllable range of 100 feet was attained with a 40MHz system. A 27MHz system didn't work nearly as well. I suspect it would have, if a larger plastic panel had been tried, but this would have destroyed some of the roof detail.

Domes on live steam locos seem to make good aerials, provided that they're well insulated from the boiler by a piece of PTFE about 1 mm thick. On tender locos a pyramid made from brass shimstock disguised as a pile of coal makes a good aerial plate. This applies to battery or live steam tender locos. Again the plate must be well insulated from the tender body. (See page 7). Aerials like this which have length, breadth and height make are best as they pick up more of the available signal. ***The forgoing applies to 27MHz and 40MHz equipment. If you're using 2.4GHz radio, I suggest NOT fitting aerial plates as this may upset the receiver circuits operating at such a high frequency.***

Choosing Motors for battery R/C locomotives

As a general rule of thumb I would aim to use motors between 6 and 12 volts. 6 volts is preferable for Gauge 0, as fewer Ni-Cad cells are required. Whilst 3 pole motors are quite controllable, 5 or 7 pole motors are better for slow running. 3 pole motors also tend to be noisier, especially with pulse power control. Motors with stall currents around 3 Amps are suggested, if used in pairs, or 5 Amps if a single motor loco. Buhler 13.21 12v motors, as used in many LGB locos, are an excellent choice. If you're using a motor that draws more current the chances are it will either burn out the controller, or the loco won't run for long on one charge. Typically, a gauge 1 diesel with two Buhlers will run for 3 hours on level track. If you want to go further then a coreless motor (more properly called an iron-less motor) is even better. More power for less current drain. Other conventional motors, such as Crailest and Mabuchi (as used in Aristocrat locos) are also suitable for battery R/C locos.

Many people believe coreless motors can't be used with pulse width control. In 26 years as an electronics engineer, I haven't had any problems using pulse power to control DC motors, coreless or otherwise. I am aware of the theory about the heating effect, but the actual physics of motor performance is rather more complex. I can only presume it is down to experience with badly designed controllers, or poor quality motors.

In Gauge 0, electric steam outline locos often require more effort and sophistication in conversion. This is mainly due to the various types of motors employed and the fact that there is limited space for batteries. Conversion to 6 volts, and Ni-Cad operation for a reasonable length of run, is best. By using coreless motors and special size Ni-Cads, it is possible to achieve up to 4 hours continuous running.

My G scale LGB locos all use Buhler motors which by chance are often used by Gauge 0 loco builders in the UK. I particularly like Buhlers, especially the 13.21. They include interference suppression inductors as a standard feature, and are designed with pulse control in mind. Many cheap motors do not have any suppression whatsoever. I found this out, to my cost, when one such motor kept on blowing the same transistor in a controller. Un-suppressed, a motor can produce spikes ten times greater than the battery supply voltage. These can blow transistors by over-voltage, even though they only last

for a few microseconds. Consequently, I now include spike suppression in all my controllers, as standard. Quite what such spikes do to other radio reception I dread to think. Perhaps with Radio 1 it doesn't matter! My original 'dumb' controller ran in my LGB Mallet loco, powered by two Buhler motors. The controller still didn't need any extra suppression circuitry after three years operation.

Suppressing motors

Unsuppressed motors can easily be suppressed just by fitting a 0.1uF capacitor across the motor terminals. This is usually sufficient, along with 'twisted pair' wiring between the battery pack, controller, and motor. A twisted pair is easily made by gripping a pair of wires in a bench vice, at one end, and in a hand drill at the other. Simply turn the drill until the wire is tight, release it and it should stay naturally twisted. The interference caused by the current flowing through the wires will tend to cancel each other out. Buhler motors are usually already suppressed so adding capacitors has little benefit, but twisting the wires can! Twisted pairs also help with wiring to and from soundcards and speakers, where significant levels of current also flow and can cause R/C interference.

Choosing 2-Rail Locomotives for Battery R/C Operation

An obvious candidate for conversion to R/C is a plastic bodied loco. In G scale those made by LGB make a good choice as long as they are not fitted with their MTS digital system. Their use of good quality motors is a point in their favour. Equally, those locos made by Bachmann and Aristocraft make good candidates. Providing there is sufficient space, the smaller locos can run quite happily on 12 AA Ni-MH cells for three or four hours e.g. the 0-4-0 Kof diesel. Larger locos, like the Aristocraft Class 66, need 14 higher capacity 5AH C cells. Mine will run for two hours working lights and smoke, and for nearly three hours if the smoke is switched off. But it does have *four* motors!

Many of the bigger, older non-digital, LGB locos are fitted with internal voltage dropping diodes. These can be bridged which saves having to make 18v batteries; 14.4 volt packs can be used instead. Indeed well charged 12 volt batteries will often suffice. This reduces the number of cells required, saving on cost, and space.

I don't like butchering the inside of a loco just to fit batteries and R/C gear. For one, it is extra work, and two it isn't very professional. If a loco was designed a particular way there must have been a very good reason. Don't forget to remove the pickups on electric locos, otherwise there is a chance the R/C controller could be damaged, if run on powered layouts.

In gauge 0, the Lima class 33 diesel is a very good starting point. It is relatively cheap, easy to take to bits, to remove the pickups, and to re-assemble. I used to view it with disdain, but the ease with which it can be disassembled, and assembled, changed my mind. It shows that a lot of thought went into making it easy to manufacture - a good example of production engineering, even if it isn't the most powerful loco around. It can be fitted with 12v worth of AA Ni-Cads which will run it for two to three hours, or more if you use Ni-MH cells.

Lima also used to make a battery version of their LMS 4F 0-6-0 tender loco. The tender was big enough to hold the controller and a receiver, with half size cells fitted in the boiler.

In 16mm and Gauge 1 there isn't much choice. Locos tend to be metal bodied whether commercially available or scratch built. If you're scratch building you can design your loco for R/C. Obviously, a metal body will shield the aerial lead, so make provision for a suitable external aerial. The isolated cab roof previously described is a good example. I have also seen metal models of Swiss electric locos, converted to R/C in Gauge 1. Here I was surprised to find that the pantograph made a very good aerial.

If you are scratch building diesel and electric prototypes then build it as a chassis and bogies with a lift off body, so that it can be run without the body for testing purposes. It is common sense, but you would be surprised how often I have to disappoint potential customers for conversions, based on these reasons. The only way out in such a case is to use a battery support vehicle (BSV) permanently coupled to the loco.

Many Gauge 1 builders use 24v motors. Whilst this gives a more powerful motor at a reduced current, it almost certainly precludes using batteries on-board the loco, whatever the prototype. Consequently, many build BSV's as previously mentioned. This does have other benefits. A BSV can be used with more than one loco, and loco conversion only requires isolation of the pickups and a connector to the BSV. Personally, I would rather use two 12 volt motors, wired in parallel. In addition with suitable switching it could also pick up from the track as a 12v or 24v loco, if required.

Table 1 - 27Mhz Bands

Band 1 Brown 26.955MHz
 Band 2 Red 27.045MHz
 Band 3 Orange 27.095MHz
 Band 4 Yellow 27.145MHz
 Band 5 Green 27.195MHz
 Band 6 Blue 27.255M Hz Also CB 'Call-up' Channel 23
 - Don't use!

Table 2 - 40MHz Bands

| Channel No. | | |
|-------------|--------|-----------------|
| European | UK New | Frequency (MHz) |
| 50 | 66 | 40.665 |
| 51 | 67 | 40.675 |
| 52 | 68 | 40.685 |
| 53 | 69 | 40.695 |
| | 70 | 40.705 |
| 54 | 71 | 40.715 |
| 55 | 72 | 40.725 |
| 56 | 73 | 40.735 |
| | 74 | 40.745 |
| | 75 | 40.755 |
| 57 | 76 | 40.765 |
| 58 | 77 | 40.775 |
| 59 | 78 | 40.785 |
| | 79 | 40.795 |
| | 80 | 40.805 |
| 81 | 81 | 40.815 |
| 82 | 82 | 40.825 |
| 83 | 83 | 40.835 |
| 84 | 84 | 40.845 |
| | 85 | 40.855 |
| | 86 | 40.865 |
| 85 | 87 | 40.875 |
| 86 | 88 | 40.885 |
| | 89 | 40.895 |
| | 90 | 40.905 |
| 87 | 91 | 40.915 |
| 88 | 92 | 40.925 |
| 89 | 93 | 40.935 |
| | 94 | 40.945 |
| | 95 | 40.955 |
| | 96 | 40.965 |
| | 97 | 40.975 |
| | 98 | 40.985 |

The new UK Channel numbers are far easier to follow than the old Euro numbers! The channel number follows the frequency, i.e. 40.665MHz is Channel 66. Just take the first two digits after the decimal point and you have the channel number!

N.B. All the channel numbers listed can be used in the UK, but not all of them are legal in the rest of Europe. France does not use the 40MHz band at all. Instead it uses the 41MHz band!

And Now there's 2.4GHz Digital R/C!

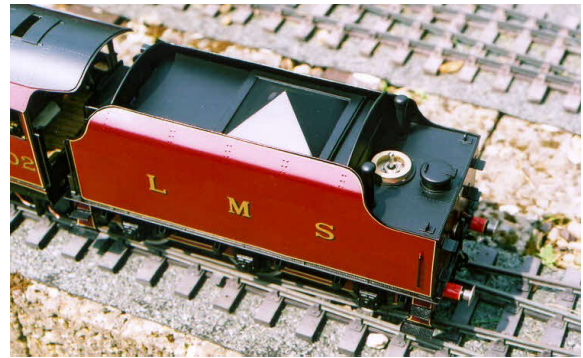
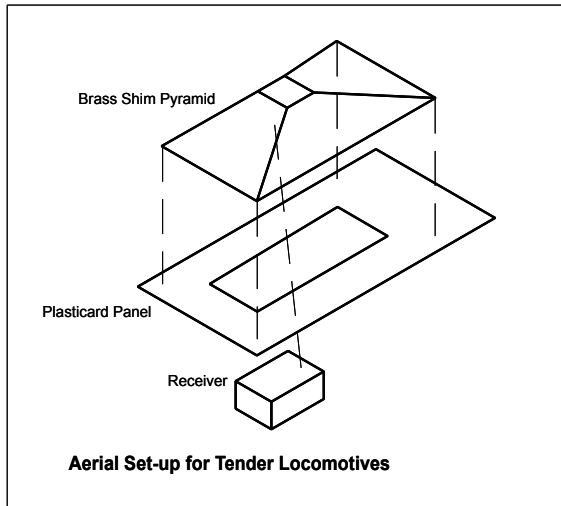
So what's it all about, I hear you say, this 'new kid on the block'?

Well for starters, as the sub-title implies, it works on a very high frequency of 2.4 GigaHertz, or 2400 Mega-hertz if you like it another way. It's a frequency higher even than that used by mobile phones, and 60 times higher than the conventional 40MHz FM analogue radio control equipment that we're already using. 'So what?'. OK, at this frequency it is well above those fre-

quencies generated by interference from things like electric motors, and other inductive devices such as solenoids, and car ignition systems. Also the signal it transmits is digitally coded and is thus virtually immune to signal reflections caused by our old pal the 'Rusty Bolt Effect'. It also spreads this signal over a wide frequency range, in the order of 1MHz. Hence you'll also see the term 'Spread Spectrum' mentioned in connection with 2.4GHz systems. This makes the radio link much more secure than conventional analogue AM and FM systems. These do the exact opposite by limiting their signal to a relatively narrow band of frequencies spread over a few Kilohertz. Hence it is much easier to 'interfere' with their signals.

Running on 2.4GHz also has the benefit of only needing short aerials on both the transmitter and receiver. On transmitters they are generally only 5" (125mm) long, and on receivers they can be as short as 30mm! In addition, no crystals are used. The sets find a spare band (or bands) i.e frequency, on which to operate. Each transmitter has a unique ID code and only receivers linked to it will respond to its signal. The sets are designed to avoid any others that are turned on and working. If there are no spare bands available (very unlikely as there are 80 frequency bands) then anyone turning on their transmitter will find it won't link up to the receiver and therefore they cannot operate their model, or anyone elses by mistake. Gone are the days when you will hear the phrase 'Oh sorry! I didn't realise you were on the same frequency as me'.

All in all it's the near perfect system. In general I would advise using 2.4GHz aircraft sets as they are designed to work over greater distances than 2.4GHz car sets. The latter are OK inside plastic bodied locos, but not so good in metal bodied locos, as the signal is attenuated i.e. cut down, by the metal work. Aircraft sets are usually designated as 'Park Flyer', typically 500 metre range, or 'Full range' which is farther than you can see, perhaps miles! Although they too have their signals attenuated by metal, it has far less effect as the signal is stronger in the first place. They also seem to work better in metal locos than 40MHz FM or AM gear too. Despite being referred to as 'Aero' sets, they are NOT limited by law for use only with flying models. They can be and are being used with a variety of R/C applications.



40MHz FM Aerial set-up on a Gauge 1 LMS Stanier tender
The filler and scoop dome assembly can be removed, enabling the plastic panel with the pyramid to be slid out for access to the R/C components inside the tender. The tender body is nickel silver.

Improving Reception

For a tender loco, an aerial in the form of a pyramid made of brass or nickel silver shim, sitting on a 1.5mm thick 'Plasticard' panel works well. The more it rises above the sides of the tender the better. This is because it has length, breadth and height. As the radio signal is emitted in all directions, it ensures that the maximum signal is picked up by the receiver giving better reception than just a flat brass insulated plate. For best performance, ensure that the base of the pyramid is at least 4mm from any other metal work. This prevents the radio signal coupling into the tender body. Also make the tender like an open topped box, so that the plasticard panel forms the 'top cover'.

The size and height of the pyramid is chosen to suit the particular model, but anything from 2" x 1" up to 3" x 2" base size would be acceptable, and up to 2" in height, or whatever looks acceptable as a pile of coal in the tender. The pyramid can be painted black (satin or gloss finish) and then painted with PVA adhesive and sprinkled with scale size pieces of coal.

Don't make the pyramid too large or else it will be too effective as an aerial, picking up interference from drive or servo motors. Ideally servos in live steam locos should not be fitted in the tender as this will bring any servo motor interference too close to the aerial. The receiver only needs a few millionths of a volt (uV) to react. So keep the receiver above footplate level and don't run the aerial lead near the chassis.

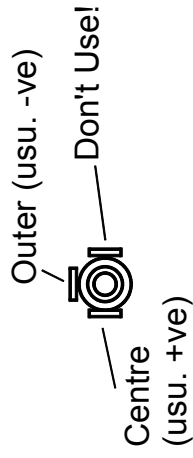
The Aerial lead can be bunched up and tied using a nylon 'Tie Wrap'. The end of the aerial lead should be stripped for about 3mm and soldered to the underside of the pyramid. Alternatively it can be connected using a 1mm pin and socket connector. Fit the socket to the underside of the pyramid and the pin to the end of the aerial lead. The receiver can be attached to the underside of the brass shim pyramid upside down using Velcro.

These instructions apply mainly to 27MHz AM and 40MHz FM equipment. With a 2.4GHz set, it's probably best if you don't attach the aerials to aerial plates, but just have them as high up on the loco, or tender, as possible, preferably not resting on any metalwork.



40MHz FM Aerial Set-up for a B.R. Class 37 Diesel Loco
In this case the roof is a fabricated clip-in plasticard panel pre-formed between two strips of metal with a heat gun. The roof enables access to the receiver in the cab, as well as providing an isolated area for the brass pickup plate to which the aerial is connected. The loco has a nickel silver body, and brass chassis with whitmetal castings.

5mm Co-ax Charging Socket
(Rear View)

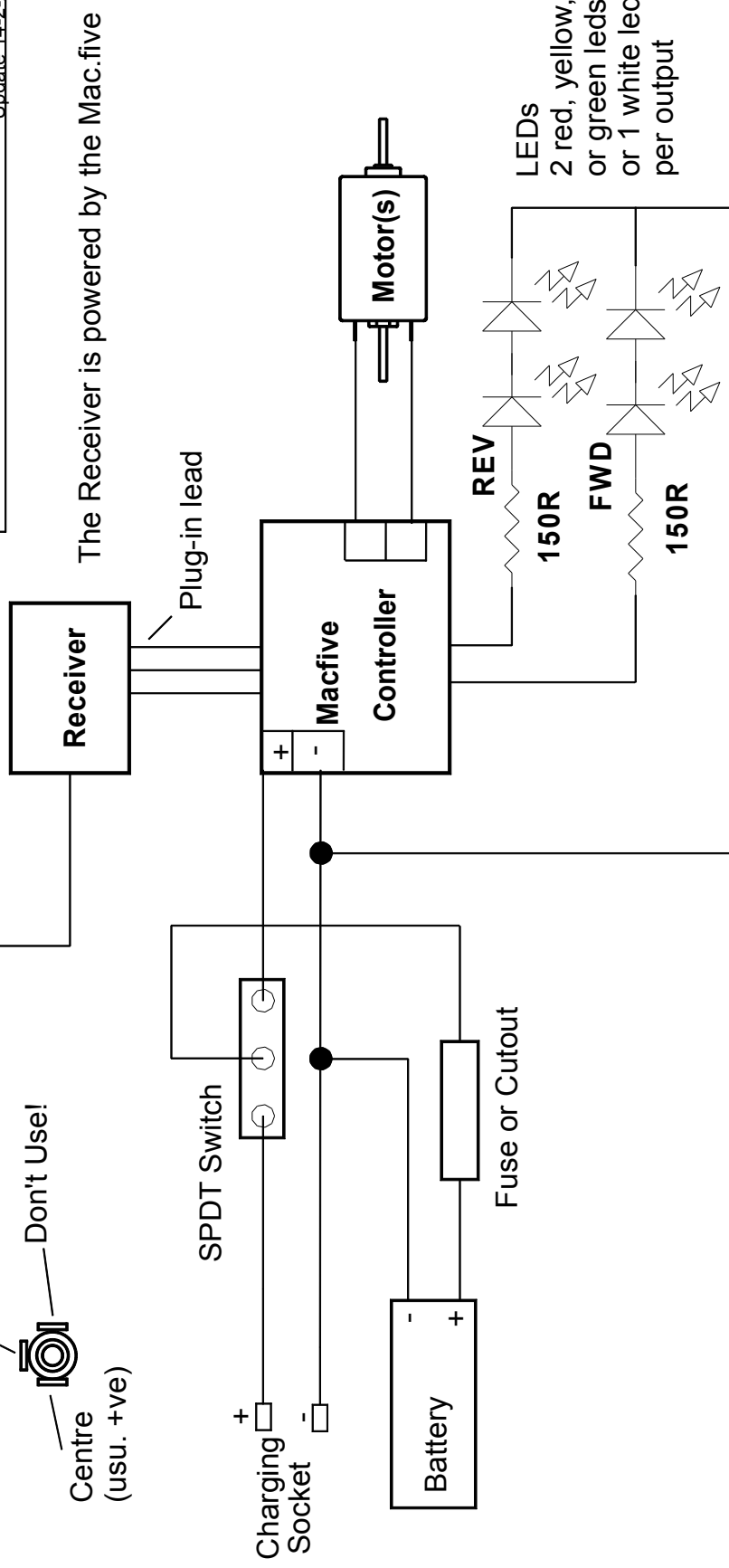


Aerial

Macfive SYSTEM WIRING DIAGRAM

BRIAN JONES c 7th NOV 1997

Update 14-2-2004



To run more LEDs or to use filament bulbs e.g. 'grain of wheat' use amplifier module LAMP-1