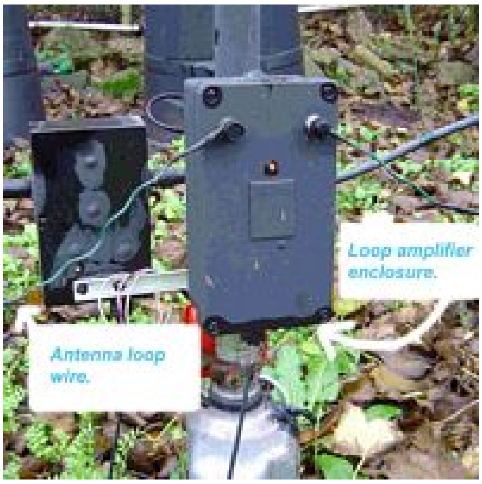
A Wide Bandwidth Active Loop Receiving Antenna.

With acknowledgements to the original design by John (G8CQX) upon which this antenna is based.

(A versatile wide bandwidth receiving antenna suitable for general short-wave amateur band reception. This antenna has also been used successfully for the reception of QRSS signals in the 20, 30, 40, 80 and 160 Metre bands)



Background.

Until a few years ago my QTH might have been described as "quiet" but due to the local proliferation of computers and other high-tech gadgets the LF, MF and lower HF bands have now become swamped with local QRM. Receiving weak signals or having QSO's became very difficult.

The combination of local QRM coupled with a requirement for a wide bandwidth antenna suitable for general SW listening prompted experimentation with several types of "active" antenna. Tests with several "active whip" antennas proved unsatisfactory. While they possessed the wide bandwidth capability desired they offered little or no improvement in signal-to-noise ratio. In all cases the antennas had been located outside some 20 Metres away from the house as far away as possible from local noise sources. Correctly balanced dipole antennas offered a partial solution to the problem but due to lack of space a full sized dipole for bands below 40 Metres was not practical. Shortened or loaded dipoles would function well on receive but proved to be poor radiators for transmitting. By contrast, a long wire antenna resonated against a counterpoise proved to be an effective radiator on the lower HF bands but picked up high levels of local QRM while receiving. I decided an effective solution might be the use of two antennas, a long wire as a TX radiator and a separate receiving antenna in the form of a balanced active loop. The switching between the two antennas accomplished using an antenna relay controlled by the rigs PTT line.

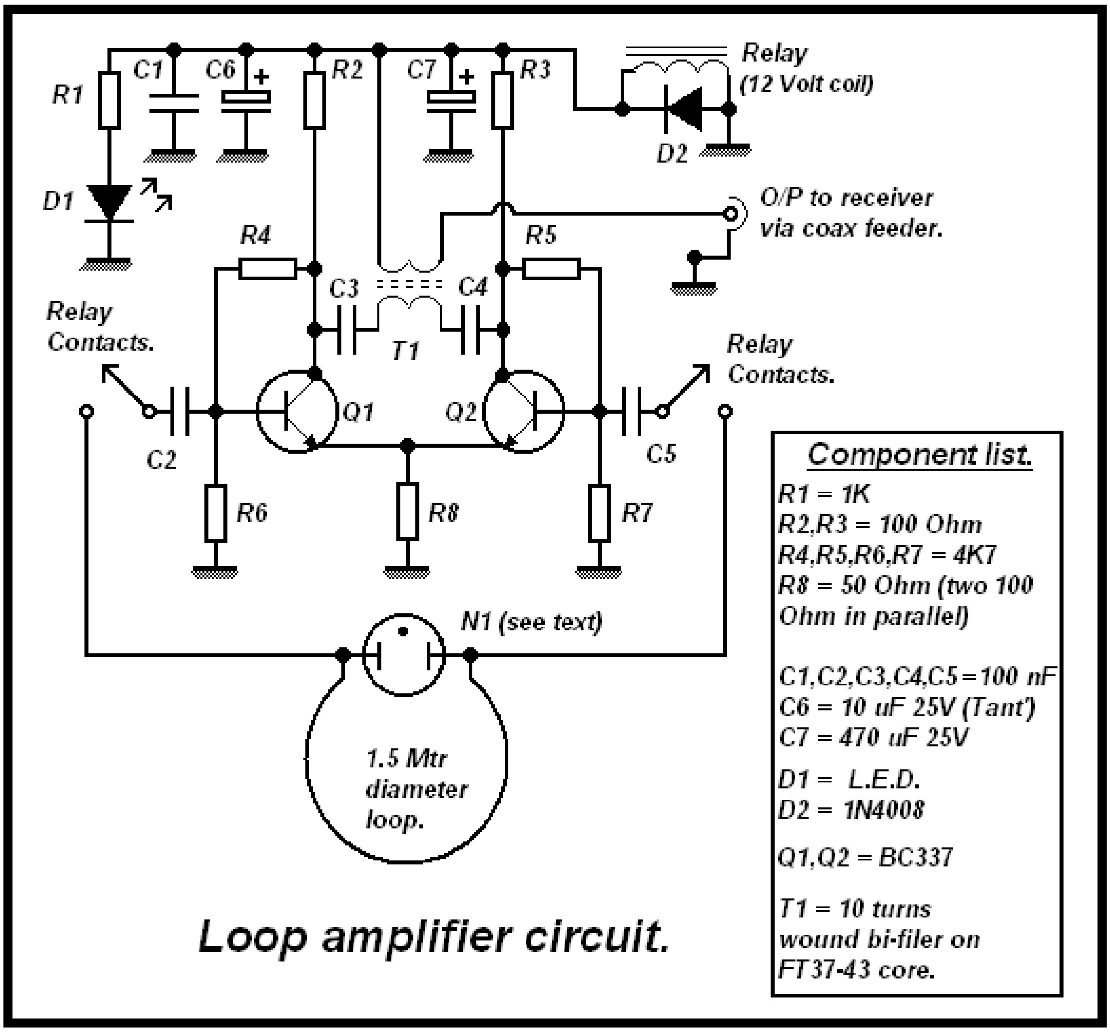
The best performing receive antenna tested was an active loop design by John (G8CQX) upon which my receiving antenna is based. I was particularly impressed by the stability of Johns amplifier design regardless of the construction methods used. Initial daytime tests with a 1 Metre diameter loop proved the loops ability to receive signals over several octaves and with much reduced local QRM levels. However, tests after dark revealed overloading of the loop amplifier from powerful SW broadcast stations. The cure for the signal overloading was to increase the standing current in the loop amplifier devices taking care not to exceed the safe collector power dissipation. The resulting modified loop amplifier no longer overloads even with an increased loop diameter of 1.5 Metres or more. The loop diameter of 1.5 Metres was found to be optimal at my QTH. The active loop antenna has now been thoroughly evaluated over a two and a half year period with very pleasing results. A nice feature of the broad bandwidth loop is that no re-tuning or adjustments are required to the antenna when changing bands.

Circuit details and constructional notes.

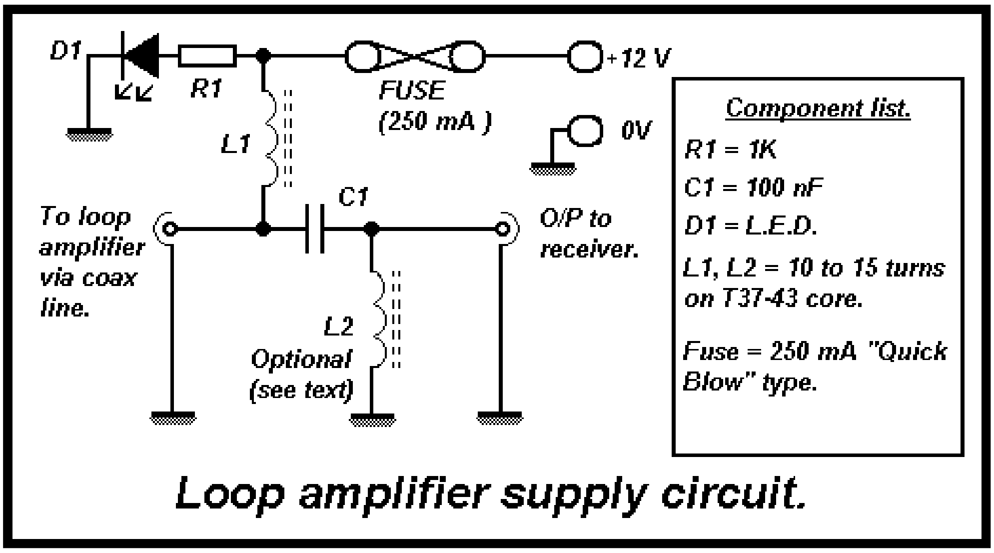
Minor modifications have been made to John's original design to protect the loop amplifier when used in conjunction with a transmitter and to improve the strong signal handling capability. The construction of the amplifier does not appear to be very critical and four versions have been successfully built using various methods of construction. The first used breadboard construction, the second and third built over a ground plane while the current version is built on a scrap of strip board. I have successfully used various devices including 2N2222, 2N3866 and BC337's. The current version is fitted with a pair of unmatched BC337's and has been in regular use for over two years. BC337 devices have been used simply because I have a good stock of these in the junk box. Both of the transistors run with 30 mA of collector current requiring a small heat-sink to be glued to each device. The loop itself is made from multi-strand (1.5 square mm) flexible wire supported on a pentagonal frame made from plastic electrical conduit. The relay shown in the ***loop amplifier circuit diagram*** protects the devices from strong signals due to the loops close proximity to the transmitting antenna. The relay has normally open contacts which close when the amplifier is powered up for receiving and open when the power is removed for transmitting or when the loop is not in use. The relay type is not critical though it should have low contact resistance. The diode ***(D2)*** across the relay coil protects the rest of the circuit from the relay coils reverse E.M.F. when the power is removed and also acts as reverse polarity protection. While nothing can protect the antenna from a direct lightening strike the open relay contacts do offer some protection from surges caused by nearby thunderstorms. The loop also has a gas discharge device connected across its terminals providing a second line of defence against surges. The discharge device itself was salvaged from an old modem. Provision has also been made to disconnect the coax cable at the antenna end to prevent currents induced in the coax from damaging the loop amplifier during thunderstorms. Transformer ***(T1)*** serves a dual function of both RF transformer and R.F. choke.

Because most of the local QRM is thought to be due to conducted and radiated emissions from the mains wiring it was decided to place the antenna outside at the bottom of the garden as far away from the local noise sources as possible. The signal is fed back to the shack via 20 Metres of RG58 A/U coax. The same coax provides a +12 Volts DC supply from the shack to power the loop amplifier. The supply unit to feed power down the coax follows standard practice except for the optional inductor "L2" ***(see loop amplifier supply circuit)*** which is to prevent "surges" or DC from entering the receiver antenna input in the event of the DC blocking capacitor ***(C1)*** failing. If such a failure should occur then L2 would provide a low resistance path for the D.C. supply to ground (0 Volt rail) blowing the safety fuse and protecting the receiver input from damage. In normal operation the inductive reactance of L2 is high enough such that it will not effect the passage of R.F. signals to the receiver. The loop amplifier is mounted in a ***"chunky" alloy box*** with all cable entry/exit points sealed with a waterproof sealant. Two small bags of "Silica-Gel" (desiccant) have been included to reduce residual moisture and condensation within the enclosure. An L.E.D is also fitted to the enclosure to confirm the power is present. When used for SW listening the loop is powered from a "wall wart" power unit, when the loop is used for transmit/receive activity power is taken from the rig's PSU via a separate unit (not shown) which provides both antenna and supply switching.

The loop amplifier circuit diagram is shown below.

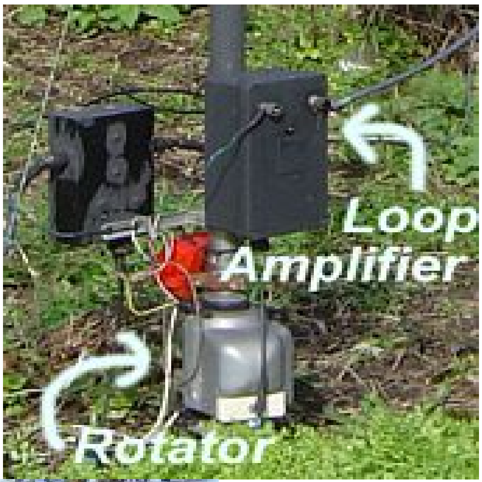


The loop amplifier "power down the coax" circuit is shown below.

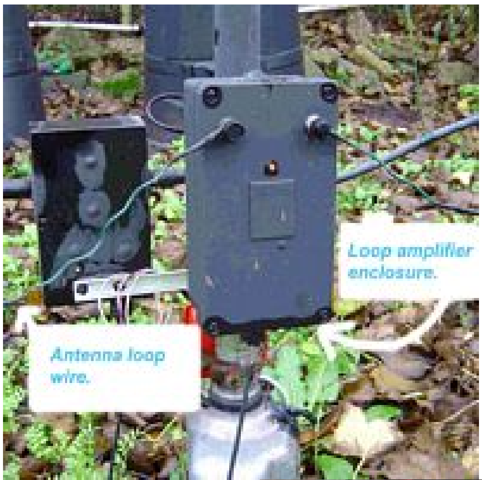


Some images of the loop antenna and loop amplifier are shown below. (Click on any of the thumbnail images for a higher resolution picture.)


Loop Amplifier.

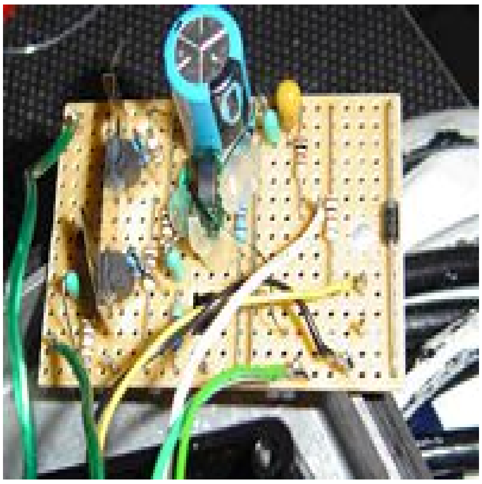

Loop
Amplifier
Rotator


Loop
Loop amplifier
Rotator


Loop amplifier
enclosure.
Antenna loop
wire.


Protection
Relay.
Loop contact.


Gas filled discharge
device (Lo-Z =350 Volts)

Possible improvements and things to try.

In order to improve the antennas high frequency performance it may be worth trying different devices with a higher frequency cut-off and/or a lower noise figure. Using a pair of matched devices may also give improved performance by virtue of the reduced distortion. Using devices capable of higher collector dissipation it should be possible to increase the standing current and further improve large signal handling capability. In an e-mail exchange John (G8CQX) pointed out that *"If you keep the collector resistors high and double the supply voltage you might find it works better as the increased open loop voltage gain will increase the feedback and reduce the input impedance further improving the linearity of the amplifier".* During the testing phase it was found that a good test for overloading was to listen around 28 MHz after dark when the 10 Metre band is normally closed. Assuming you are using a receiver with good dynamic range then any trace of broadcast stations on that frequency might indicate overloading within the loop amplifier or distortion due to a pair of badly mismatched devices.

My loop antenna is at a height of 1.8 Metres and some improvement in performance might be expected with increased height. The loop also displays some directivity (particularly on the lower bands) making it possible to "null" some sources of interference or strong broadcast signals by rotation of the loop. Any directivity observed on broadcast signals in daytime all but disappears after dark as the sky-wave propagation increases. I would avoid making the loop much larger than the 1.5 Metre diameter quoted, while a larger diameter improves the strength of lower frequency signals it risks overloading of the loop amplifier due to strong SW broadcast signals.

Note:
In the event that this antenna causes "overloading" to the receiver it is connected to then it might be tempting to reduce the gain of the loop amplifier and/or reduce the loop size. However, I would refrain from this coarse of action unless the loop amplifier is itself overloaded. In my opinion a better coarse of action would be to fit an attenuator at the shack end of the coax feeder in order to preserve the best signal-to-noise ratio possible. Any noise picked up on the coax line will be less of a problem if the signal-to-coax-noise ratio is kept as high as possible.

Closing comments.

Using the receiving loop described it is again possible to enjoy general SW listening and operation on the lower HF amateur bands thanks to the significant reduction in the level of QRM. As an example, using a long wire antenna noise on the 80 Metre band was typically S8, the loop has reduced this to S1 or better. The loop has been successfully used to receive signals from L.F. (60 kHz MSF time signals) to 30 MHz. The receiving loop has also proved successful for receiving very weak signals associated with QRSS operation within the 20, 30, 40, 80 and 160 Metre bands. If you are also troubled by local QRM sources on the lower HF bands then give this antenna a try, you may be pleasantly surprised at the results.

My thanks to John (G8CQX) for giving his permission to reference his excellent design.

References.

The "Technical Topics" column of the June 1986 edition of "RadCom" (The R.S.G.B.s monthly publication)

"HF active receiving loop antenna" by John Hawes, G4UAZ (now G8CQX)

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e-mail 

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