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A GYRATOR TUNED VLF RECEIVER

This VLF monitoring receiver uses a gyrator circuit to eliminate LC-type tuning

Previously published articles[1,2] have described two different types of VLF receivers used to monitor very low frequency stations for sudden ionospheric disturbances. These effects have been discussed in **References 1** and **2**. In the spring 1993 issue of *Communications Quarterly*, Peter Taylor and I described a VLF receiver with three separately tuned states using 88-mH toroid coils and air variable capacitors. This arrangement worked well but was somewhat cumbersome.

After publication of the spring 1993 article, I received a communication from Phillip Eide, KF6ZZ, suggesting a gyrator circuit for tuning that eliminated the LC type of tuning used in the previous receivers. I immediately started to experiment with the gyrator approach. This article is the result of my work with a gyrator tuned VLF receiver.

Note that the gyrator directly replaces the cumbersome toroids and slug-tuned coils used in earlier receiver circuits. The Q of a gyrator greatly exceeds that of the iron/copper inductances. Furthermore, the "L" value is easily changed by a resistance. With this type of circuit, it's easy to construct a complete SID receiver around a single 89 cent IC package. Another advantage of this new design is that there is only one stage of LC tuned circuit as opposed to several in previous designs.

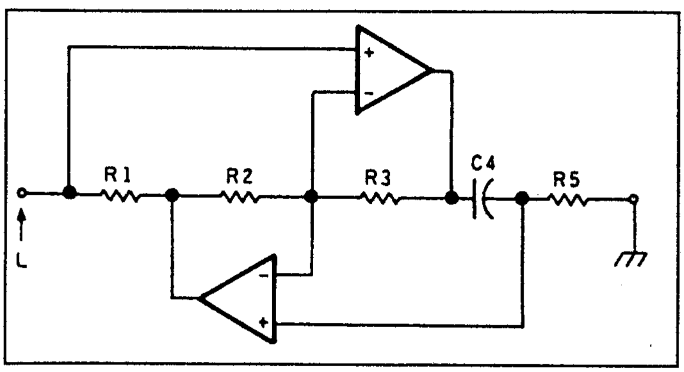


Figure 1. A basic gyrator circuit.

Gyrator circuits

I'll make no attempt here to get into gyrator theory. It's sufficient to say that a gyrator is a simple circuit topology that superbly simulates an inductor. The theory is well covered by Moschytz.[3] A basic gyrator is illustrated in **Figure 1**.

The inductance is calculated using the following formula:

$$L = \frac{R1\ \ R3\ \ R5}{R2\ \ 1/C4} \text{ for } R2 = R3 \quad L = R1\ \ R5\ \ C4$$

In this circuit, I have chosen R1, R2, and R3 as 3.3 k. R5 is a series combination of 3.3 k fixed and 10 k variable. With C4 as 0.001 μF, the inductance range of the gyrator is from 43.9 mH to 10.9 mH depending on the setting of the 10 k pot. This, with a parallel capacitance of 0.002 μF, provides a tuning range of 17 to 34 kHz, a useful range for our purpose. These values will vary somewhat due to the tolerance of the components.

Following the tuned input circuit is a variable gain stage with a gain up to 40 dB feeding into a precision rectifier with another gain of 40 dB. The final capacitor, C6, provides a long time constant to smooth the trace of the Rustrak

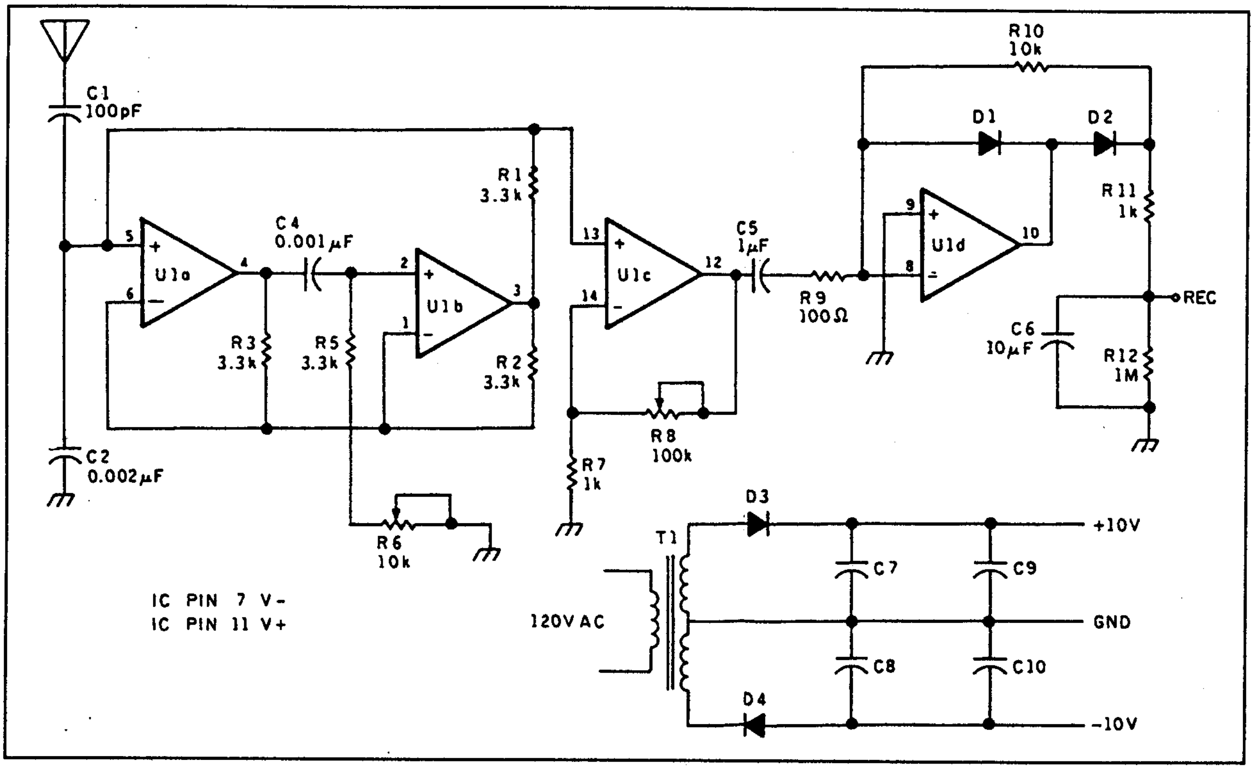


Figure 2. Receiver schematic.

recorder. The schematic is shown in **Figure 2**.

Potentiometer R6 controls the tuning, and overall gain is controlled by R8. A center-tapped 12-volt transformer is used for the bipolar power supply.

Construction

After some experiments with wire-wrapped circuits and a few printed circuit board layouts, I settled on the arrangement shown in **Figure 3**. There was some tendency to oscillate in a few of the tests, but I eliminated this problem with bypass capacitors on the power supply leads and shielded leads to the pots. Most of the components are Radio Shack parts. A list is provided with **Figure 4**. I recommend the 4136 op amp as best for this purpose. It's well suited for the gyrator and also the final amplifiers.

The circuit board is mounted on standoffs in

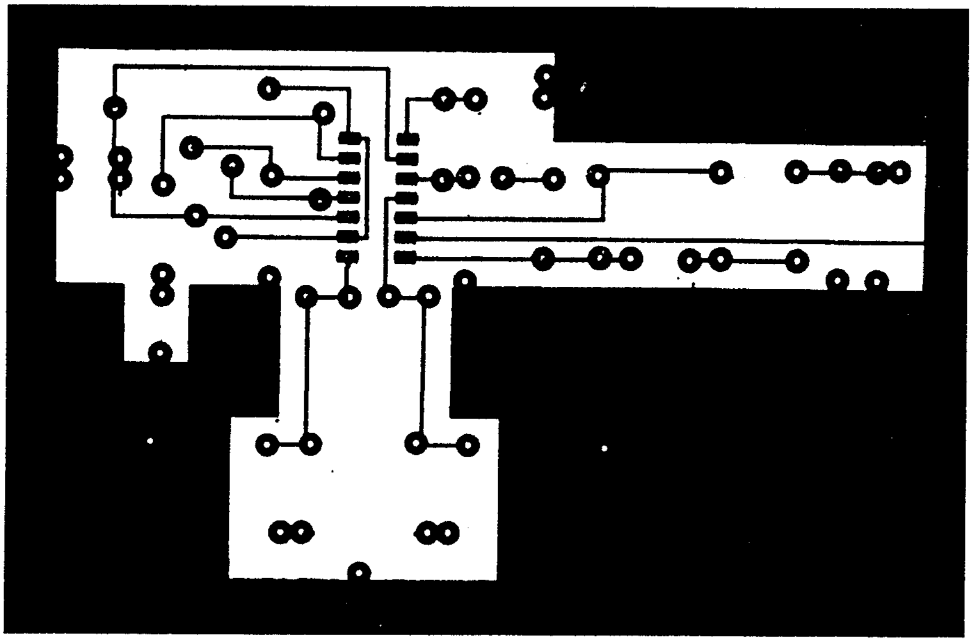
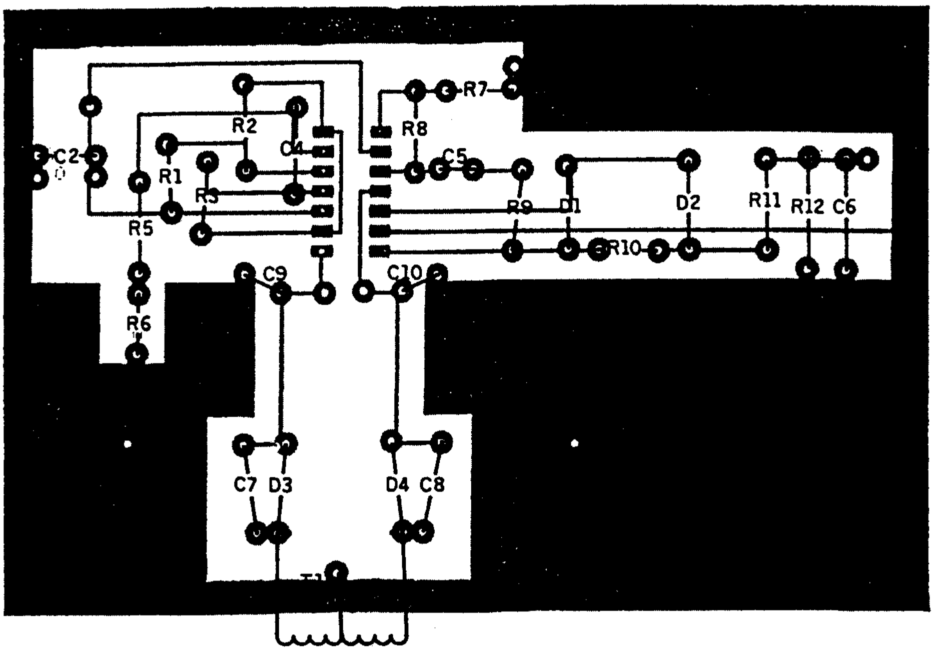


Figure 3. Circuit board layout.



Parts List: VLF Receiver

R1,R2,R3,R5	3.3-k resistors, 1/4 watt	C4	0.001-μF ceramic capacitor
R7,R11	1-k resistor, 1/4 watt	C5	1-μF electrolytic capacitor
R9	100-ohm resistor, 1/4 watt	C6	10-μF electrolytic capacitor
R10	10-k resistor, 1/4 watt	C7,C8	470-μF electrolytic capacitors
R12	1-meg resistor, 1/4 watt	C9,C10	0.1-μF ceramic capacitors
R6	10-k linear pot	D1,D2	1N34 diodes
R8	100-k linear pot	D3,D4	1N4001 diodes
C1	100 pF ceramic capacitor	U1	4136 integrated circuit chip
C2	Two parallel 0.001 μF ceramic capacitors	T1	12-volt CT transformer
		Metal cabinet and miscellaneous hardware.	

Figure 4. Parts placement diagram.

a metal box with the potentiometers on the front panel. A BNC connector for the antenna and a 1/8-inch jack for the recorder are mounted on the back panel.

Inasmuch as the receiver was intended to be used for SID monitoring on a continual basis, the output is designed to operate a 100 μA Rustrak Recorder. The tuning potentiometer is calibrated on the front panel by feeding a signal from a signal generator through a 100-k resistor to the antenna connector.

Summary

I've described my experiments with a somewhat novel method of tuning a VLF receiver. It has performed very well at my location in northern Ohio on 24 kHz and 21.4 kHz signals from NAA and NSS in Annapolis, Maryland and Cutler, Maine, respectively. Various antennas have been described in other articles. I generally use an insulated 24-foot vertical aluminum tube as an antenna. This is connected to the receiver through the center conductor of a coax line. The shield is grounded to an earth ground. A small diamond shaped loop antenna 14 inches on a side with 100 turns of no. 26 enamelled copper wire has also proved very effective on these stations. The loop was tuned with the proper capacitance in parallel to resonate at each of these frequencies. No ground was needed with the loop.

Acknowledgment

My sincere thanks to Phillip Eide, KF6ZZ, for his basic suggestion of the gyrator and the precision rectifier. Without his encouragement and assistance this project would not have been possible.

Those who wish , may purchase the circuit board for this project from Far Circuits, 18N640 Field Court, Dundee, IL 60118, for $7 plus $1 shipping and handling. ■

REFERENCES

1. Peter Taylor and Arthur Stokes, "Recording Solar Flares Indirectly," *Communications Quarterly*, Summer 1991, page 29.
2. Peter Taylor, "The Solar Spectrum," *Communications Quarterly*, Spring 1993, page 51.
3. G.S. Moschytz, *Linear Integrated Networks*, Van Nostrand Reinhold Company, New York, New York, 1975.