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Solid-State Tuned Circuits Improve IF Amplifier Reliability

Two new components fabricated of a piezoelectric ceramic eliminate the need for periodic realignment of IF circuitry. In addition, the solid-state tuned circuits, called Transfilters, permit miniaturization with no degradation of selectivity, and are unaffected by shocks exceeding 100 G and temperatures to 200°C. The IF amplifier portion of a reflex transistor portable radio has been "ceramitized" to illustrate a few of the applications possible with these new devices.

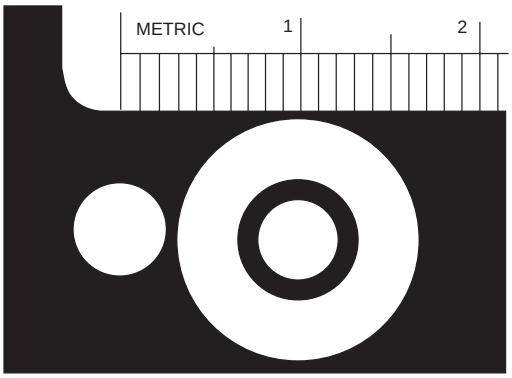
The two types of piezoelectric ceramic resonators used in this receiver are in the form of round flat discs with silver electrodes on both faces. Each has different electrical characteristics. The fundamental radial resonator is free of spurious response in the vicinity of its fundamental resonance, and acts as a highly selective tuned circuit with low impedance. The overtone radial resonator is made to operate efficiently at its first overtone by special electroding. Operating in this mode, it becomes a four-terminal network with two terminals in the form of "dots" at the centre, and the other set in the form of a "ring".

In the first stage of the IF amplifier, a fundamental mode resonator is used to couple the IF transformer to the base of a 2N140 transistor. This series coupler provides a pass band at its series resonant frequency, and a pole of attenuation above the pass band. If a symmetrical filter characteristic were desired at this point, a shunt coupler could have been placed across a tap on the primary of the IF transformer to ground. However, it was decided to use a shunt coupler at another point in the circuit.

The first and second IF stages are coupled by a "ring" and "dot" resonator that provides impedance matching and broad band filtering. A phase reversal exists between the dot electrode and the ring electrode ;and can be used for feedback, if necessary for neutralization.

A shunt coupler is placed between the second and third IF stages. This unit is a ring and dot disc with the two sets of electrodes cross connected, so that excitation is in phase at both sets of electrodes. With the disc excited in this manner, its response is exactly the same as that of a fundamental resonator. However, it is much lower in impedance. The disc is parallel resonant with the input capacity of the transistor, thereby raising the impedance level. This increases the IF power gain of the previous stage.

The third IF stage is coupled to the detector by a ring and dot resonator and functions the same as the resonator used to couple the first and second IF stages.



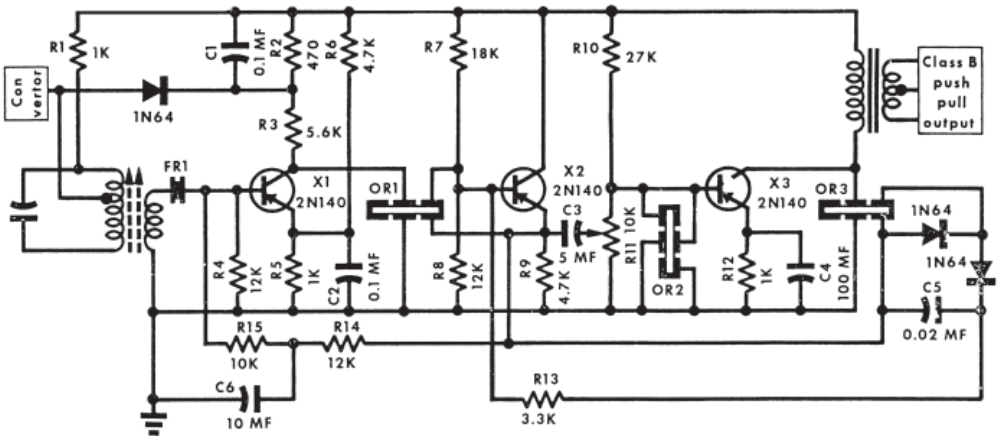
SOLID - STATE tuned circuits are available in two shapes, each with a different characteristic. Both are in the form of round flat discs with silver electrodes on both faces. This permits operation in the relatively spurious-free radial mode.

The audio signal is returned to the second IF stage where it is amplified and passed on to the next stage through the volume control potentiometer. Since the shunt coupler in this circuit provides a high impedance at low frequencies, it does not affect the audio signal. After amplification in the last IF-AF stage, the audio signal is coupled to a class B push-pull amplifier. The ring and dot resonator that couples the third IF stages to the detector provides excellent separation of the IF and AF signals, thereby preventing regeneration.

Contact to the resonators used in this receiver was made by spring leads. This method was found to be free of many of the problems associated with soldered leads. Wearing of the electrode at the contact area has been found to be negligible. This has been made possible by making contact to the discs near the nodal areas, and using fired silver electrodes which are thicker—therefore, more durable than evaporated

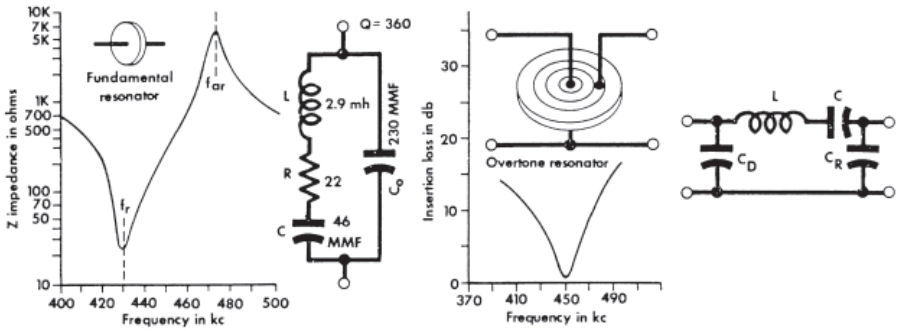
electrodes. In addition to being used for series and shunt coupling, Transfilters can be used as emitter by-pass elements. In such applications, a fundamental resonator replaces the emitter by-pass capacitor to improve selectivity and long range reliability. Time and temperature stable piezoelectric units used for this purpose greatly simplify circuit alignment procedures.

The IF amplifier portion of the "ceramitized" receiver was designed by Clevite Electronic Components, Division of Clevite Corporation, Cleveland, Ohio. The two configurations of piezoelectric ceramic discs discussed are presently available from Clevite. Other devices, still in their experimental stages, will offer an increasing selection of tuned circuits to the designer of band-pass amplifiers.

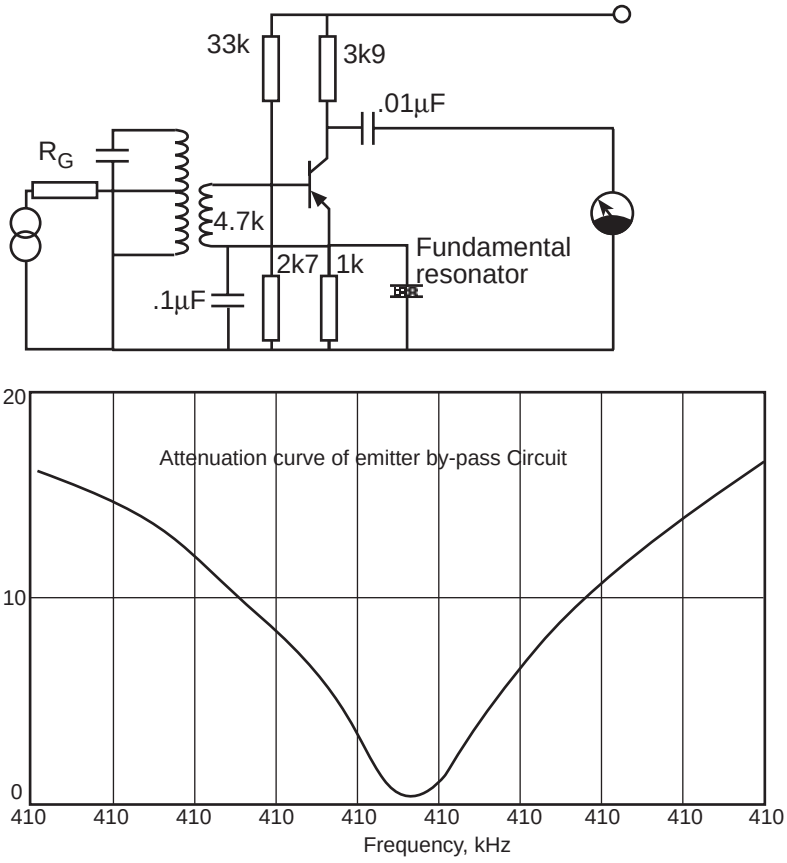


IF AMPLIFIER portion of reflex transistor portable radio uses fundamental and overtone resonators. Series resonator FRI is used to couple IF transformer to base of transistor Xl. This series coupler provides pass band at its series resonant frequency, and pole of attenuation above pass band. First and second IF stages are coupled by ring and dot resonator, ORl. This unit provides impedance matching between the two IF stages, plus broad band filtering. Phase reversal exists between dot electrode, and ring electrode, and can be used for feedback. Shunt coupler OR2 is placed between second and third IF stages. This is ring and dot disc with two sets of electrodes cross connected, so that excitation is in phase at both sets of electrodes.

With disc excited in this manner, response is same as that of fundamental resonator, but lower in impedance. Disc is parallel resonant with input capaciq of transistor, thereby raising im pedance leved. This increases IF power gain of previous stage. Resonator OR3 couples third IF stage to detector. Its function is idendcal to OR1. Audio signal is returned to second IF stage for amplificadon and fed to next stage through volume control Rll. Shunt coupler, being a high impedance at low frequendes, does not affect audio signal. After amplificatdon in last IFAF stage, audio signal is coupled to class B push-pull amplifier. Resonator OR3 provides excellent separation of IF and AF signals, thereby prevendng regeneration.



EQUIVALENT CIRCUITS are shown for fundamental and first overtone resonators. Curve at left shows impedance variation versus frequency for the fundamental resonator, and curve at right shows insertion loss versus frequency for first overtone resonator. Typical values for fundamental resonator are given for a disc 0.030 inch thick and resonant at 430 kHz. For fundamental resonator, the nearest overtone response is 2.6 times fundamental response. For disc resonant at 455 kHz, first overtone frequency is approximately 1.18 MHz. Equivalent circuit of overtone resonator resembles pi-coupler. Impedance transformation is possible between dot and ring electrodes. Maximum transformation ratio is 10.1. For disc operation at 455 kHz, maximum impedance at dot electrode is approximately 5000 ohms. Minimum impedance of ring is approximately 200 ohms.



ATTENUATION CURVE AND CIRCUIT APPLICATION are shown for emitter by pass resonator. At series resonant frequency, disc forms low impedance path for signal. Gain of transistor stage at this frequency is greater than that obtained with 0.01 µF by-pass capacitor. Impedance of disc is less than 15 ohms at this point. At frequencies on either side of resonant frequency, negative feedback is introduced in emitter circuit by rising impedance of disc, resulting in an emitter degenerative amplifier. Since impedance input of transistor increases with increased degeneration in emitter circuit, degree of filtering obtainable with emitter by-pass disc increases markedly in power matched circuits.