Latching Receiver Protection Circuit

This design guards front-end circuits from high input signal damage

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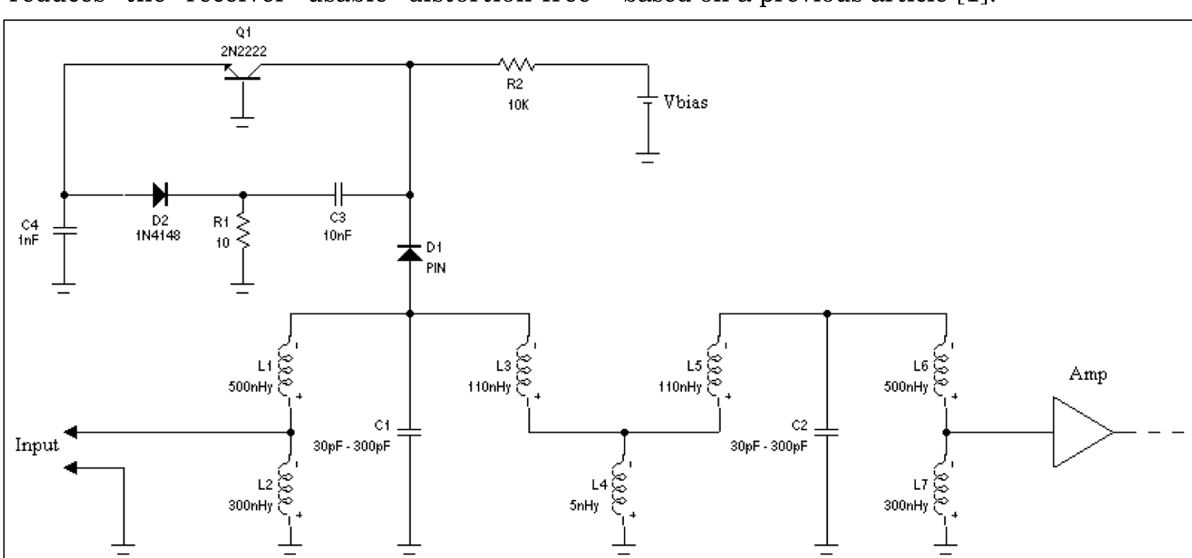
This article discusses a radio receiver protection circuit that protects receiver front-end circuits from damage when an input signal of more than 10 watts is present.

Low VHF communication equipment often has to function at a base station with a large number of radio transceivers that share a common band of frequencies, using antennas that are at a short distance to one from the other. This co-location situation means that from time to time a large amount of power that is transmitted by one transmitter enters a neighbor receiver and can damage its input circuits.

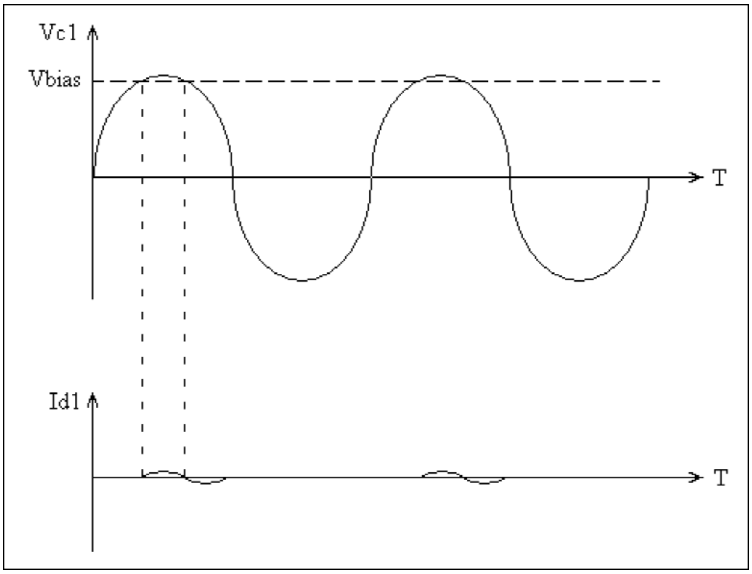
The usual protection circuit, a TVS-like diode connected in parallel to the receiver input, is not a good solution for three reasons. First, the diode's high, nonlinear capacitance deteriorates the linearity of the receiver input circuits and reduces the receiver usable distortion-free dynamic range. Second, the protection diode directly at the receiver input will activate it with an interfering signal at a frequency that is far away from the receiver frequency. Thus, the protection circuit will be activated frequently, and interference to the reception will be significant. A third drawback is that during the protection time the power that enters the receiver is clipped by the TVS and is retransmitted as a distorted signal with a wide spectrum, causing more interference with other communication channels.

Circuit description

The receiver input circuit, shown in Figure 1, is composed of a two tuned band-pass filters connected between the antenna input and the amplifier. The design of the band-pass filter is based on a previous article [1].



▲ **Figure 1. The proposed circuit.**



▲ **Figure 2. The upper graph shows the voltage on C1 (Vc1). The lower graph shows the current through the PIN diode D1.**

During regular operation, PIN diode D1 (a 1 to 2 pF, 1 to 2 uS carrier lifetime, 70-volt reverse breakdown voltage PIN diode) is reverse biased by the 10-volt power supply. Transistor Q1 is in a cut-off state. In this state, the protection circuit has negligible loading of the tuned circuit, a $Q>100$, 1 to 2 pF capacitor. The low loading does not compromise the distortion-free dynamic range of the receiver.

When an increasing amplitude signal appears at the receiver input, a large voltage will develop on the first resonator only if the signal frequency is close to the tuned circuit resonant frequency. A typical bandwidth of the input-tuned circuit is five percent of the center frequency, so only a signal that appears at a small frequency fraction of the total frequency band will enter the input filter.

When the signal amplitude peak voltage across the first resonator exceeds the PIN diode reverse voltage bias, an electric charge will be injected into the "I" region of the PIN diode. At the rest of the signal period, when the voltage across the PIN diode is at a reverse bias state, the same electric charge will be extracted back from the "I" region or, in other words, small pulses of current will get through the PIN diode at the signal rate, depending on the polarity of the PIN diode instantaneous voltage. The same charge that was injected to the PIN diode during the forward voltage period was extracted from the PIN diode during the reverse voltage period. This is shown in Figure 2.

The current peaks through the PIN diode flow to ground through R1. The voltage peaks across R1 are rectified by D2. If the input signal amplitude is large enough that the rectified signal at the anode of D2 turns on Q1, a latching sequence will begin: as Q1 turns on, its current will lower its collector voltage, which will lower the PIN diode reverse bias that will force the PIN diode to pass more signal which will eventually drive Q1 to higher conduction.

At the end of the latching sequence, the PIN diode will be in continuous forward current conduction, showing an AC resistance of less than one ohm and, in effect, shorting the first resonant circuit by the 10-ohm resistor. Most of the input signal will drop on L1, and a small portion will drop on R1. The input impedance of the receiver will be very close to a perfect inductance. Almost all of the input power will be reflected back, without adding any distortion to the reflected signal.

L2 and to a lesser degree L1 should be high *Q*, low-loss inductors to minimize their power dissipation in this state.

The latching state will terminate when the input signal drops in value to one that cannot sustain the conductance of *Q*1. This input signal level is lower than the latching initiating level, so there is a hysteresis-like operation of the protection circuit.

The protection circuit will operate also when the radio is turned off. The reverse bias of the PIN diode will be zero so the protection circuit will be activated with lower input signals. The rectification of the input signal itself provides the current for the shorting action of the PIN diode.

Summary

A radio receiver protection circuit was presented, offering advantages including negligible loading of receiver circuits during normal operation; circuit activation only for signals that are close to the receiver frequency; latching operation that reflects the signal linearly, almost without dissipating power; latching operation that removes protection when the input signal is removed; and operation when the radio receiver is turned off. ■

Reference

1. Victor Koren, "Design Of A Constant Insertion Loss Variable Frequency LC Band Pass Filter," *Applied Microwave & Wireless,* Vol. 12, No. 9, September 2000.

Author information

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