

# **An Impulse Noise Blanker for HF Receivers**

by

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## Introduction

For shortwave listeners (SWLs) and radio amateurs alike, having your reception deteriorated or even destroyed by high intensity impulse noise can be more than just frustrating. Post-detection noise blankers, even sophisticated ones such as those using digital signal processing (DSP) methods, can be rendered ineffective when the noise seriously impacts the early stages of the receiver.

A wide variety of circuits have been published for dealing with impulse noise interference in the early stages of the receiver, however the majority of these designs are either incorporated within the overall receiver design or require some degree of modification of the receiver, which may not be practical in some cases.

Described herein is an impulse noise blanker that is intended to be used between the antenna and the receiver, requiring no modification of the receiver at all.

## The Lamb Impulse Noise Blanker

One of the earliest forms of effective impulse noise suppression is that of J.J. Lamb (1, 2, 3). Shown in one of its basic forms in Fig. 1, the circuit consists of two vacuum tubes, the first being a pentagrid (upper envelope) and the second being a pentode with a pair of diodes (lower envelope). The pentode of the lower envelope amplifies the incoming signal, which is presumed to be the IF output of a mixer stage. The amplified signal is then applied to the two diodes, and by way of the threshold voltage controlled by the potentiometer at the cathode of the pentode, blanking pulses are generated at the centre tap of the transformer. These blanking pulses are then applied to the first control grid of the pentagrid, which then gates the input signal at the second control grid, thereby suppressing the noise impulses.

The Lamb circuit is ingenious in its overall simplicity, making use of common tubes and a bare minimum of circuitry, which is attested by the numerous subsequent patents and pub-

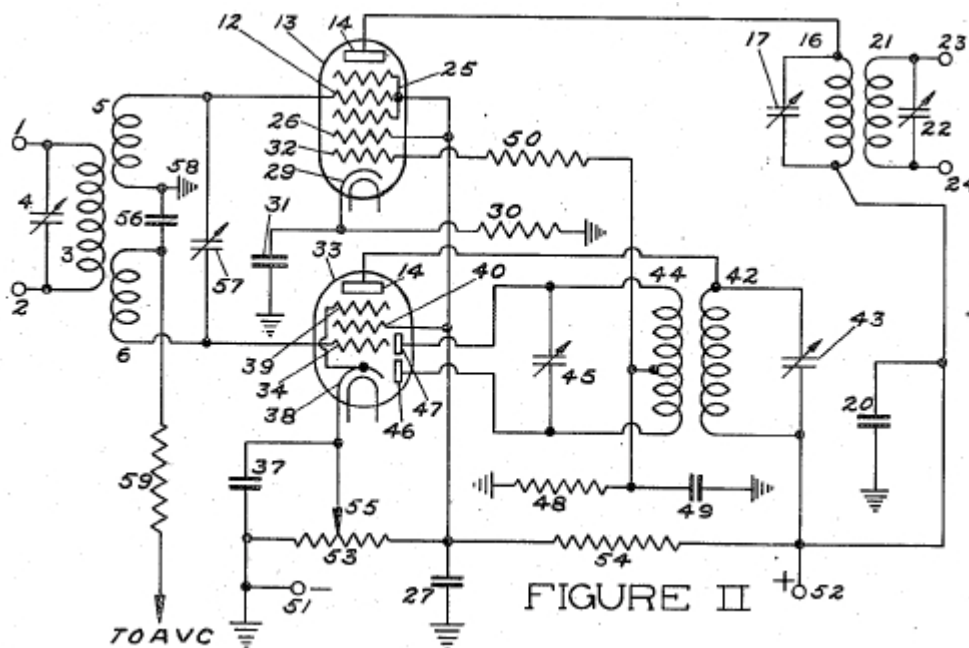


Figure 1 - The Lamb Impulse Noise Blanker (from US Patent 2,101,549)



about 80dB and a bandwidth of 80kHz to 800kHz. The germanium limiting diodes at the outputs of the first two stages prevent the amplifier from saturating, which would result in ringing and additional time delay. The silicon diodes at the output of the last stage condition the noise impulses for triggering the one-shot multivibrator.

The multivibrator was necessary in order to compensate for the ringing and subsequent lengthening of the impulses that resulted from the signal passing through tuned circuitry in the receiver. Chow mentions that it would be more desirable to remove the impulses prior to the receiver, but that the time delay required might not be easily incorporated within the receiver.

In the era in which Chow devised his circuitry, commercially available transistors were still in their infancy and his remarks about the problems of time delay when attempting to remove noise impulses prior to the receiver were undoubtedly a result of the low frequency capabilities and consequential long propagation times of the devices available at the time. The germanium 2N247 PNP transistor that Chow used was the first commercially available germanium drift transistor, developed primarily by Herbert Kroemer at RCA Labs in the mid 1950s and later marketed by Sylvania. When introduced in the late 1950s, this device cost \$US3.00 each. Very few details about this device can be found, however it's immediate replacement, the 2N274 had a transition frequency ( $f_T$ ) of just 30MHz, so you can easily

imagine that the propagation time was lethargic.

This, of course, is no longer the case. Even PNP switching transistors having turn-on and turn-off times of less than 50 nanoseconds (nSec) are readily available for very little expense. The devices that were chosen in this design were selected on the basis of propagation time as well as their cost and availability, resulting in an impulse noise receiver and detector having a time delay of less than 100nSec and a cost of less than \$US25.00, not including the delay line.

### Impulse Noise Blanker Theory

The overall concept for the impulse noise blanker presented herein is derived primarily from the works of Lamb and Chow together with portions of that by Collins and others. A block diagram for the impulse noise blanker is shown in Fig. 3, and consists of a noise limiter, an impulse noise receiver, an impulse noise detector, an impulse noise gate, and a time delay, the details of which will be described in turn.

The noise antenna may be a separate short whip or the communications antenna itself, the latter being very convenient and which helps simplify the issue of time delay equalization.

The noise limiter provides protection from high energy impulses, such as lightning strikes, and also provides for some degree of time

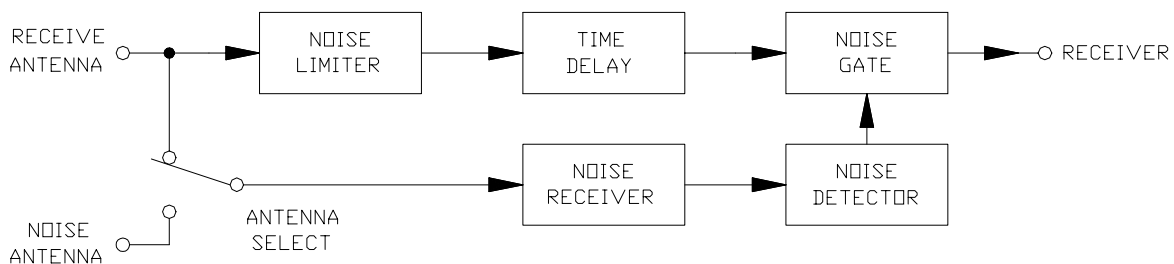


Figure 3 - Impulse Noise Blanker Block Diagram

delay equalization.

The output from the noise receiver is passed to the impulse noise detector, where signals that are above a desired threshold level will generate switching pulses that are then passed to the impulse noise gate.

The noise gate then disables the path between the antenna and the receiver for the duration of the noise impulse. By making use of wideband transformer techniques, the Collins noise gating circuit is made suitable for frequencies throughout the HF spectrum, and therefore the need for modifying the receiver proper, as with earlier designs, is avoided, which was a desirable goal of the design.

The delay line corrects for the difference in the time delay of the signal passing from the antenna to the noise gate and the time delay of the impulse noise receiver and detector.

### Noise Limiter

The noise limiter, shown in Fig. 4, provides protection of the receiver from high energy impulses such as lightning strikes. Borrowed directly from Palladino and Sugarman (7) with modification of the parts values, the limiter consists of two anti-parallel pairs of high speed Schottky switching diodes embedded in a 9-pole Butterworth lowpass filter having a 3dB cutoff frequency of 33MHz. The noise limiter has a time delay of approximately 29 nSec, which is useful in the issue of time delay equalization.

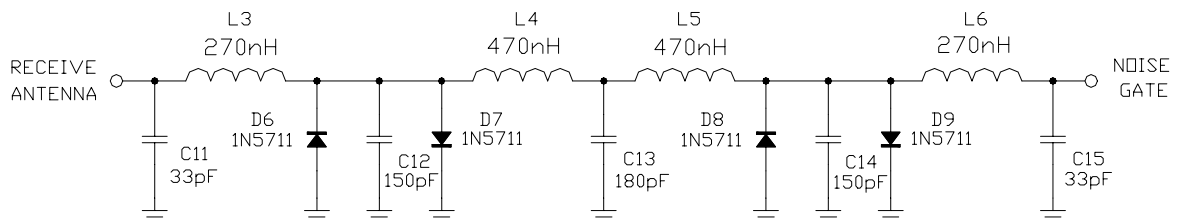


Figure 4 - Noise Limiter Schematic

### Impulse Noise Receiver

As Chow (7) and others (8, 9, 10, 11) have demonstrated, it is important in the overall design that the noise receiver not introduce any excessive time delay, which means that all forms of tuned circuitry need to be avoided. Therefore, the noise receiver used here is a wideband video amplifier, similar to the method used by Chow but whose bandwidth incorporates most of the HF spectrum. This is a matter of convenience as there are no exceptionally strong HF sources in the immediate vicinity, and those in other areas will need to assess the spectrum in their locale and possibly make necessary adjustments to the amplifier's bandwidth.

Shown in Fig. 5, each stage of the amplifier consists of a J309 JFET and an MPS6523 PNP bipolar transistor, providing a very high input impedance, a propagation time of less than 30nSec, and a voltage gain of approximately 25. Inductors L1 and L2 are chosen to give the amplifier a low frequency cutoff that is well above the medium wave broadcast band (MW BCB). The high frequency cutoff is a result of the interaction of the transistor capacitances with the two inductors and the noise detector seen by the collector of Q4.

It is interesting to note that in the prototype of this circuit there was very little in the way of intelligent signals seen at the amplifier output when used with a short whip antenna of 0.5m in length but that the noise impulses that prompted this design had an amplitude in ex-

cess of 2V. Similar results were seen when the noise antenna input was connected to the receiver antenna input and a 1m diameter series-tuned loop antenna was used.

### Impulse Noise Detector

Referring again to Fig. 5, the impulse noise detector consists of a full-wave envelope detector and a simple voltage comparator. The envelope detector consists of transformer T1, diodes D1 and D2, and resistor R9. The output from the noise receiver passes through transformer T1, which provides a balanced pair of signal voltages so that both positive and negative noise impulses are detected by diodes D1 and D2 and then appear across the noise detector load resistor R9. Transformer T1 has a turns ratio of 1:2CT, and may be a Mini-Circuits T4-1 or T4-6T.

Since noise impulses are of very short duration and have very sharp rise and fall characteristics, it is necessary that fast switching diodes, preferably of the Schottky variety, be employed in the envelope detector. The 1N5711 (or 1N5712) was chosen as it has these characteristics, and they are readily avail-

able together with numerous substitutes in both leaded and surface mount (SMT) form.

To provide blanking pulses for the noise gate, a very fast voltage comparator with a controlled threshold voltage is required. Monolithic comparators such as the LM311 have response times in excess of 200nSec, which is simply not suitable for this design when the issue of time delay is taken into consideration.

The voltage comparator used here consists of a differential pair of PNP transistors, Q5 and Q6, and a current mirror, being transistors Q7 and Q8. The transistors used here, the 2N5771 and 2N2769, are very fast, reasonably priced, and widely available. Although it has been pretty much obsolete, the 2N2369 may be used in place of the 2N5769 if desired. With these transistors, the output blanking pulses have exceptionally short rise and fall times and the propagation time delay is less than 15nSec.

The 5.1V Zener diode D3 provides a stable voltage reference for the impulse noise detector. Potentiometer R14 determines the pulse detection threshold voltage. Resistors R13 and R15 are selected such that the range

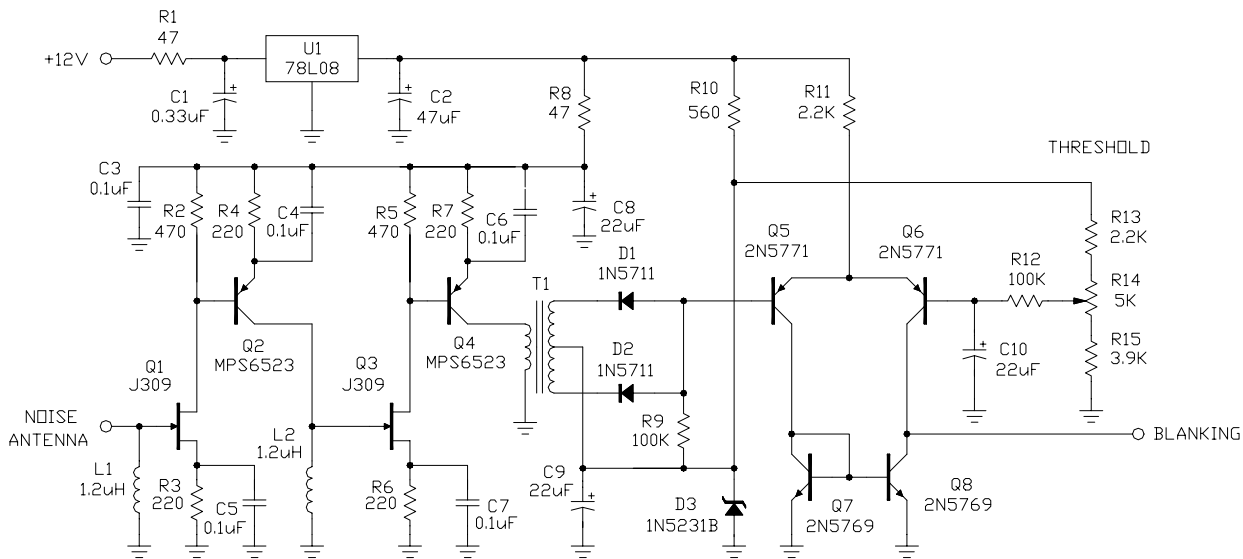


Figure 5 - Impulse Noise Blanker Receiver and Detector Schematic

of the threshold voltage will vary from the point just at the ambient noise floor to the point just above the impulse noise peaks. Since this will vary from one locale to another, users may need to experiment some in order to arrive at values that will provide the desired range of control, though the values shown may well be suitable for most circumstances.

### Impulse Noise Gate

The impulse noise gate circuit is shown in the schematic of Fig. 6. Here, the 1N5711 Schottky switching diodes are driven by the blanking signal from the impulse noise detector circuit of Fig. 5. By virtue of the balanced nature of the circuit, the blanking signal voltage is not conducted to the impulse noise gate output. Transformers T2 and T3 have a turns ratio of 1:2CT, and may be a Mini-Circuits T4-1 or T4-6T.

### What's All This Group Delay Stuff, Anyhow?

In order for impulse blanking systems such as this to be effective, the blanking needs to take place at the exact same time as the impulse itself. As the duration of the noise impulses becomes shorter, the timing of the blanking becomes increasingly important. Any difference in the timing will cause the impulse blanking to become increasingly ineffective, and when the delay of the blanking exceeds the length of the impulse there will be no suppres-

sion of the impulse at all. Even in the case of the Lamb circuit there is some degree of time delay, and many of the approaches that were reviewed for this design overlooked this aspect of the problem.

In circuits such as that of Lamb, where the noise blanker is within the IF of a receiver, the fact that it operates over a very narrow range of frequencies makes the solution trivial, requiring nothing more than a short length of transmission line or an equivalent lumped element delay line. In other circuits such as those of Collins, the use of two separate antennas and two distinctly different signal paths makes the problem far more complex and potentially unresolvable.

In addition, the installation of this circuit is such that a single solution to the delay problem is entirely practical. The propagation delay between the noise receiver input and the impulse noise blanker will generally remain constant, or at worst vary very little over the HF spectrum.

Lumped element group delay networks can be very demanding (12), and their alignment requires a network analyzer that has a group delay function, which is beyond the means of most hobbyists and even some professional laboratories.

A practical alternative is that of a single length of cable between the noise limiter and the noise gate. For RG-58A/U coaxial cable that complies with recognized industry or Mil Spec standards, therefore having a velocity factor of 0.66, a 100-foot (30.5m) section equates to a time delay of 153nSec, and for this design a section of 65 feet, providing a delay of approximately 100nSec, will be sufficient, and lengths varying from 50 feet to 75 feet should give satisfactory performance. There will, of course, be some degree of signal loss, and at 20MHz a 65MHz section of RG-58A/U cable

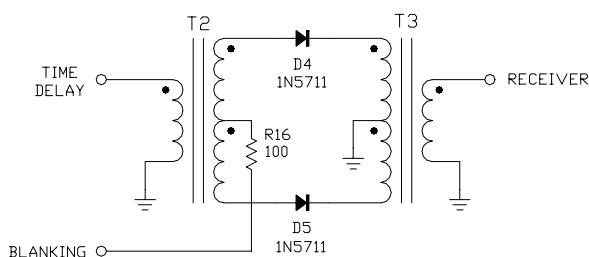


Figure 6 - Impulse Noise Gate Schematic

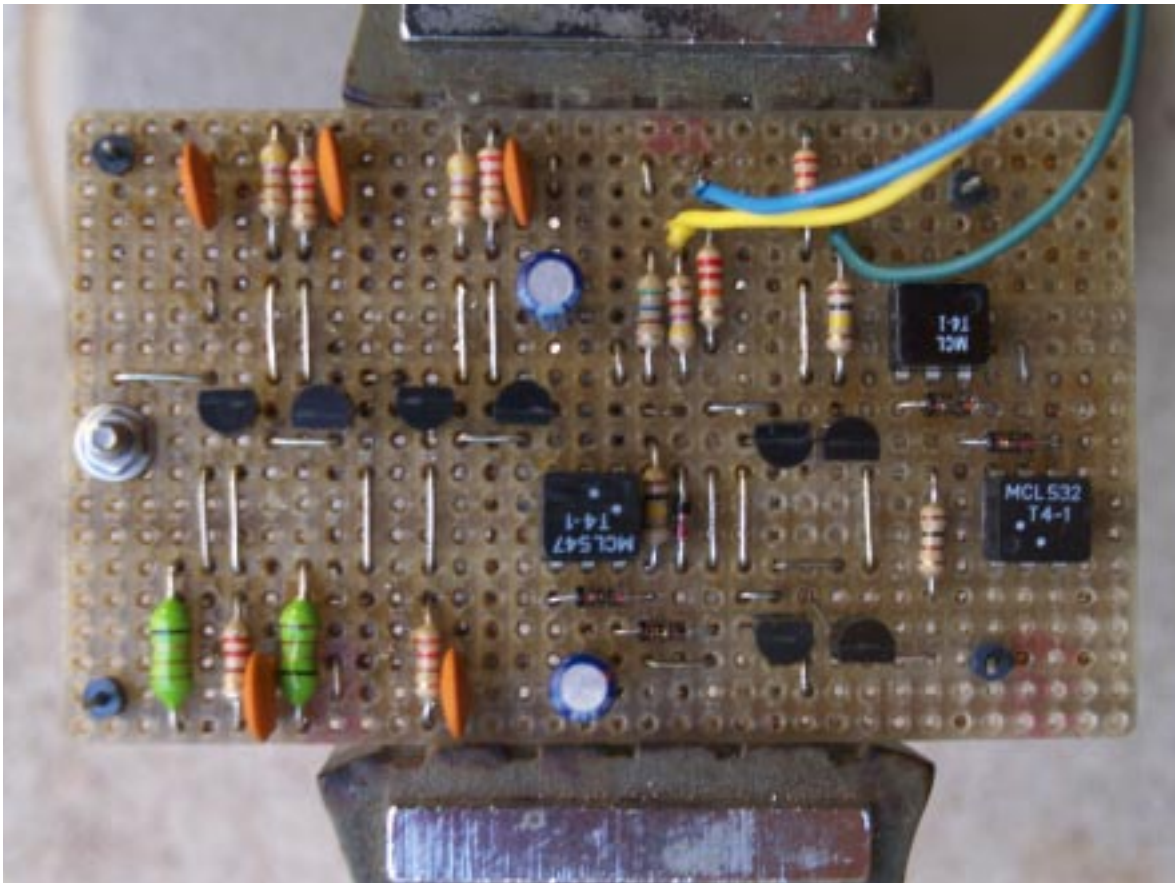


Figure 7 - Impulse Noise Blanker Receiver, Detector, and Gate Prototype

will have a loss of approximately 1.9dB.

Another alternative is that of commercially available distributed delay lines. Quite a few manufacturers of these devices can be found, however when the requirement of 30MHz bandwidth is applied the number of manufacturers diminishes greatly. One manufacturer, Data Delay Devices of Clifton, New Jersey, makes delay lines with exceptional bandwidth performance. The 1515-100A, for instance, has a delay time of 100nSec and a frequency bandwidth of 38MHz, which is ideal for use with this design. Although the cost of these devices is around \$US12.00, they are far less expensive than a 65-foot section of good quality RG-58A/U cable, and they are certainly much more convenient.

### Prototype Construction

A prototype of the noise blanker was constructed and tested, and is shown in Fig. 7 and Fig. 8. In Fig. 7, the threaded stud to the far left is a mount for a short telescoping whip antenna. The transformer close to the centre is T1, and the group of components to the far right is the noise gate circuit.

Testing showed that the circuit performed well with both a short whip antenna and also when connected to a 1m diameter series-tuned loop that is regularly used for the receiver. The noise impulses that prompted this design were as much as 2.5V peak across the noise detector load resistor. Total time delay through the noise receiver and detector was approximately 90nSec. The finite bandwidth of the circuit re-

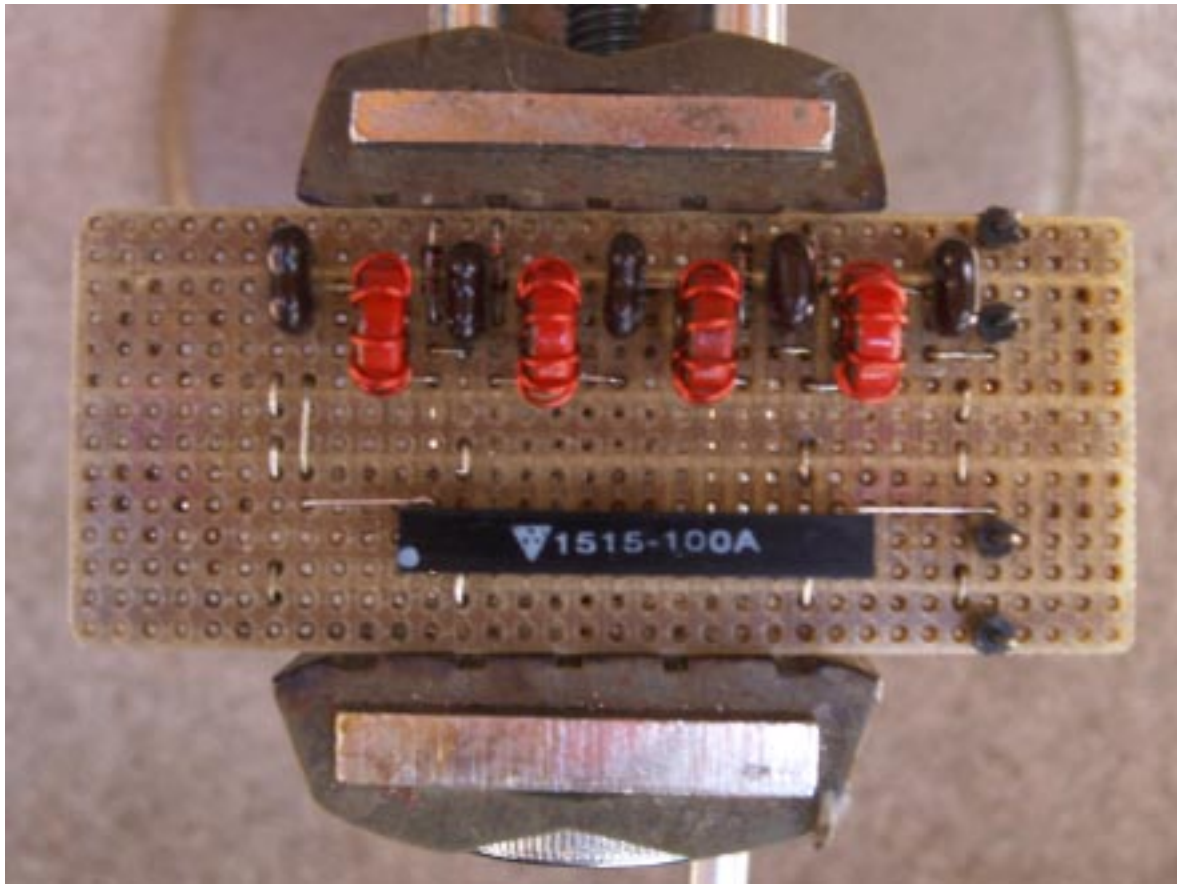


Figure 8 - Impulse Noise Limiter and Delay Line Prototype

sults in a slight lengthening of the pulses of about 1uSec.

The noise limiter was constructed on a separate piece of perf board and is shown in Fig. 8. Inductors L3 and L6 are made with seven turns of AWG #24 enameled wire on a Micrometals T37-2 toroid core. Inductors L4 and L5 are similar, being made with nine turns.

The large object seen in Fig. 8 is the Delay Data Devices 1515-100A delay line. Together with the noise limiter, the total delay time is 145nSec and the 3dB cutoff frequency is 33.7MHz. Insertion loss is approximately

1.0dB, which is considerably better performance than with the RG-58A/U cable delay line. Together with the slight pulse lengthening in the receiver and detector, the extra 55nSec of delay time beyond that of the noise receiver and detector provides ample room for variations over temperature without incurring the need for some manner of adjustment.

### Synopsis

Although work continues on this project to improve the time delay problem and reduce the circuit complexity, it works sufficiently well that it should be reproducible by others.

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