# Diode Switching For Signals and Circuits

**Diodes are increasingly in use to overcome some of the problems that occur with regular switches. This article about switching diodes is written from the point of view of a designer using them in an amateur transceiver. But principles do not change and in other applications switching diodes will operate in the same way. Varactor-tuned TV front ends (described in Jan. '71 *electron*) and many FM receiver designs now use this technique. You should know about it.**

by **M. J. Goldstein,** VE3GFN

For the builder of multiband equipment, the greatest design problem to overcome is how to lay out the various tuned circuits around the bandswitch. The necessity of juggling the requirements of short leads, minimum stray capacity, minimum stray coupling between circuits, neat layout, and one control shaft inevitably results in compromised performance and a migraine headache.

Add to this the problems of changing i.f. filters without degrading their shape factors and routing signals around a transceiver without level attenuation or undesired coupling between circuits, and we end up with a weird mechanical switch coupling, a front end layout that looks like Godzilla's hairdo, and chassis control cables that put the Hoover Dam to shame.

The question is, how can we arrange the tuned circuits where they are needed (not around a switch) and how can we switch signals (or filters) at signal intersections, still controlling these functions from the front panel, but eliminating the abovementioned mess?

The answer (in part) is diode switching.

Diode switches have been popping up in amateur gear for a while now, without much being said about them . . . some 2-meter men use them for changing crystals remotely . . . one receiver design in *QST* magazine used one to change the VFO in a receiver slightly.

### The Diode As a Switch

Let's look at some of the things that can be done with diode switches, and consider some of the "no-no's".

The mechanical switch is a very good short circuit when it is closed, and a pretty fair open circuit (very high impedance) when it is open. On the other hand the solid-state diode has a definite forward-bias resistance (forward resistance) when it is "closed" and has a definite, and sometimes large reverse-bias capacitance (reverse capacitance) when it is "open". This reverse capacitance is certainly not a high impedance at high frequencies.

Besides these endearing qualities, the diode has a non-linear dynamic characteristic (the diode current is not directly proportional to the diode voltage) and this is the prime requirement for a good mixer - or harmonic generator. This must be taken into consideration when putting a diode in series with signal paths.

One last thing to keep in mind is that the drop across a silicon diode is about 0.7 volts when it is forward biased, and will maintain that voltage as it conducts more and more current. Hence it is not possible to connect diodes directly to a supply line, as they will promptly clamp that line to near ground level, and then proceed to conduct enough current to commit suicide.

So what are the basic considerations for making diode switches work?

First, have the diode conduct lots of current (10 mA or more): in the "closed" mode this minimises the forward resistance, operates the diode well away from the very non-linear "knee" of its dynamic curve, and ensures that signal currents passing through the diode will not be a significant factor of the bias current.

Second, ensure that the voltage level during reverse-bias is as high as possible. This will reduce the reverse capacitance to a minimum. When operating at high frequencies, it might be wise to use VHF varactor diodes, which will have a very low reverse capacitance indeed.

Third, the diode switch should be isolated from its d.c. bias supply by a resistance which limits the diode current to the desired value without adversely affecting the supply line.

Last, the diode switch must be r.f. decoupled from the d.c. bias supply line, so that r.f. is not diverted from its chosen path to wander around the power supply. (The current-limit resistor usually performs this function as well.) Figures 1,2, and 3 illustrate these considerations.

### Diode Switching Tuned Circuits

Let's first look at a typical application for diode-switching of tuned circuits. Suppose we have a mixer in a "heterodyne oscillator" type of system, where the variable-oscillator for a multiband single-conversion receiver is derived from mixing a VFO with various crystal oscillators. We have the usual bandswitch for the signal-path r.f. amplifier and mixer, but we can't build the "het. mixer" around the bandswitch for fear of stray coupling of signal and mixing paths. We do have one switch wafer available for switching a d.c. line (maybe it controls d.c. to the different crystal oscillators). Figure 4 shows the basic problem we are faced with, and the circuit which solves the problem.

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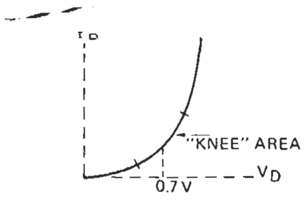


Figure 1 - Diode Characteristic Curve

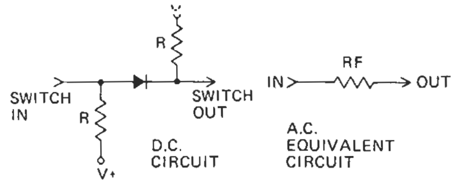


Figure 2 - Forward - Bias Conditions

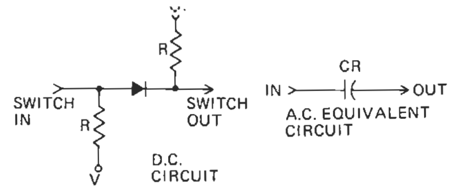


Figure 3 - Reverse - Bias Conditions

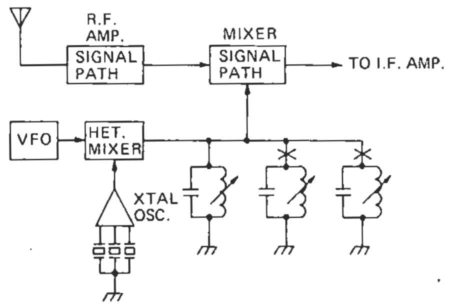


Figure 4A

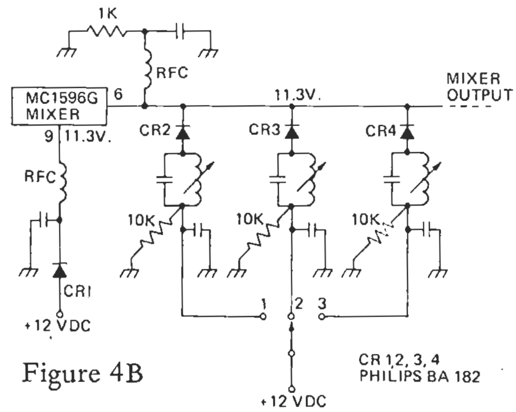


Figure 4B

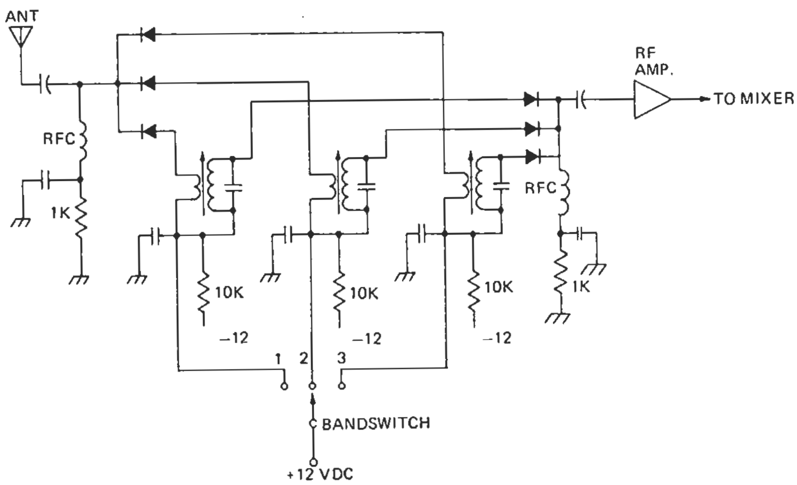


Figure 5 - Method of Diode-Switching Signal-Path Tuned Circuits

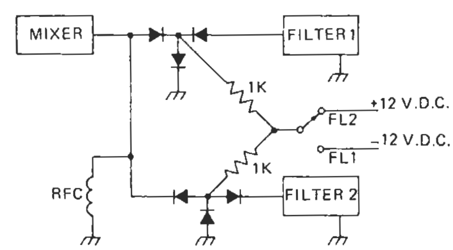


Figure 6A - Switching Mechanical Filters in a Receiver I.F.

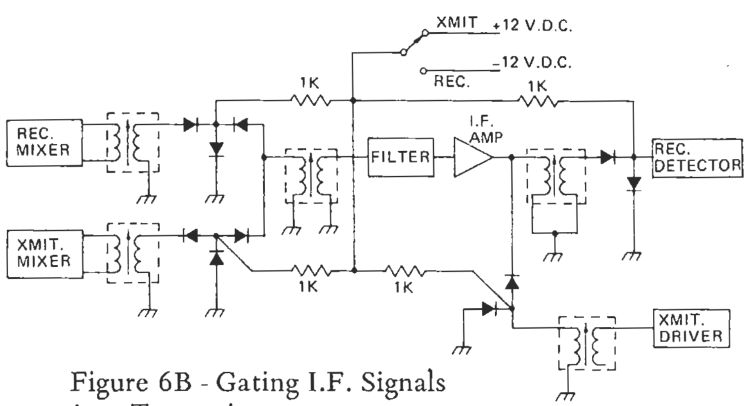


Figure 6B - Gating I.F. Signals in a Transceiver

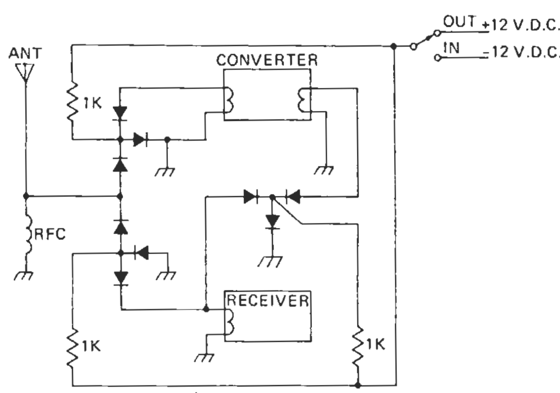


Figure 6C - Gating a Converter In or Out of a Receiver System

**Diodes** *(continued from p. 29)*

Figure 4A shows the het. osc. system; our problem is that the het. mixer must see only one of the three tuned circuits at any one time, the other two must be isolated from the output and from each other. As well, it is desirable to supply the mixer with d.c. current only through the tuned circuit in use at any one time.

Figure 4B illustrates the circuit approach to this problem. The mixer is a MC1596G integrated-circuit, which requires the same d.c. bias level at its two output pins, 9 and 6. The diode CR1 in the supply line to pin 9 makes up for the diode junction voltage imbalance at pin 6.

The network of the 1k resistor and the RF choke forces extra current through the switching diodes, as the mixer itself only draws a small current. When the bandswitch is in position one, CR2 conducts d.c. current to the mixer, as it is forward biased. The cathodes of CR3, CR4 are at 11.3 volts, but their anodes are close to ground level, tied down by the 10K resistors. These diodes are therefore reverse-biased by about 10 volts, isolating the other two tuned circuits from the mixer output, and from each other.

The diodes are Philips BA182 varactor diodes, designed for purposes such as this. The forward resistance is about one ohm (100 mA max.) and the reverse capacity is about 0.8pF. at 35 volts. It was not necessary to tie the 10K resistors back to -12 volts (instead of ground) to decrease the reverse capacity further, in this case.

As the stray capacity increases with increasing the number of circuits and switches, it is best to install all the tuned circuits before each one is tuned up for final resonance. This circuit has been tested to output frequencies up to 40 MHz, with excellent results, using four tuned circuits in the mixer output.

There is another point to watch. As the operating frequency goes above 35MHz, output circuits are liable to interact because the reverse capacitance of the diode provides more coupling between them.

It is quite possible to apply these techniques to the signal-path circuit switching as well; this approach has been put down in the past by them what know, due to problems of cross-talk and stray mixing in the diode switches. With the diodes available today, this may no longer be a problem. While this application hasn't been tried yet by this writer, Figure 5 shows what the ultimate circuit would be.

#### Diode Switching (Gating) of Signals

The same problems, considerations, and solutions previously discussed apply to signal gating with diodes as well, except the application here is not nearly so critical. Ordinary switching diodes can be used, or even "cheapy" germanium signal diodes. A solid-state transceiver has been built, using diode gating for all the i.f. signal and filter switching, with great success. This way of doing the job eliminates the need for running coaxial lines all around the chassis, or mounting small (or not so small) relays at the signal intersections. The only lines are d.c. control lines, and there are no mechanical parts to click and thump (and it's faster). A few sample circuits show how to do it (Figure 6).

There are many applications for diode switching besides those illustrated here, but these ideas should start you on your way. ■