ELECTRONOTES

1 PHEASANT LANE

ITHACA, NY 14850

APPLICATION NOTE NO. 200

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SOME SIMPLE GOOD DESIGN IDEAS

We will close out our 1980 year and out 200th AN with three good design ideas we have come across lately. Each of these offers a simpler solution to design problems than those that are often found.

A SIMPLE FULL-WAVE RECTIFIER:

Over the years, full-wave rectifiers have evolved from a bridge of four diodes with a differential output, to precision FWR's formed with two op-amps (see AN-120). One would therefore be somewhat surprised to find a new rectifier circuit in an academically oriented journal such as Proc. IEEE, and would be astounded if it turns out that it uses only a single transistor and a two resistors. But this is exactly what we find in Vol. 67, No. 4, April 1979 in a communications from S. Pookaiyaudom, C. Watanachaiprateep, and K. Dejkan in "A Single Transistor Full-Wave Rectifier." The circuit is shown in Fig. 1. Your first reaction is probably disbelief, but it does in fact work, and quite well. The circuit is not new, just ignored. As P. Garde pointed out an the Nov. 1979 Proc. IEEE, at least one earlier version of the circuit was given by Robert Moog in his 1965 J. Aud. Eng. Soc. paper that introduced the basic ideas of the voltage-controlled music synthesizer. Moog used it as a sawtooth-to-triangle converter.

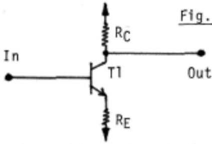

Fig. 1

Nominally, $R_C = R_E$, but our experiments indicate that RC should be a bit larger than R_E (about 8% to 20% depending on transistor type). The circuit of Fig. 1 gives a positive output. By using a PNP transistor instead of an NPN, you get a negative output (of course you reverse the + and - supplies as well). General purpose type transistors such as the 2N3904 NPN and the 2N3906 PNP will work well up to about 5 kHz. The linearity around zero ±100 mV is a bit off, so you should plan on using a large signal into the base for best results. Trimming either RC or R_E for output symmetry will pretty well tune up the circuit. The resistors may be as small as 1k to give an output impedance on the same order. The base should be driven from a reasonably low source impedance.

Why does it work? Well, in Fig. 1, if the input is negative, the circuit is pretty much your ordinary transistor inverter. When the input goes positive, the transistor saturates, and the output follows the input. This circuit should certainly come in handy in many if not the vast majority of applications.

LINEAR CA3080 DRIVE WITH A TRANSISTOR:

The CA3080 is a popular control device (see AN-21 through AN-24). It is controlled by a control current into pin 5. To use as a voltage-control element, some sort of voltage-to-current drive is needed. The simplest of these is to just use a resistor (Fig. 2a) from the control to pin 5. The disadvantage of this is that the control voltage is with reference to about -14.3 volts. Referencing to ground is accomplished with the circuit (due to W. Jung) of Fig. 2b. With this circuit, the CA3080 must drive into ground or some positive voltage. Another control circuit (Fig. 2c) due to

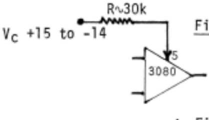

Fig. 2a

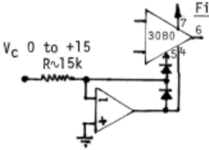

Fig. 2b

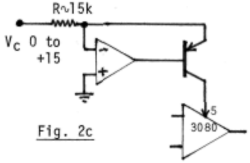

Fig. 2c

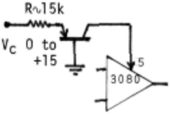

Fig. 2d

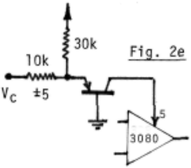

Fig. 2e

J. Moskovitz achieves a linear current drive using an op-amp and transistor, and avoids the restrictions on the output drive of the CA3080. Here we want to call your attention to the circuit of Fig. 2d, which is about as simple as you can get. We have seen this before in the CA3080 application notes from RCA, where it is used as a control driver where V_C takes on 0 and some positive digital level (thus as an analog switch control). A reader suggests that this can be used linerally as well. In fact, it can, although the precision around zero control is not as good as that of Fig. 2b and Fig. 2c. It is quite satisfactory for control voltages positive and somewhat larger than 500 mV. Fig. 2e shows a variation on this for bipolar controls, the circuit offering 100% amplitude modulation.

SIMPLIFIED EMERGENCY EXOR GATES:

It is not unusual to need an Exclusive-OR gate and at the same time not need four of them as you get in the standard IC packages. Although the excess gates can often be used for inverters, there will be occasions that it would be more convenient to just have one. In other cases, you won't have the EXOR package at all, or the input requirements are not those of standard TTL or CMOS. One more or less standard way of making one Exclusive-OR gate out of a more readily available IC package is to use the configuration of Fig. 3a, or one of several variations as given in AN-144. An Exclusive-OR gate formed from two op-amps was given in AN-93, based on the identity:

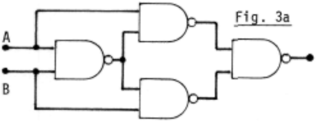

Fig. 3a

$$A \text{ EXOR } B = A + B - 2(A \text{ AND } B)$$

A somewhat simpler circuit can be achieved by using instead the identity:

$$A \text{ EXOR } B = |A - B|$$

from which we see that all we need do is to take the difference and then the absolute value of that difference.

A realization of this second identity is shown in Fig. 3b, where we use for the absolute value circuit the single transistor version given above. Note that if the former type of absolute value circuit were used, we would have three op-amps total, and things would be a bit impractical. Thus the one transistor absolute value circuit makes this method an excellent choice. As set up, the circuit works exactly like a CMOS circuit as far as voltage levels go. If the op-amp is a low bias cirrent type such as a BIFET, you can increase the 470k reisitors to even higher values. It is probably not necessary to trim the 10k resistors, since only digital levels need be achieved. You might suppose that since saturation does not matter, that you could get rid of all four of the 470k resistors, and work open loop. You can't however, because infinite gain would cause a very small difference between both ones or both zeros to pin the op-amp output, not giving the zero difference needed.

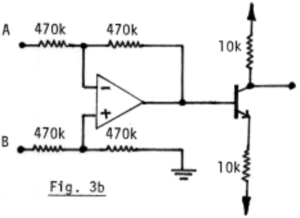

Fig. 3b