Basic Electronics

An unusual audio amplifier

Build it & learn about pulse width modulation

The 555 timer integrated circuit has been with us since 1973 and, by now, most people familiar with it probably think that the applications for it have been exhausted. But did you know the 555 can be used as an audio amplifier? Well it can! It may not be really practical but it can be done.

by LEO SIMPSON

The main application for the 555 integrated circuit is in timing and oscillator circuits. It is not a linear device and cannot be used to amplify audio signals in the usual way. But it can be used to provide the basis for a simple "pulse width modulation" amplifier. As such, it is not a practical amplifier — it is not likely that you would use it in preference to a more conventional amplifier. But it can be demonstrated.

The idea for this article came to the author on an otherwise uneventful day when he was staring into the middle-distance during postprandial depression. This latter remark means that I had had quite a lot to eat and I wasn't sure whether it was for the best.

But in spite of its inauspicious origins (it must have been the garlic prawns), the idea has a certain compelling quality about it. After all, the 555 has apparently been used in just about every thinkable application (and probably a few that are unthinkable) except as an audio amplifier. Now that is a challenge that no self-respecting designer could possibly overlook.

Here I must confess that the idea is not completely original. After all, the original literature from Signetics Corporation did provide some information about pulse-width modulation and pulse-position modulation. But Signetics did not (to my knowledge) suggest the 555 as an audio amplifier.

Whether or not you really believe the above scenario is immaterial. Really, on the afternoon that I write this, I am suffering from "Friday afternoon" syndrome and serious communication is difficult if not impossible. Here it would probably end, were it not for the fact that our draughtsman, Bob Flynn, has already prepared the diagrams.

Well, to be serious, if that is possible, the 555 functions in many circuits as an astable multivibrator. That is to say, it can be a source of square waves with a fixed duty cycle. But it is also possible to vary the length of each output pulse and that is the mechanism by which we achieve this very simple pulse-width modulated amplifier.

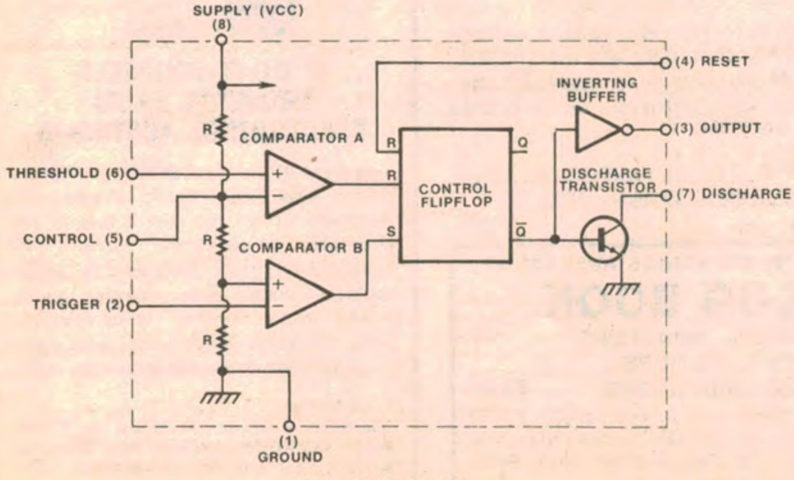

FIG. 1 : INSIDE THE 555

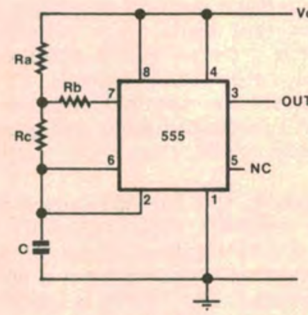

FIG. 2 : THE 555 AS AN ASTABLE

Let us first briefly discuss how the 555 is used to generate square waves and then we can see how modulation is achieved.

A detailed description of the 555 was featured in our August 1979 issue under the title, "A square wave oscillator".

Refer to Fig. 1 which shows the basic circuit elements inside the 555. Ignore the flipflop, buffer and discharge transistor for the moment. The important parts are the two comparators which are both referenced by a string of three resistors which are all of the same value, 5k. Thus, comparator A is referenced to 2/3 Vcc while comparator B is referenced to 1/3 Vcc. Vcc is the supply rail.

ASTABLE MULTIVIBRATOR

Now refer to Fig. 2 which shows how the 555 is connected in a typical astable multivibrator circuit. Pins six and two of the 555 are connected together, which means that the non-inverting input of comparator A connects to the inverting input of comparator B. In this way, the comparators monitor the voltage across capacitor C which is charged from Vcc via resistors Ra and Rc.

When power is first applied to the circuit, there is no voltage across the capacitor and thus the inputs of both comparators are held low. This means that the output at pin three is high and the discharge transistor at pin seven is held off. The capacitor now charges up towards 2/3 Vcc. When it reaches this point, the output of comparator A toggles the flipflop and the output at pin three goes low. At the same time the discharge transistor at pin seven turns on.

Capacitor C now discharges towards 1/3 Vcc via resistors Rb and Rc. When the capacitor voltage drops to 1/3 Vcc, the output of comparator B toggles the flipflop again so that the output at pin three goes high and the discharge transistor at pin seven turns off. Capacitor C then begins to charge up again.

normal by external means, the repetition rate of the output square wave will be increased. But if the voltage at pin five is continuously changed by an audio signal the net effect will be to change the mark/space ratio of the output waveform.This is shown in Fig.4.

Reference to the complete circuit of Fig. 3 shows just how this modulation is performed. An NPN transistor Q1 is connected as a common-emitter amplifier with its collector connected to pin five of the 555. Q1 provides a higher input impedance than is available at pin five and also gives a modest order of gain, about 3.5 times.

Feeding an audio signal into the base of Q1 produces an amplified version of follows the input sinewave.

In effect, the loudspeaker functions as a mechanical low-pass filter, removing the high frequency "carrier" and reproducing only the modulating signal.

This amplifier really does work and gives quite good results although the effective power output is low, of the order of a few milliwatts at maximum. Any signal source such as a cassette deck or tuner, will drive it to full output. Why not give it a try?

FOOTNOTE

Some readers may not be fully satisfied with the explanation of this amplifier. While it does demonstrate

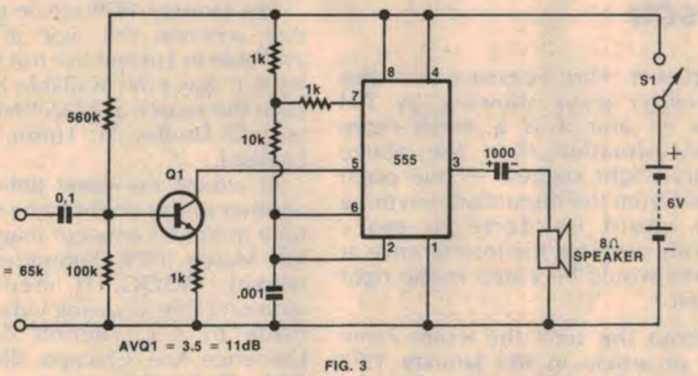

FIG. 3

This unconventional circuit will function as an audio amplifier when fed with a signal of up to several hundred millivolts RMS. Why not try it just for fun?

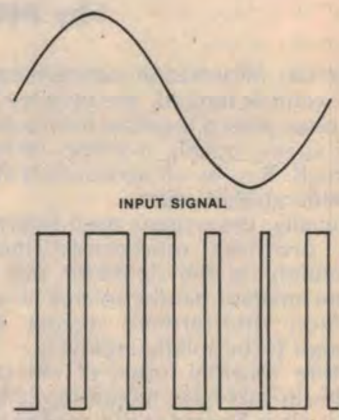

FIG. 4 : PULSE-WIDTH MODULATION

The loudspeaker functions as a mechanical low-pass filter and so responds to the average value of the output waveform.

This cycle continues indefinitely, or until you turn the power off! The result is a pulse waveform at pin three and a sawtooth waveform across capacitor C. By suitable selection of resistors Ra, Rb and Rc we can arrange for the output at pin 3 to be an almost exact square wave.

MARK/SPACE RATIO

There is another method whereby we can change the mark/space ratio of the output waveform. This uses pin five which is labelled "control" or "FM" in some manufacturers' data. Pin five is connected to the string of 5k resistors which set the thresholds for comparators A and B. It is possible to change these comparator thresholds merely by connecting external resistors from Vcc or Ground to pin five, or by feeding an external voltage into this point.

Normally, pin five is set at 2/3 Vcc by the internal voltage divider of 5k resistors, referred to earlier. If pin five is held higher than 2/3 Vcc by external means, capacitor C will take longer to reach the new threshold for comparator A and longer for the capacitor to discharge to the threshold for comparator B. The net effect of this is to lower the repetition rate of the output square wave.

Similarly, if pin five is held lower than the signal at pin five. Pin five then continuously changes the thresholds of the two internal comparators in the 555 to produce an output square wave with a continuously changing mark/space ratio. This waveform is coupled to a loudspeaker via a 1000uF capacitor.

With no signal applied to Q1, the output square wave is roughly 66kHz. Naturally, the loudspeaker does not respond directly to this high frequency. Instead the loudspeaker responds to the average DC value of the modulated square wave. Referring again to Fig. 4 it can be seen that the average DC value of the output square wave roughly

the principle of pulse-width modulation, it is, strictly-speaking not a pulse-width modulation amplifier. More correctly speaking, the circuit produces "pulse-position modulation" or, more simply, frequency modulation. Literature supplied by Signetics Corporation gives a more complicated circuit employing the 555 which does result in pulse-width modulation. We preferred the circuit presented here as it is simple and self-contained.