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Simple fuzz box for electric guitars

Feel like some fuzz on your guitar? What is fuzz anyhow? Does it have anything to do with policemen? These and other hairy questions are answered in this article which shows you how to make a fuzz box for your electric guitar.

by PHILIP WATSON

We first described a fuzz box back in August 1967 (File No. 1/GA/10) and it proved extremely popular. So much so, that we were recently inspired to take a fresh look at the original design, with the aim of simplifying construction. As a result it now uses a PC board and employs CMOS switching to circumvent a shortage of suitable mechanical switches as used in the original.

For those who may be a little hazy as to just what a fuzz box is, or how it works, let us recapitulate from the original article.

A fuzz box is a piece of circuitry introduced into the guitar amplifier chain to deliberately distort the waveform. It produces a sound which is "buzzy" by nature, not unlike that from a heavily overloaded amplifier or from a loudspeaker whose voice coil is fouling in the magnet gap. In fact, the similarity of fuzz to overload is no accident, because a fuzz box deliberately simulates or introduces an overload condition.

By nature, the waveform from an electric guitar ranges from the reasonably sinoidal to one carrying mainly consonant harmonics – depending on playing technique and the position of the pickup coils in use. A fuzz box squares up, or otherwise distorts the waveform envelope, adding multiple harmonics as it does so, and also adding further dissonant frequencies by intermodulation of those actually being fed in from the pickup coil. The naturally "round" tone of a guitar therefore takes on a strident quality.

Just how a fuzz box treats the wave envelope passing through it depends largely on the circuitry involved. Straight clipping circuits, for example, square off the tops of the waveform, so that predominantly sinoidal waves begin to look quite square on a CRO. As might be expected, the sharper the corners, the wider the spectrum of the harmonics so generated.

In actual fact, most guitarists tend to regard squared waves as too conservative in terms of fuzz, particularly when generated from substantially pure waveforms; a squared sine wave has a rather pleasant "woodwind" quality and is anything but strident. Again, while a broad spectrum of harmonics may be generated in the first instance by simple clipping, those above about 4kHz don't count for much in the average guitar situation.

The kind of guitar fuzz which is likely to have greater impact is that in which there is a concentration of spurious harmonics within the normal musical range of a guitar system – that is, up to about 3kHz. Aurally, the requirement seems to be met best by circuitry which tends not just to clip waveforms, but to generate waves with generous overshoot at either or both ends of the plateau.

In short, fuzz is a gimmick intended primarily to add stridency to single tones or, at most, simple chords. It should not be used with complex chords and needs to be switched out before such chords are attempted.

The method we have used to produce fuzz is to pass the guitar signal through a small transistor amplifier whose operating conditions can be modified to operate in overload mode from direct guitar signals.

The characteristics of our fuzz box may be summed up as follows:

(1) Completely self-contained, connecting between an individual guitar and its normal input jack to the main amplifier. It should operate with almost any typical guitar system.

(2) Output on "normal" and "fuzz" is at substantially the same level and, in both modes, the unit contributes a small amount of gain.

(3) In addition to the normal fuzz footswitch, a control allows the degree of fuzz to be varied as required.

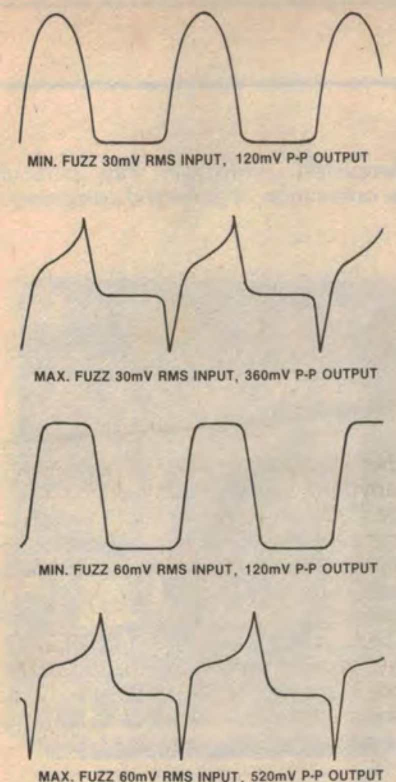
As can be seen from the circuit diagram, the device consists of, basically, two DC coupled transistors operating as

Why make it beautiful if you're only going to tread on it?

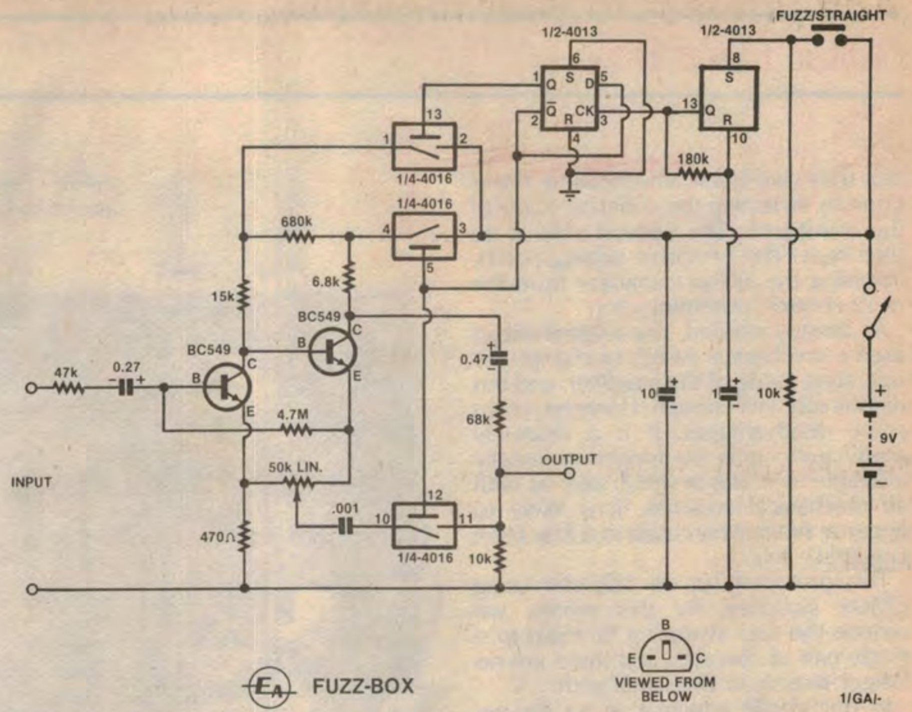
We estimate that the current cost of parts for this project is approximately

$19

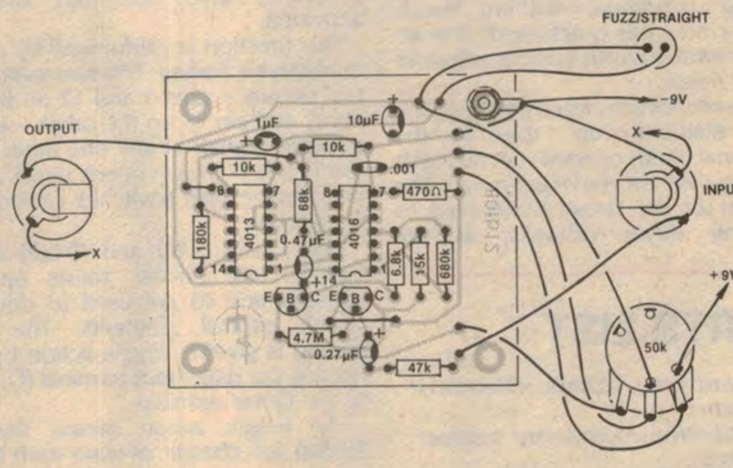
including sales tax.



Shown above are typical waveforms from the unit. As can be seen, the "fuzz" at minimum is amplitude dependent but at higher levels of distortion the waveform is determined mainly by the "fuzz-control" setting.



The circuit consists of two DC coupled transistors operating as an amplifier in the guitar line. It is designed to deliberately introduce distortion.



This wiring diagram shows the PC board as viewed from the component side. Observe the usual precautions when soldering in the CMOS ICs (see text).

an amplifier in the guitar line. By means of three CMOS switches (4016) the operating conditions can be changed from a simple distortion-free mode, to a high distortion mode, but with the degree of distortion variable over a useful range.

To understand how this is done, imagine that two of the switches – pins 3,4,5 and 10,11,12 – are closed and the third one – 1,2,13 – is open. Under these conditions the load for the first transistor is made up from the 15kΩ and 680kΩ resistors. This, with the forward bias applied, is sufficient to bring the stage near to current saturation. Because the second transistor base is DC coupled to the first collector, the second transistor will simultaneously be held to near cut-off.

When a sinoidal signal is applied to the first transistor base, the base will be driven alternately positive and negative. On the positive swing of the input signal the transistor will be driven into complete saturation, limiting the collector's voltage swing and resulting in a clipped signal peak at the collector.

On the other hand, the quiescent voltage across the load is sufficient to allow a full and unclipped collector voltage swing on the other half-cycle of the signal. The resulting waveform at the first collector is therefore a sinusoid with a clipped negative peak.

Now for the other transistor. The unaffected signal peak at the first collector will drive the second transistor into a complete cut-off, thereby delivering a signal at the output which has both peaks clipped.

The actual gain through the fuzz unit is largely a function of the output divider, the 10kΩ and 68kΩ resistors being chosen to give a small amount of gain in both modes, actually about 1.5 times.

However, as we have already pointed out, waves which are merely squared produce rather modest fuzz, and further elaboration of the distortion circuitry is called for, at least for the more extreme effects.

Looking again at the circuit, a distorted signal appears also at the emitter of the second transistor and, by adding the higher frequency components from this distorted and out-of-phase waveform to the output from the collector circuit, the end result is a large spike above the trailing edge of the initial squared, output waveform.

By using a potentiometer as the emitter load for the second transistor, it is possible to vary the basic fuzz shape to one with the superimposed spike, as already mentioned.

This explanation assumes that the output from the guitar will be sufficient to overdrive the transistors, but this will normally be the case **provided the guitar is operated with its own volume control fairly well advanced.**

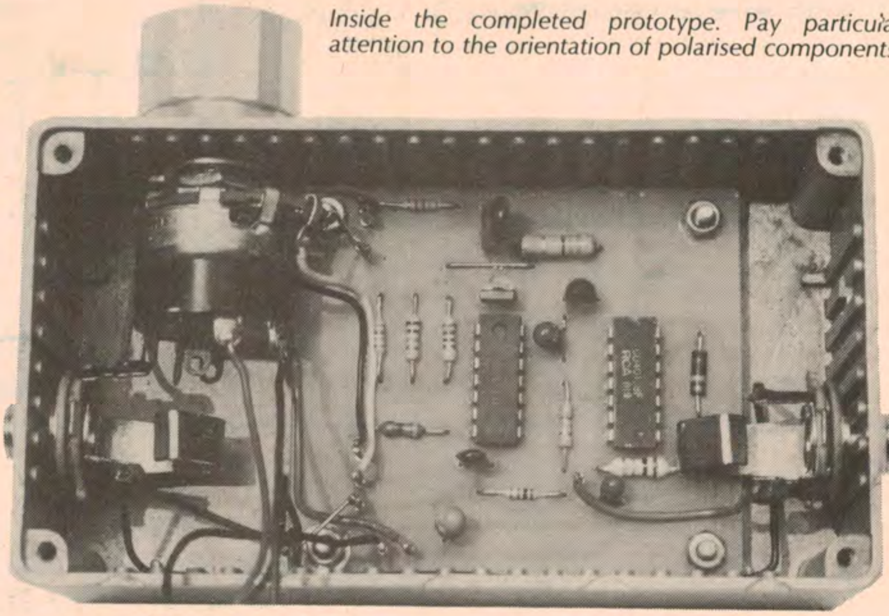
When the CMOS switch positions are reversed, ie, the 1,2,13 section is closed, and 3,4,5 and 10,11,12 are open, two things happen. Firstly, the operating condition of the transistors is changed so that they give linear amplification; this is done by switching the collector loads of the transistors. The second step is to disconnect the harmonic adding circuit, involving the .001μF capacitor from the "fuzz control" potentiometer.

As already implied, the original circuit used a mechanical switch to change the operating mode of the amplifier, and this did the job well enough. However, it has some disadvantages. It is a relatively costly item, it is no longer as readily available as it was in 1967, and, as with all mechanical switches, it is likely to become noisy when used in a low level circuit like this.

This prompted us to consider using CMOS switches. By this means we reduce the fuzz switching function to a single pair of contacts, and these are no longer directly in the signal path.

In our circuit explanation so far we have simply assumed that the three 4016 bilateral switches have been open or closed, as required for a particular operating condition, without much regard for how this is achieved. The actual operation is worth looking at in a little more detail.

These switches are closed by taking the control element "up" towards the positive rail, and opened by taking it "down" to deck, or the negative rail. The remainder of the circuit is devoted to generating these voltages, as appropriate, when the foot switch is activated.



Inside the completed prototype. Pay particular attention to the orientation of polarised components.

This function is performed by a 4013 dual-D type flipflop. The two switch control circuits – pins 5 and 12 on the one hand, and pin 13 on the other – require opposite signals at any one time. When pin 13 is low (switch open), pins 5 and 12 need to be high (switches closed), and vice versa.

Pins 1 and 2 (Q and Q-bar) of the flipflop will deliver these opposite voltages and so are used to drive the switch control elements. The same flipflop is given a toggle action by connecting the data input terminal (D, pin 5) to the Q-bar terminal.

The toggle action means that the flipflop will change its state each time a positive pulse is fed to the clock terminal (pin 3) and, in theory, such a positive pulse could come directly from the positive rail via the footswitch (with suitable current limiting).

In practice, bounce in the mechanical contacts would inevitably result in more than one pulse being generated, giving an unreliable end result. For this reason the second flipflop is used as a debounce circuit, the 180kΩ resistor and the 1μF capacitor providing the necessary time constant.

Thus, although the footswitch is only a simple momentary-make switch, it is made to function, as far as the user is concerned, in the same manner as the original mechanical switch, ie, in a "push on-push off" mode. Each time the switch

PARTS LIST

- *1 Diecast box, 122mm x 66mm x 40mm*
- *1 Pressbutton momentary contact switch*
- *2 6.5 panel sockets*
- *1 9V battery (Type 216 or similar)*
- *1 Connector to suit battery*
- *1 Aluminium knob, 25mm dia*
- *1 50kΩ linear potentiometer with switch*
- *2 BC549 NPN transistors*
- *1 4013 dual-D type flipflop*
- *1 4016 quad bilateral switch*
- *1 PC board, code 80fb12*

CAPACITORS

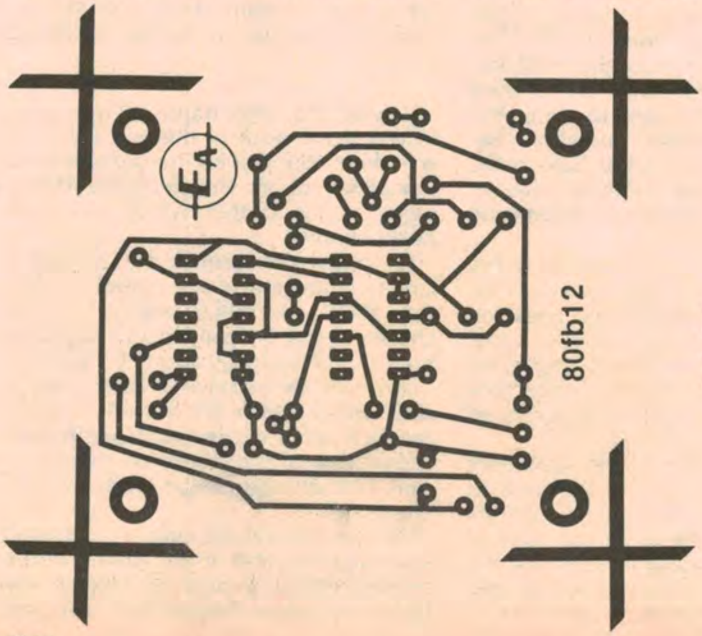
1 x 10μF tantalum, 1 x 1μF tantalum, 1 x 0.47μF tantalum, 1 x 0.27μF tantalum, 1 x .001μF greencap.

RESISTORS (¼ or ½W, 5% tolerance)

1 x 4.7MΩ, 1 x 680kΩ, 1 x 180kΩ, 1 x 68kΩ, 1 x 47kΩ, 1 x 15kΩ, 2 x 10kΩ, 1 x 6.8kΩ, 1 x 470Ω

MISCELLANEOUS

4 mounting screws, nuts, and spacers. Hookup wire, solder, etc.



At left is an actual size reproduction of the artwork for the PC board.

is pressed, even briefly, the operating conditions are changed.

CONSTRUCTION

So much for how it works. Construction is simplified by the use of a printed circuit board (80fb12). This should be readily available from the same source as the other components.

Points to watch during assembly of the board include the polarity of electrolytic capacitors, correct interpretation of transistor lead connections, and correct orientation of the ICs. In regard to the latter, some makers provide a groove at one end, as shown on the component diagram, and some identify pin No. 1 by means of a small dot moulded on the top of the package.

Another point about these ICs concerns soldering precautions. Being CMOS devices, they are more sensitive to stray voltages than some other types. A good precaution is to connect the barrel of the soldering iron to the negative rail of the board, and to solder the two supply pins – pins 7 and 14 in this case – before other pins are soldered.

The complete circuit is housed in a small diecast box measuring 122mm (L) x 66mm (W) x 40mm (D). Input and output sockets are mounted at opposite ends of the box, the footswitch on the lid, and the fuzz control/on-off switch on the side. The board is mounted in the bottom of the box, using four screws with suitable nuts and spacers to lift the board clear of the metal surface.

And that's about all there is to it. It is a relatively simple circuit, with little to go wrong. If built with reasonable care and with due regard to the simple precautions we have mentioned, it should go first time.