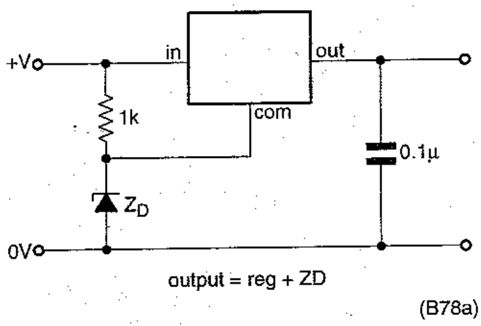
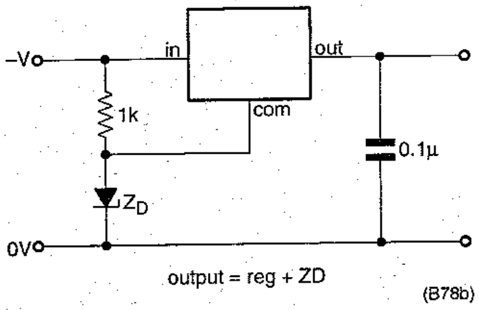
High-power, low-cost supplies

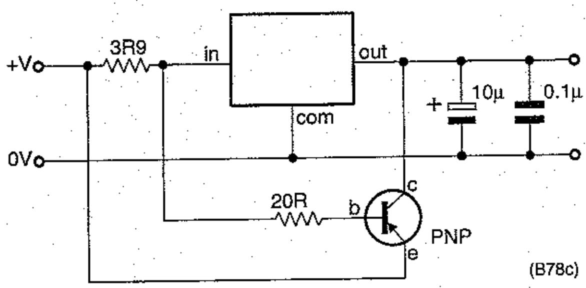
Regulated power supplies to provide positive and negative rails at 3A or more can be expensive. Using *78xx Series* positive and *79xx Series* negative 1A voltage regulators allows the design of supplies to give 5V, 12V and 15V output, but it is often necessary to obtain odd voltages. There are variable regulators such as the *LM317T*, but they cost about three times as much as fixed ones, are single-rail output types and only provide up to 37V at 1.5A. Circuit arrangements shown here illustrate just how versatile the *78/9* devices can be.

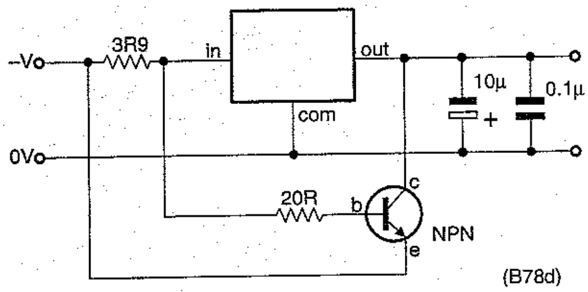
Increased voltage. These regulators have in, out and common pins and, to obtain more output it is only necessary to connect a zener between common and circuit





Figs 1 and 2. Increasing regulator output voltage by the addition of zener to give an output of V_z+V_{reg}.





Figs 3 and 4. For more current, use a bypass transistor of the current rating required.

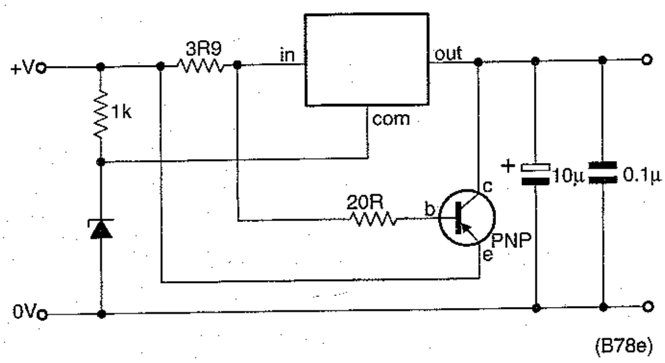


Fig. 5. Both circuits may be used together to give both voltage and current increase.

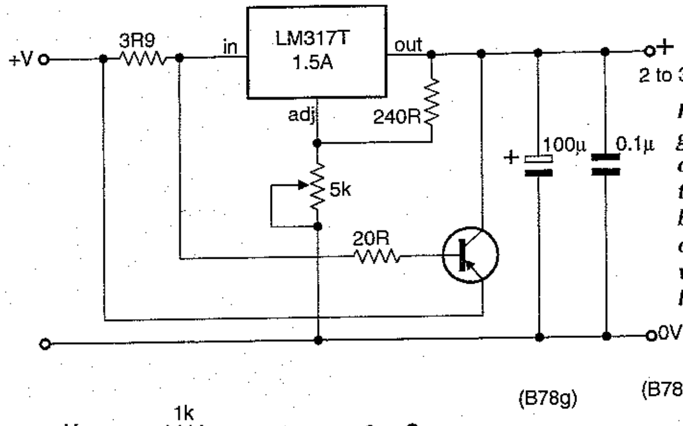


Fig. 6. The LM317T gives an adjustable output, but only up to 1.5A. Use the bypass transistor to obtain adjustable voltage output at a higher current.

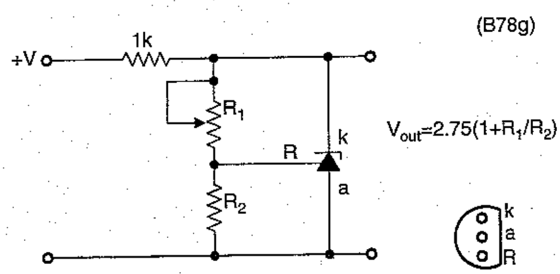


Fig. 7. Alternatively, an adjustable zener used in place of the fixed one in Figs 1, 2 and 5, will give the same performance as the circuit in Fig. 6.

0V, as in **Fig. 1**, to get the regulator output plus the voltage of the zener. A 20V zener and a *7805* would therefore give 25V. For a negative output, simply reverse the zener, as in **Fig. 2**.

More current. A bypass transistor and two resistors, arranged as is shown in **Fig. 3** with a 78xx regulator for a positive supply, will give more current up to a maximum set by the current rating of the transistor. For example, a *BD540C* would provide 5A and a *BD54C* 8A. The 3.9Ω resistor limits regulator current to the 1A maximum. **Figure 4** shows a *79xx* regulator and an n-p-n transistor to give a negative output. Both the increased current circuit and the voltage augmenters may be used together, as in **Fig. 5**, to provide both increased voltage and current, thereby allowing the design of single or dual rail supplies with almost any voltage and current output needed.

High-current, variable voltage. A popular variable-output regulator, the *LM317T*, gives a 1.2-37V output and may be used with the bypass transistor arrangement to give more than the 1.5A provided by the regulator itself, **Fig. 6**. An alternative to an adjustable regulator is seen in **Fig. 7**, where an adjustable zener performs the same function in the circuit of Fig. 1.

Use heat sinks on all power transistors.

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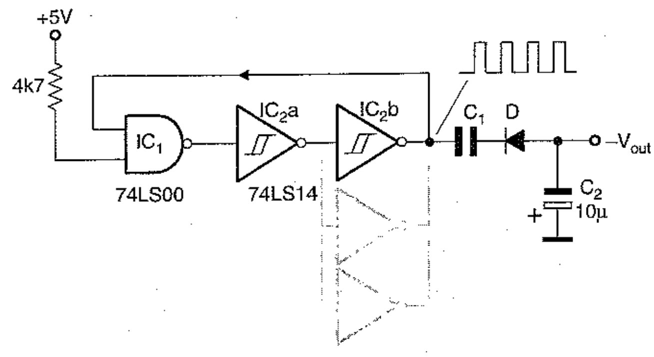
Negative voltage converter



Although simple in the extreme, this circuit converts a positive voltage supply to a negative one without using an oscillator, regulator or translator.

It relies on propagation delay between stages to produce a ringing oscillator whose output is a ttl-level pulse in the region of a few tens of megahertz. This output is isolated by C_1 and rectified by D to obtain the negative voltage, C_2 filtering the rectified voltage to provide the output.

To obtain more power, the other sections of the *74LS14* can be paralleled.

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Electronic dc circuit breaker

This arrangement replaces an ordinary fuse in a dc circuit and has the advantage of a reset switch.

Transistor Tr_1 is a series-pass device, forming a darlington pair with Tr_2, the pair being biased by the zener diode. If current through R_x becomes excessive and the voltage drop is more than 0.6V, Tr_3 turns on and triggers the thyristor $Tr_{4,5}$, cutting off the series pair. Switch S_1 restores the *status quo*.

Series resistor R_x should be selected to drop 0.6V at the required current.

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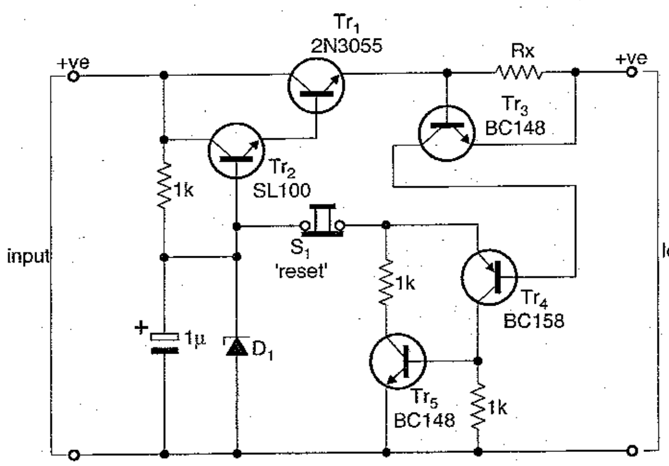

Replacement for a wire-type fuse has a reset facility.

Fx(mA)	Rx	Watt
100	6	0.25
500	1.2	0.5
1000	0.6	1.0
5000	0.12	3.0

(B56)

Multiplying frequency synthesiser

If the loop between the voltage-controlled oscillator and the phase comparator in a phase-locked loop contains a divider, the circuit becomes a multiplier.

In this case, the divider is a *74HC161* programmable counter, programming being applied to pins 3, 4, 5 and 6, which are weighted as 1, 2, 4 and 8 respectively. If n is the sum of the weights of the pins tied high in the diagram, the division ratio is $16-n$, in this case 5. Output from the circuit is then five times the fundamental frequency.

Since the phase comparator is a mixer, the output of which therefore contains sum and difference frequencies, it is necessary to filter out the sum component which may otherwise cause a reduced capture range.

As mentioned by Wheeler (*EW*, November 1996, p.892), using two cascaded dividers gives a division ratio of $256-n-16$, giving frequency multiplication by all integers to 241.

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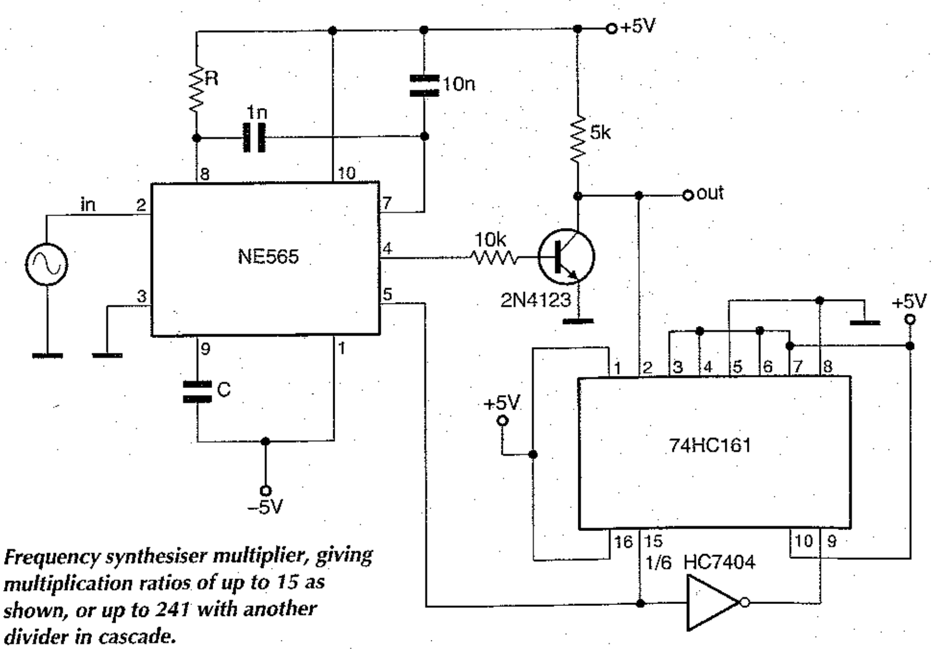

Frequency synthesiser multiplier, giving multiplication ratios of up to 15 as shown, or up to 241 with another divider in cascade.

"Bullet-proof" rf mixer

This mixer was designed for use in an image-cancelling superheterodyne with a low if and may be used in a direct-conversion receiver.

An input transformer takes the rf input, matching the source impedance of the signal to the mixer and providing two signals in antiphase to the *74HC4053* multiplexer/demultiplexer. Resistors $R_{1,2}$ terminate the mixer and provide a current drive, no diplexer being needed in this type of circuit.

This current is amplified in the current-to-voltage converter IC_2, overall mixer gain being set by R_5. Low-pass filter $R_{1,2}C_1$ limits unwanted mixer products to IC_2 and R_3 isolates C_1 from the op-amp input at high frequencies.

Using this mixer a receiver will provide a dynamic range of 132dB and a noise figure of 12dB.

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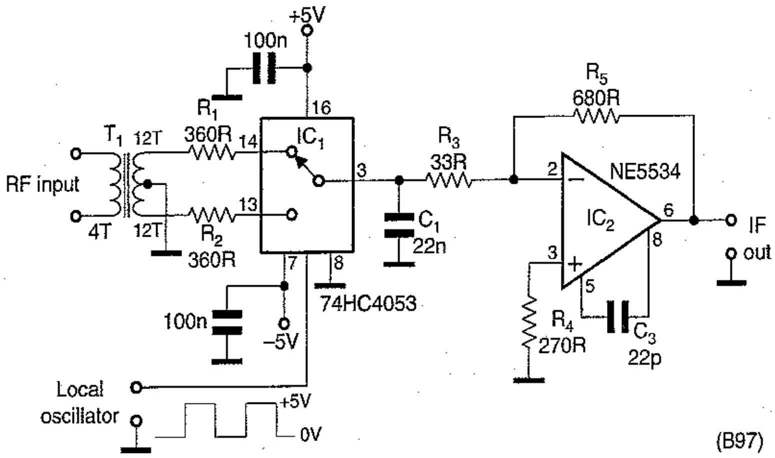

Rod Green calls this the Ned Kelly mixer, since it is relatively bullet-proof.

Bias voltage generator

As an example of the advantages of on-chip transistors over the discrete type, the current through Tr_2 in **Fig. 1** is virtually constant, as is Tr_2 bias voltage. In the absence of resistor R_2, the circuit would be a simple current mirror, I_2 being the same as that in R_1.

If R_2 is made equal to the emitter resistance of Tr_1 i.e., R_e=26/I_1, current I_2 will be almost constant, since R_2 and Tr_2 behave as a zero-gain amplifier; as the current changes the voltage across R_2 matches the change in base/emitter voltage, so long as the change is not great. Bias voltage V_2 may then be used as a constant bias for other circuits.

Since matched transistors on a chip are considerably more expensive than matched discrete ones, the variation in **Fig. 2** can be used. In this, R_2 is 52/I_1 to take diode D_1 into account. Voltage V_1 is around $2V_{BE}$ or 1.3V and V_2 about the same, since R_2 only drops about 52mV.

Ripple voltage turns out to be,

$$\Delta V_2 \approx 2V_T[\ln(1+K)-K]$$

$$\text{where } K=\frac{\Delta I_1}{I_1}=\frac{\Delta V_A}{V_A-2V_{BE}}$$

$$V_T \approx 26\text{mV at } 30°\text{C}$$

Improved ripple and temperature performance result from using a zener of around 6V instead of D_1, at which voltage temperature coefficient is small. With this arrangement, temperature coefficient of the current in Tr_2 is substantially reduced and the output voltage is now V_{BE} plus the zener voltage.

Resistor R_2 should now be equal to the intrinsic emitter resistance plus the zener slope resistance.

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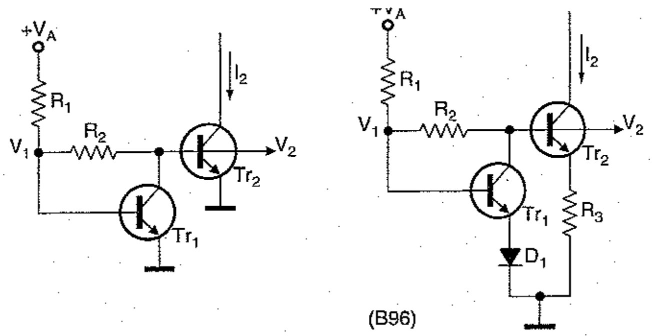

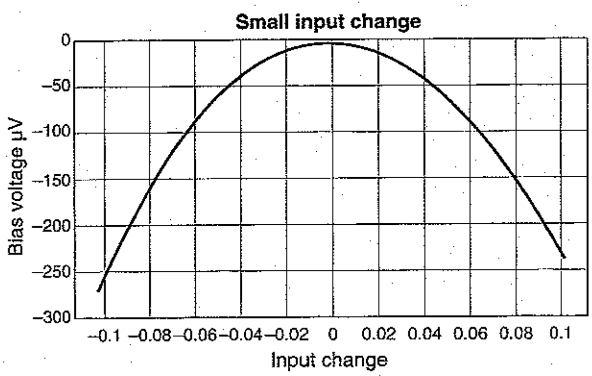

Simple modification to the current mirror circuit produces a constant current and bias voltage.