Improved-accuracy current mirror

Current mirrors of the form shown in **Fig. 1** achieves increased accuracy by virtue of the emitter follower to reduce input base current. Assuming that all three βs are equal,

$$A = \frac{1}{1 + \frac{2}{\beta(\beta+1)}}$$

To improve bandwidth, Tr_1 may be biased by an emitter resistor which, unfortunately, reduces mirror accuracy by the increased base current.

To regain accuracy, the circuit of **Fig. 2** offers an alternative approach by deriving an extra base current and adding it to the output. Again, all βs are equal and gain is now,

$$A = \frac{1 + \frac{2}{(\beta+1)^2}}{1 + \frac{2}{\beta(\beta+1)}}$$

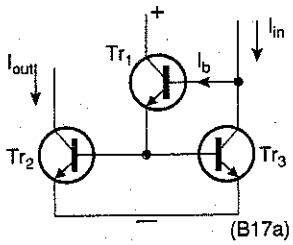

Fig. 1. Emitter follower in this current mirror improves bandwidth, but increased base current does nothing for accuracy.

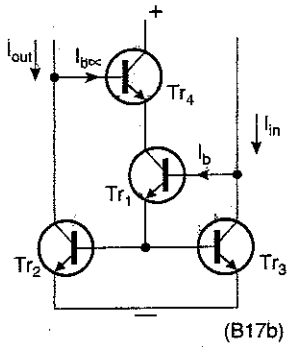

Fig. 2. Further base current added to output restores accuracy while retaining improved bandwidth.

Adding Tr_4 does have the effect of slightly lowering output impedance, but the improved accuracy and bandwidth normally outweigh the effect.

Figure 3 shows the final circuit, in which R_1 helps to reduce errors caused by offset voltage and R_2 sets the quiescent current in $Tr_{1,4}$. Reducing the value of R_2 does not affect the accuracy significantly, due to the effect of Tr_4.

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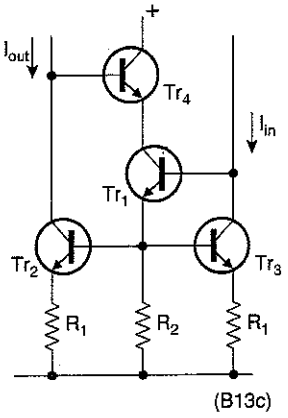

Fig. 3. Practical circuit of the wider bandwidth current mirror with uncompromised accuracy.

Longer-life led flasher

This 1.5V high-efficiency led flasher is an astable multivibrator with voltage doubler. The two transistor pairs are wired in Darlington mode to increase gain and reduce current consumption.

Values of C_1 and C_2 can be changed to adjust the flashing rate. The ultra-bright led is obtainable from RS Components and Farnell Electronics. Ordinary leds can be used, but the flashing intensity is very much reduced since the circuit is trimmed for minimum current consumption.

An ordinary 1N4148 type diode can be used instead of the 1N5819 schottky-barrier diode but led intensity will be reduced due to the higher voltage drop.

Idle current of the circuit is 0.2mA and with the led on, the current goes up to 0.3mA. With such a low current consumption, a 1.5V cell lasts a long time.

The popular *LM3909* led flasher from National Semiconductor idles at typical 0.55mA and with the led active it drains 0.75mA. According to National's handbook the *3909* will run for around 3 months continuously on an ordinary AA sized cell or for around 6 months on an alkaline type cell.

The circuit shown here should give you twice as much battery life.

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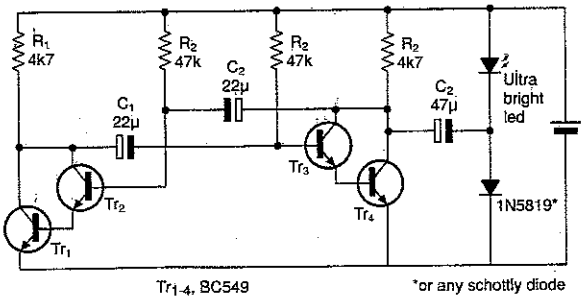
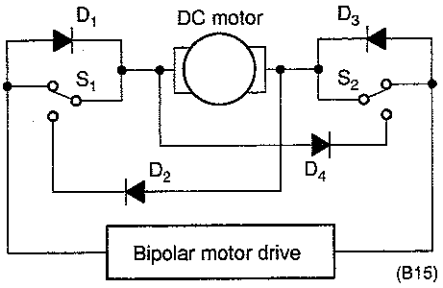


Comprising a multivibrator followed by a voltage doubler, this led flasher should run for up to a year on one alkaline AA cell.



A reliable (and cheap) method of stopping a dc servo motor very quickly without recourse to electronic sensing.

Rapid stop for dc motors

When used in servos, dc motors usually need travel limit switches. This circuit arrangement stops a motor quickly when the switch is tripped.

When the servo reaches a limit, the bipolar drive circuit should be able to reverse the motor; $D_{1,3}$ across the limit switches perform this function.

Dc motors stop much more quickly if a short circuit is placed across the terminals, since the motor then behaves as a generator. Diodes $D_{2,4}$ provide a virtual short circuit in the direction in which the motor is is moving when the limit is reached. This process is particularly suitable when moving high-inertia loads and does not rely on any exotic sensing devices; it is, therefore, more reliable when driving critical loads. It appears simple and somewhat obvious, but we have not seen it published before.

Limit switches and diodes must be suitably rated. ■

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