A Switch-mode Power Supply for the Nikkai Baby 10

These popular colour portables suffer from a common fault that greatly affects reliability. You can put an end to the trouble by fitting the module that Michael Dranfield describes in this article

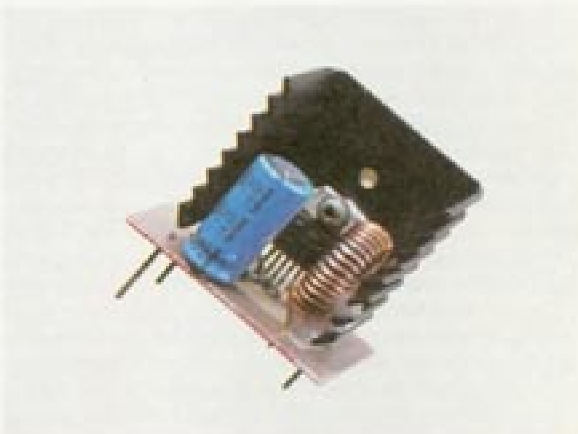
Over the past year a Nikkai Baby 10 colour portable has been a regular visitor to the workshop. Each time the problem has been the same, failure of the regulator chip IC402. So far we've fitted four new regulators, three of them free of charge as we give a twelve-month parts and labour guarantee with all new components fitted.

Initial Experiments

I remember seeing, some time ago, an article in *Television* suggesting the use of a fixed 12V regulator as a replacement for IC402. This seemed worth a go, but IC402's output is 10·9V, not 12V. So I experimented with an RS Components 12V, 5A regulator, using two 1N5408 diodes in series to provide a 1·4V drop. The output would then be 10·6V, which is near enough. The problem with this was that the two diodes, passing the 2·4A required to run the set, got too hot.

After some thought I decided to shunt the two diodes with a 1Ω, 4W wirewound resistor to pass two thirds of the total current, leaving the diodes to pass only 700mA. I made up a small PCB to carry the resistor and diodes, and fitted it in the space occupied by IC402. The 12V regulator was mounted above the line output transistor on the set's chassis frame. All was well – until the 12V regulator failed a week or so later as a result of excessive heat dissipation, probably because the chassis, being made of steel, is a poor conductor of heat.

My next idea was to build a linear series regulator on the base of the original regulator's heatsink. A suitable circuit was devised and the top of the heatsink was drilled to take a TO3 transistor. I selected a BUT13 transistor which has a 28A maximum collector current rating. This again worked well, but the heatsink wasn't large enough to dissipate the 60W odd required. As a result the transistor soon suffered from thermal runaway. Use of a larger heatsink within the set was not possible, so it was back to the drawing board.



The Solution

To reduce the dissipation, I started to think about the possibility of a chopper circuit. After searching through some catalogues I came across a National Semiconductors device, the LM2576-ADJ, which is referred to as a "simple switcher". Its specification is impressive. The case is a TO220, like a TDA2020, and only six external components are required to form a complete switch-mode power supply.

To quote from the manufacturer's data sheet: "The

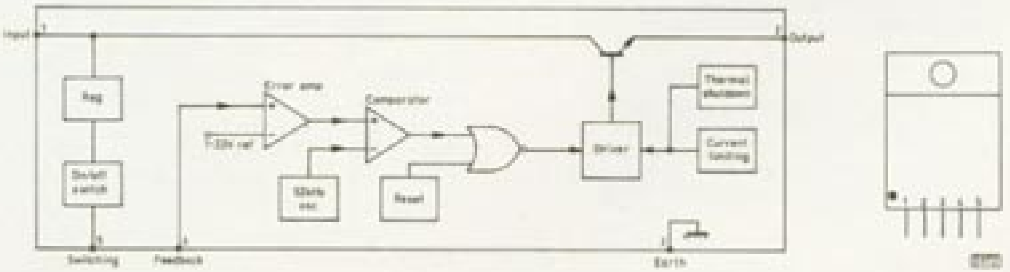


Fig. 1: Block diagram of the LM2576-ADJ switch-mode power supply chip. Also pin connections, viewed from the front.

LM2576-ADJ series offers a high-efficiency replacement for popular, three-terminal adjustable linear regulators. It reduces the size of the heatsink required substantially – in fact in some cases no heatsink is required."

A block diagram of the circuitry within the device is shown in Fig. 1. The oscillator's frequency is 52kHz, fixed. The unregulated input is fed to pin 1, while the output is at pin 2. There is feedback to pin 4, which is one of the inputs to the error amplifier stage. This compares a potted-down sample of the output voltage with an internal 1·23V reference. Any difference will vary the pulse width of the output at pin 2.

Pin 5 enables the device to be switched on/off. This feature is not required here. High is off, low on. The device has full thermal shutdown and current limiting, and a maximum switched current capability of 3A.

Fig. 2 shows the complete circuit. C1 decouples the input at pin 1. The chopper transistor within IC1 provides a squarewave output at pin 2. It's driven by a pulse-width modulated squarewave at 52kHz. Feedback is taken from the junction of R1 and R2 to pin 4.

The output at pin 2 is fed to a low-pass filter that consists of L1 and C2. When the chopper transistor is switched on, diode D1 is reverse biased and C2 charges via L1. When the chopper transistor is off, D1 conducts and the energy stored in L1 and C2 supplies the load. Our original prototype developed about 10mV of ripple across C2. If you think that the circuit looks familiar, this is probably because it's the basic series chopper circuit used in several TV chassis from the Thorn 3000/3500 series on.

D1 is a fast-switching Schottky barrier diode. C1 and C2 are of the low ESR (effective series resistance) type, especially suited for switch-mode power supply use. If you try to use components other than those specified in positions D1, C1 and C2 the result may be poor stability and incorrect regulation. The output voltage is set at 10·9V by the values of the potential divider resistors R1 and R2, which have a one per cent tolerance. This is the full-load output voltage: off-load the output may rise slightly to 11V.

Testing

The first regulator I built worked well on the bench, even when it was run at slightly above 3A. But problems were encountered when the module was fitted in the TV set. The original bobbin inductor used generated too much EMI (electromagnetic interference), which was picked up by the scan coils. The interference produced fine horizontal lines that ran up the picture. Use of a toroid inductor solved the EMI problem – this type tends to hold the magnetic flux within the core. The one used was obtained from Maplin – neither Farnell nor RS Components stock a suitable toroid inductor.

Construction

Fig. 3 shows a suitable PCB layout. The board is the same size as the original regulator. Thus the module can be made up as a plug-in, pin-for-pin replacement for IC402. The heatsink specified gives good results in free air but runs on the warm side within the set. A good alternative is to use the original IC's heatsink, turned upside down with a hole drilled to take the LM2576-ADJ – see Fig. 4. Apply heatsink compound to IC1's tab before fitting it to the heatsink. An insulating washer is not required as the tab is connected to the earth line.

The leadout wires trimmed from D1 can be used to make the three mounting pins. A blob of Araldite can be used to hold L1 against the heatsink.

One advantage of this module is that individual components can be replaced should they fail. This is not possible with the original regulator, which is potted in epoxy resin and is thus non-repairable. ■

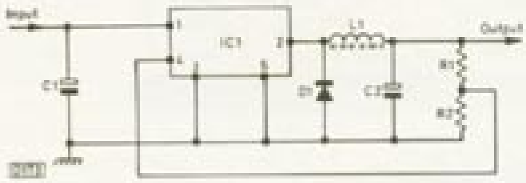


Fig. 2: Circuit diagram of the module.

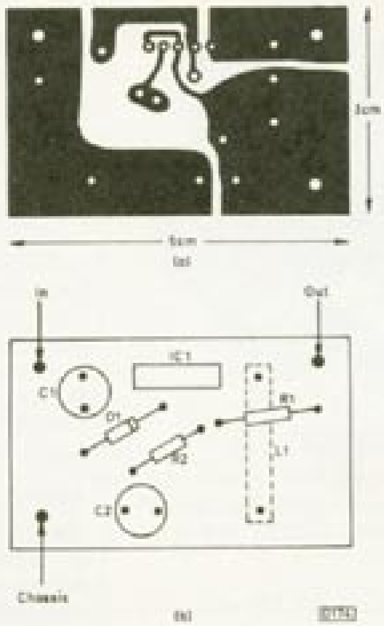


Fig. 3: PCB layout, shown with Farnell 179-935 heatsink. (a) Underside, (b) top.

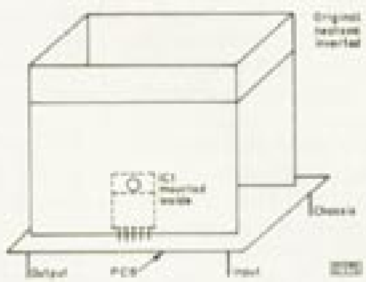


Fig. 4: Alternative arrangement using the original heatsink mounted upside down on the PCB.

Component details

C1	100µF, 35V low ESR	Farnell 580-533
C2	1,000µF, 25V low ESR	Farnell 236-767
D1	SB340 Schottky diode	Farnell SB-340
R1	8·06kΩ 1%	Farnell 340-042
R2	1kΩ 1%	Farnell 339-179
IC1	LM2576-ADJ	Farnell LM2576-ADJ
L1	150µH, 3A	Maplin JL72P
TO220 heatsink		Farnell 179-935

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