The 'power down' mains appliance timer

Have you ever turned on your electric radiator to warm a room in the morning and forgotten to turn it off on your way out? What about the patio light — ever turned that on and forgotten to turn it off until the next day? This project will not only solve those problems, but has many applications besides.

Geoff Nicholls

THIS IS a press-button mains appliance timer. You plug the project into a wall socket, plug your appliance into the project, then press the button to turn the appliance on. Some predetermined time later, the project will automatically *'power down'* (or turn off) your appliance.

No doubt you're familiar with those time switches installed in the stair wells of apartment buildings that control the stairway lights. You press the big button and the lights come on just long enough for you to *not quite* make it up the stairs! These devices employ a mechanical timer, their major problem being that, with use, the period decreases. In addition, you can't preset them to a convenient time over a wide range.

Many 'deluxe' electric heaters these days incorporate a timer of some sort so that the heater can be turned on for a preset period, then turn itself off. 'Super deluxe' models go so far as having a timer with digital display and programming facilities to turn it on and off whenever you like each day for a fortnight! That's probably going a bit far for many applications, though.

Getting 'closer to home', so to speak, take the case of an EPROM eraser. This basically comprises an ultraviolet lamp and a period timer. You bung your EPROMs under the lamp and turn on the timer. The timer then turns the lamp off the required period later (typically, 20 minutes).

In photographic work, film and print exposure times are often handled with a simple period timer. When making multiple exposures for comparisons, etc, binary-related exposure times are frequently used, e.g: print exposures of eight minutes, then four minutes, then two minutes, etc.

This versatile little timer will handle all the above applications and can be configured to suit a huge variety of other applications, probably only limited by your imagination.

This project can be set up for timing periods ranging from one minute up to at least 50 hours. Although I haven't tried it, it is certainly possible to extend the period to around 400 hours (16-17 days). Binary 'segments' of the basic period can be selected by the simple addition of a suitable switch. The project is low in cost and can be built into an appliance if you so wish.

Design

The unit is quite straightforward. Figure 1 shows a block diagram. It consists of an oscillator, a divider, a flip-flop, a relay driver and relay. The relay contacts are used to connect and disconnect the mains power from an attached appliance.

The oscillator output is divided down 8192 times. The divider's output drives the 'reset' input of the 'reset-set' (RS) flip-flop. The flip-flop has two outputs — A and B. In the initial, or reset, state, output A is high, resetting the divider in preparation for counting. Output B of the flip-flop is low and the relay is not operated.

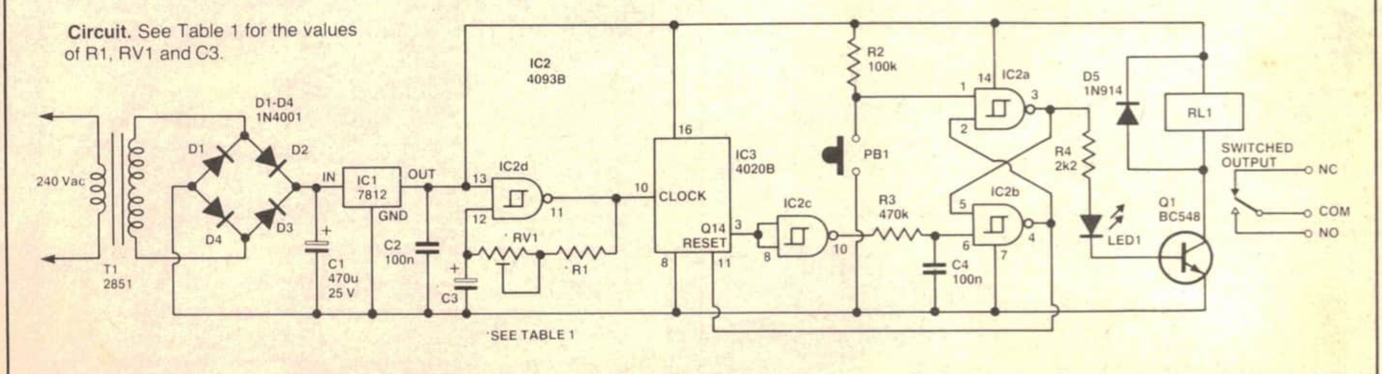
When the start button is pressed, the RS flip-flop is 'set'. Output B goes high, operating the relay and turning on the appliance connected via the relay. Output A goes low, enabling the divider to count down.

At the end of its count, the divider's output goes low, resetting the flip-flop. Output A goes high again, stopping the divider, and output B goes low. The relay then drops out, turning off the appliance connected via its contacts.

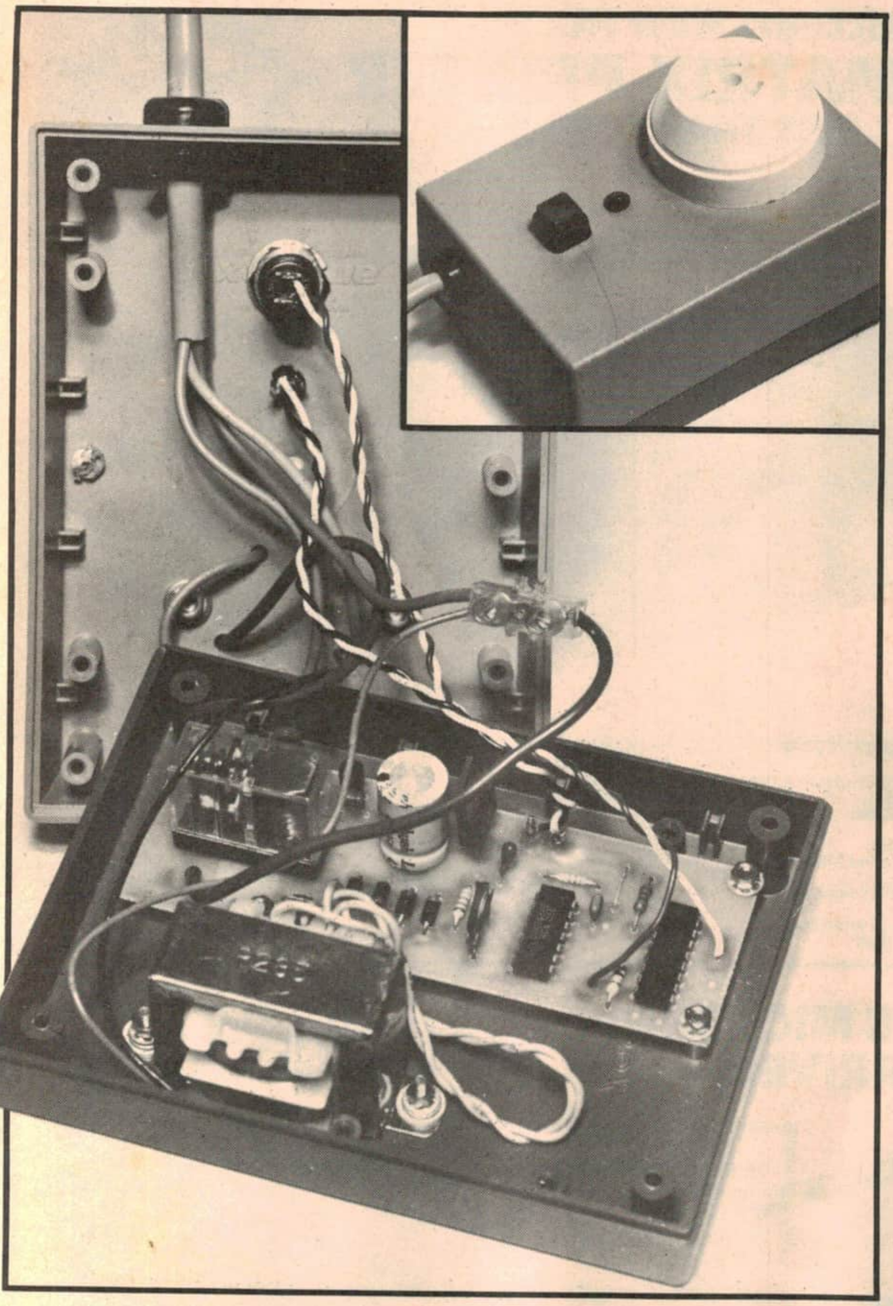
The oscillator's frequency will determine the basic period. Because the division ratio is so high, minor drifts or variations in the oscillator frequency will not materially affect the timing period, hence a simple oscillator can be used.

As the required timing period is determined by R1, RV1 and C3, the values you need for these components should be determined from Table 1 before commencing construction. It would be reasonable to expect a kit supplier *not* to include these in a kit, or to perhaps only include, say, a 1u RBLL or tantalum for C3 and perhaps a 1M trimpot, as these would cover a wide range of timing periods, leaving the choice of R1 to you.

Note that C3 should either be a tantalum type or single-ended 'low leakage' electrolytic for repeatable results. ▶



Circuit. See Table 1 for the values of R1, RV1 and C3.



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On the inside. Showing construction of the project and how I mounted it inside the Unibox case. Note that one of the internal pillars is cut down to provide clearance for the transformer. **Inset.** The completed project.

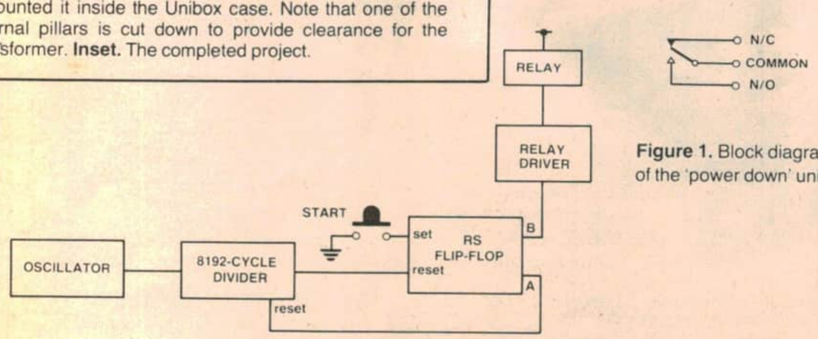


Figure 1. Block diagram of the 'power down' unit.

HOW IT WORKS — ETI-265

The overall design of the project is discussed in the text, so this shall largely be a blow-by-blow description of how it works. Let us start at the 'rear end' first.

Two gates from the 4093, IC2a and b, form the reset-set (RS) flip-flop. This is in the SET state when pin 3 of IC2 is high and pin 4 is low. It is in the RESET state when pin 4 is high and pin 3 low.

When the flip-flop is SET, Q1 is turned on as the high on pin 3 of IC2 biases on its base via R4 and LED1, which lights, indicating the unit is 'active'.

A momentary low on pin 1 of IC2 will SET the flip-flop, while a momentary low on pin 6 will RESET it.

On power-up, C4 will look like a short circuit and keep pin 6 of IC2 low long enough to RESET the flip-flop. Thus, pin 4 of IC2 will be high and reset IC3, a 4020B 14-stage binary counter with a division ratio of 8192:1.

Pin 3 of IC3 (the stage 14 output) will be low after the IC is reset and IC2 will invert this, pin 10 driving pin 6 high, allowing the flip-flop to be set when PB1 is pushed momentarily.

As soon as PB1 is pushed, the counter begins to count cycles of the Schmitt gate oscillator comprising IC2d, R1, RV1 and C3. The frequency of the oscillator is determined by RV1, R1 and C3 and the threshold voltages of the inputs of IC2d. (See 'Why some CMOS circuits don't work as you expect', Lab Notes, in this issue.)

After 8192 cycles of the oscillator, pin 3 of IC3 goes high, thus resetting the flip-flop via IC2c. Pin 3 of IC2 will thus go low and the relay will drop out.

The oscillator works as follows: At power-up, pin 12 of IC2d will be low as C3 appears as a short circuit. Pin 13 will be high and thus pin 11 will be driven high. C3 will charge via R1 and RV1. When the voltage on C3 reaches the gate's upper threshold, pin 11 will go low and C3 begin to discharge via RV1 and R1. When the voltage on C3 falls to the gate's lower threshold, pin 11 will again go high and the cycle will be repeated.

The oscillator frequency is related to the timing interval (or period) as follows:

$$f_o = \frac{8192}{T}$$

where f_o is the oscillator frequency in Hertz, and T is the period in seconds. Expressing this in terms of the period:

$$T = \frac{8192}{f_o}$$

Table 1 allows you to set up the project for a particular timing interval. The range of adjustment provided should compensate for most of the variation in threshold voltages of the different manufacturers' 4093s. The time interval shown in the table refers to the prototype project. If you add the rotary switch to give four ranges, the longest interval will be as per the table, the next will be half that, then quarter that, etc.

The power supply is quite straightforward. Transformer T1 drops the mains voltage to 12.6 V RMS. This is rectified by a bridge diode comprising D1 to D4. Capacitor C1 is the rectifier reservoir. About 18 volts is developed across C1 and this is regulated to 12 V by a 7812 three-terminal regulator, IC1. Capacitor C2 ensures regulator stability.

Diode D5, across the relay, shorts the reverse-emf generated by the relay coil when Q1 switches off, preventing the high voltage generated from destroying Q1.

Construction

I built one prototype and mounted it in a plastic case, which you see in the photographs here, and another unit which I mounted inside an appliance (ask no questions and . . .)

I used an all-plastic Unibox (P/N144) measuring 135 mm long by 100 mm wide by 50 mm deep. (Magraths in Melbourne are a major supplier of these.) It has ample room inside. You could use a UB-1 zippy box (50 x 90 x 150 mm), but an all-plastic case is recommended for safety's sake. Jaycar stock a range of smart, all-plastic (ABS) cases in various colours. The HB6150, 1, 2, 3 series (orange, grey, blue, black) would suit.

First thing to do is determine the mounting positions of the printed circuit board and transformer. Lay the unassembled pc board and the transformer in the base of whatever box you're using and mark the positions of the mounting holes.

Then mark out suitable positions for the mains cable entry, the pushbutton, the LED and the mains socket. For the mains cable entry, I used a Heyco clamp-type grommet to suit the mains cable I used (grommet #1210, SR-6P-4). There are plenty of similar types available. If you don't use a clamp-type grommet, then use an ordinary rubber grommet and a nylon cable clamp.

The mains socket requires holes to be drilled in the box to allow cables to the active, neutral and earth pins to pass through to the socket terminals. I first loosened the grub screws on the socket terminals, then positioned the socket where I wanted it and drilled pilot holes in the case through the terminals.

After drilling all the holes, mount the transformer, output socket, LED and pushbutton, but not the pc board — you've got to assemble that yet! To mount the transformer, I used insulating washers from a TO-3 power transistor mounting kit. An alternative is to use nylon bolts. The latter were used to mount the pc board.

Note that, if you wish, the section of the board on which the relay mounts can be severed from the rest of the board, allowing the relay to be mounted away from the main portion of the electronics.

Assembly of the board is pretty straightforward. Start with the smaller components. Solder all the resistors in place, then the five diodes, C2, C3 and C4. Watch the orientation of C3 and the diodes. Solder a link of tinned copper wire in the position shown, between C4 and R4. Now you can solder IC2 and IC3 in place.

These are CMOS ICs. Use an iron with an earthed tip and only handle the ICs with your thumb and forefinger gripping the ends of the package. Avoid touching the pins. When you have each in place, solder pins 7 and 14 of IC2 first and pins 8 and 16 of IC3 first, before going on to solder the other pins. If you wish, IC sockets may be used without affecting operation of the project.

Next solder Q1 in place. Its orientation can be ascertained from the pinout diagram and the component overlay.

Now solder the electrolytic, C1, in place, taking care to orientate it correctly, followed by IC1 (get it the right way round) and RV1. The relay can be soldered to the board last of all.

Wires are run from the pc board to the mains circuitry, the pushbutton and the LED. Only ordinary light hookup wire (10 x 0.12 mm) need be used to connect up the LED and the pushbutton. The 2851 transformer primary wires are generally coloured red and black. It has three secondary wires, two the same colour. These are wired to the rectifier diodes D1-D4, as shown in the overlay/wiring diagram.

Wire the transformer primary very carefully. The brown active wire from the mains input cable goes to a terminal connector, where it joins the red wire from the transformer. Take a length of brown mains wire and connect it between this terminal connector and the COMMON relay terminal pad on the pc board. Another length of brown mains wire is run from the normally open (N/O) relay contact pad on the pc board to the active terminal of the mains output socket.

The blue neutral wire runs from the mains input cable direct to the neutral terminal on the mains output socket, along with the black wire from the transformer.

The green and yellow striped earth wire from the mains input cable goes direct to the earth terminal on the mains output socket. This wire should be longer than the other two from the mains input cable for safety reasons. Should the mains cable be accidentally pulled out from the case, the earth wire will be the last to break.

All finished? *Check everything thoroughly.*

That's all there is to it. Next thing to do is test and calibrate it.

Test and calibration

Set RV1 to the middle of its travel, then close the case so that you can't accidentally come in contact with the lethal mains voltage present.

Plug a bedside lamp into the output socket, plug the project into the mains and switch on. Nothing should happen. If all's well, press the pushbutton and the lamp should light. Now time how long it remains on (if it's 50 hours or more, you're going to need a *lot* of patience!).

If you have access to a frequency counter, then setting the timer is much easier. Just attach the frequency counter to pin 11 of IC2. The oscillator frequency is related to the timing period as follows:

$$\text{Frequency} = \frac{8192}{T}$$

where T is the desired period in seconds and the frequency is in Hertz.

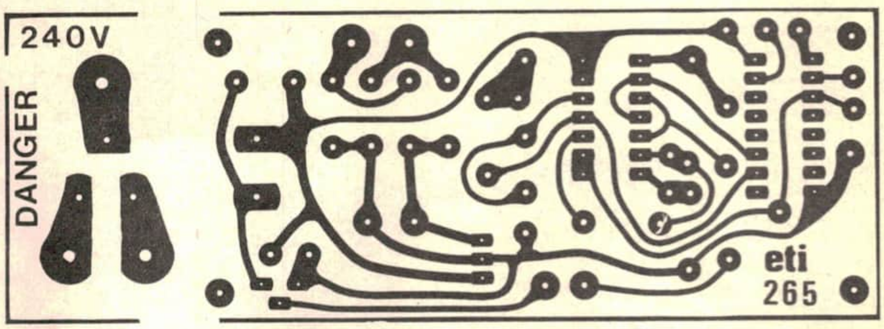
For a timing period of ten minutes, the frequency should be 13.65 Hz. For really long times, you're better off measuring the period of the oscillator output.

All you need do is to adjust RV1 for the correct frequency.

Binary periods

As mentioned earlier, the simple addition of a switch can give you binary (half, quarter, eighth) segments of the basic period. Details are shown in Figure 2.

Cut the track that runs beneath the body of IC3, then wire a single-pole, four-position switch as shown. Position 4 gives you the full period. Position 3 gives the half period, position 2 one-quarter and position 1 gives one-eighth the period. ●



PARTS LIST — ETI-265

Resistors .... all ¼ W, 5% unless noted

R1	47k
R2	100k
R3	470k
R4	2k2

Capacitors

C1	470u/25 V single-ended electro.
C2,C4	100n greencap
C3	1u/16 V tantalum

Semiconductors

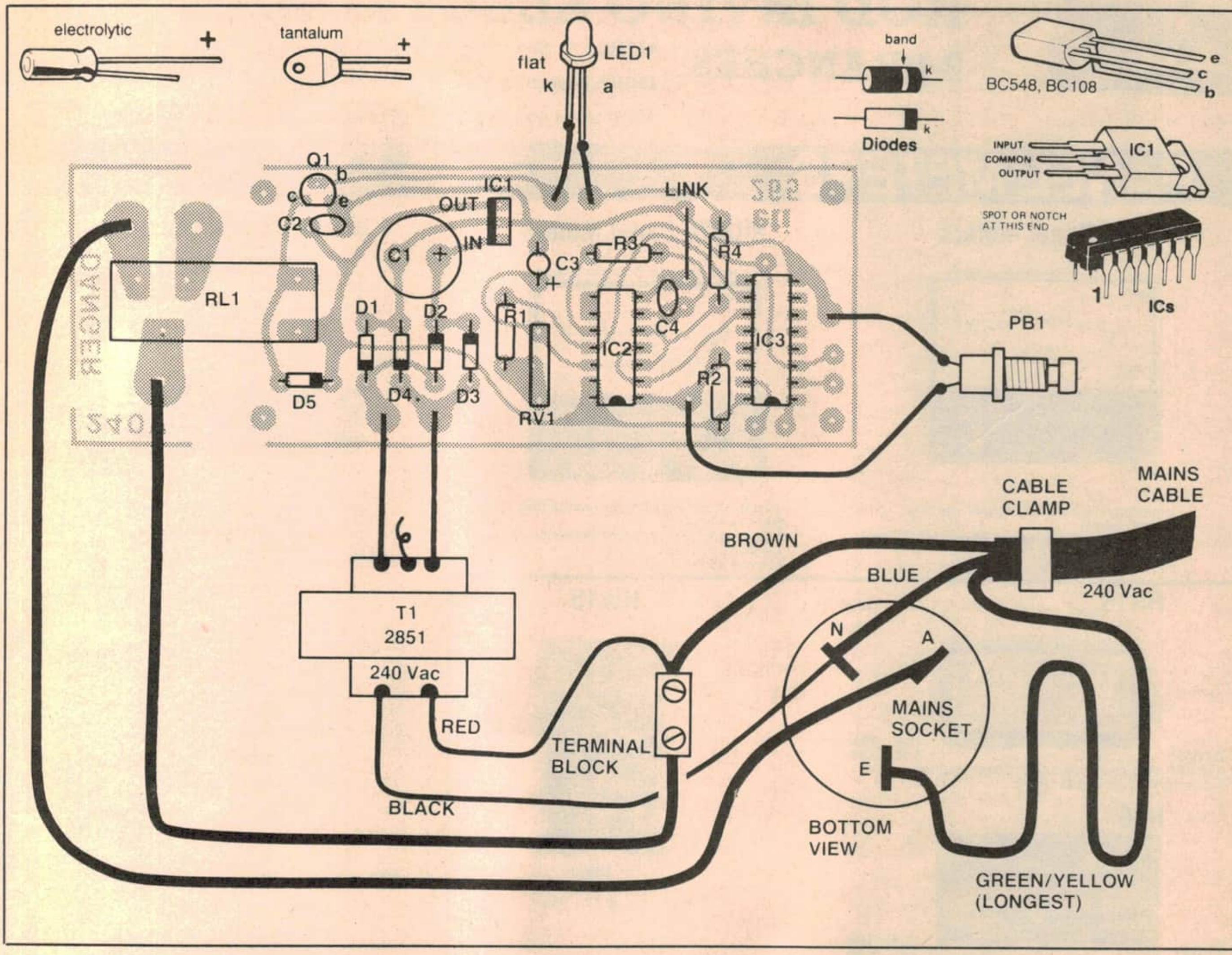
D1-D4	1N4001, 1N4002 or similar
D5	1N914, 1N4148
IC1	7812
IC2	4093B
IC3	4020B
LED1	TIL220R red LED
Q1	BC548

Miscellaneous

PB1	momentary action pushbutton, large (e.g: D.S.E. no. S-1199 or similar)
RL1	pc mount relay, 12 V coil SPDT/5 A contacts (e.g: D.S.E. S-7125, or similar)
T1	2851 transformer, 12.6 V CT @ 150 mA

ETI-265 pc board; case to suit (e.g: Unibox P/N 144, 100 x 135 x 50 mm, or similar); LED mount; 240 V wall socket; mains cable plug, cable and clamp; wire, etc.

Price estimate $32-$37



Timing Interval	C3	R1	RV1
1 minute	100n	47k	100k
5 minutes	100n	270k	500k
10 minutes	100n	470k	1M
20 minutes	1u	100k	220k
30 minutes	1u	150k	220k
45 minutes	1u	270k	500k
1 hour	1u	270k	500k
1½ hours	1u	390k	1M
2 hours	1u	680k	1M
4 hours	1u	1M2	2M2
10 hours	100u	27k	50k
20 hours	100u	56k	100k
50 hours	100u	150k	200k
100 hours	100u	270k	500k
200 hours	100u	560k	1M
400 hours	100u	1M2	2M

TABLE 1

Binary period switching. How to add a switch to get selections of full period, half period, quarter period and eighth period.