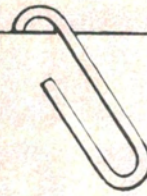


Lab Notes



Super timer — from μs to days

Timing long periods has always been a problem because of the high leakage characteristics of the timing capacitor. This is no longer true! The XR-2240 IC is a programmable timer capable of producing ultra-long time delays without sacrificing accuracy.

Barry Davis

THIS IC can generate time delays from microseconds up to five days, and with a little ingenuity can generate a delay of a couple of years! A functional block diagram of the IC is shown in Figure 1.

2. Programmable delays:
 - 1.CR to 255.CR
3. Wide supply voltage range: 4 V to 15 V
4. TTL compatible inputs and outputs
5. High accuracy: 0.5%
6. Excellent temperature stability
7. Period $T = C \times R$

The timebase generator produces timing pulses with a period, T , equal to $1/\text{CR}$. These clock pulses are counted by the binary counter inside the IC and the timing period is complete when a positive-going pulse is applied to pin 10 (i.e: the circuit is reset). In most applications one or more of the output terminals are connected back to the reset input. The circuit will commence timing when the trigger pulse is applied, and automatically reset on the completion of the timing period.

Remember, the outputs are normally high and are set to low when timing is initiated, returning again to the high level on completion of the timing period.

Circuit operation

The timing cycle is initiated by a positive-going pulse on pin 11. This trigger pulse performs three functions:

1. Activates the timebase generator
2. Enables the counter
3. Sets all counter outputs to the *low* state

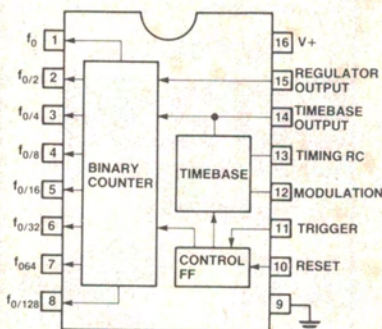


Figure 1. Functional block diagram of the XR-2240.

The circuit consists of an internal timebase generator, a programmable 8-bit counter and a control flip-flop. The time delay at the output is set by an external CR network and can be any period from $1/\text{CR}$ to $255/\text{CR}$. Herein lies the secret. The CR timebase generator can be set to give a very accurate short period, and binary multiples of this short period are then programmed and taken from the output. Each output is capable of sinking approximately 5 mA of load current.

The features of the IC are:

1. Timing from microseconds to days.

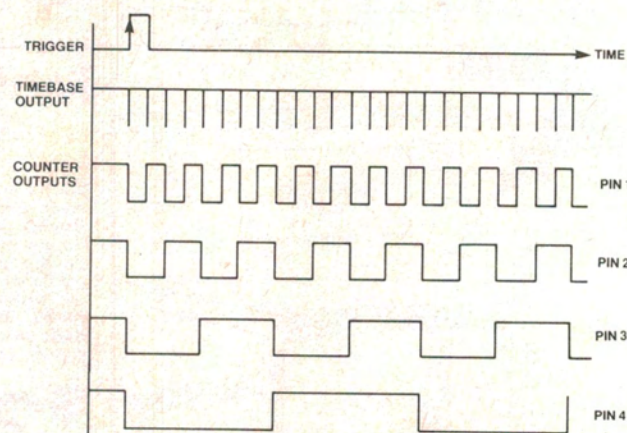


Figure 2. Output waveforms and timing diagram.

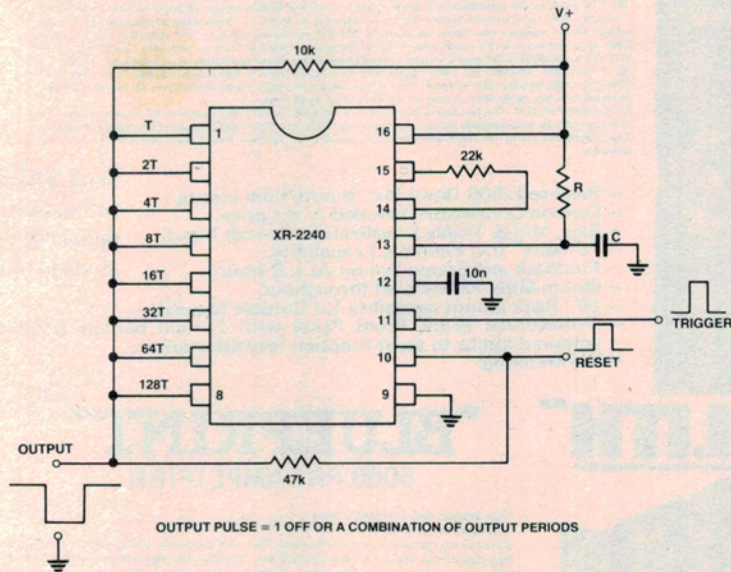


Figure 3. Connections for a practical circuit.

Circuit construction

The binary outputs, pins 1 to 8, are open collector and can be connected together to a common pull-up resistor. The output of the timer will be low as long as any one output is low. In this manner the time delays associated with each output can be added by simply connecting them together to a common bus. The outputs can be used individually or wired together.

For example, the output at pin 4 is $8 \times CR = 8T$. If pins 4 and 3 are connected together the output will become $12 \times CR = 12T$.

Figure 3 shows the actual connections for a practical circuit. When the power is applied, with no trigger or reset inputs, the circuit sets up to the initial state of all outputs high. Once triggered, the circuit is totally immune to any additional trigger inputs until the timing period is completed, or a reset pulse is applied.

Choice of timing components

Once a signal timing period, T , is established, the output can be determined by 'wiring-in' periods of T following a binary progression. However, the procedure may have to be reversed when a certain accurate output period is required.

For example, if a timing period of 6 hours 30 seconds is required, firstly convert the time to seconds:

$$= 6 \times 60 \times 60 + 30$$

$$= 21630 \text{ seconds.}$$

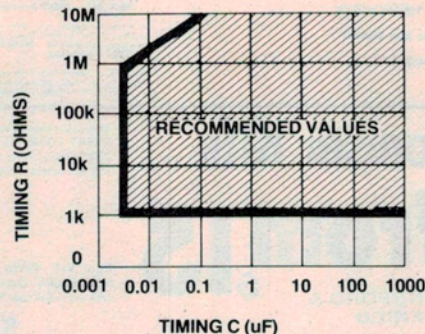
The maximum number of timing periods available with one IC is $(1+2+4+8+16+32+64+128)T = 255T$. Therefore the period of T can be calculated:

$$T = \frac{21630}{255}$$

$$= 84.82 \text{ seconds}$$

With a low-loss capacitor (such as tantalum) as one timing component, R can be calculated. If $C = 100 \mu\text{F}$:

$$T = CR$$



a) RECOMMENDED VALUES

Therefore:

$$R = \frac{T}{C}$$

$$= \frac{84.82}{100 \times 10^{-6}}$$

$$= 848.24 \text{ k}\Omega$$

This can be tailored precisely for very accurate timing with a resistive network or potentiometer, or simply rounded off to $850 \text{ k}\Omega$.

Figure 4 shows two graphs which will assist you in choosing:

1. The recommended range of timing component values.
2. The time period, (T) up to 100 seconds, to be expected from combinations of C and R values.

An example of output periods to be expected using a $100 \mu\text{F}$ capacitor (tantalum) and $1 \text{ M}\Omega$ resistor as the timing components is shown in Table 1.

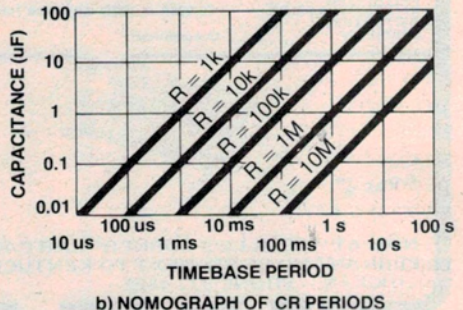
| T | Period of Output |
|---|------------------------|
| $T = CR = 100 \mu\text{F} \times 1 \text{ M} = 100 \text{ seconds}$ | |
| 100 | secs = 1.7 min |
| 2T | 200 secs = 3.3 min |
| 4T | 400 secs = 6.7 min |
| 8T | 800 secs = 13.3 min |
| 16T | 1600 secs = 26.7 min |
| 32T | 3200 secs = 53.3 min |
| 64T | 6400 secs = 1.8 hours |
| 128T | 12800 secs = 3.6 hours |
| 255T | 25500 secs = 7.1 hours |

Table 1. Example of accurate time available using the XR-2240.

The type of circuit operation discussed to this point has been monostable i.e: the output goes low on triggering, stays low for the timing period and returns to a high level. It will not time again until it is retriggered. An XR-2240 can also be used in a free-running or astable mode.

Astable operation

To operate in this mode the reset line to pin 10 is disconnected from the output.



b) NOMOGRAPH OF CR PERIODS

Figure 4. Graphs to assist in the choice of values of C and R .

Lab Notes

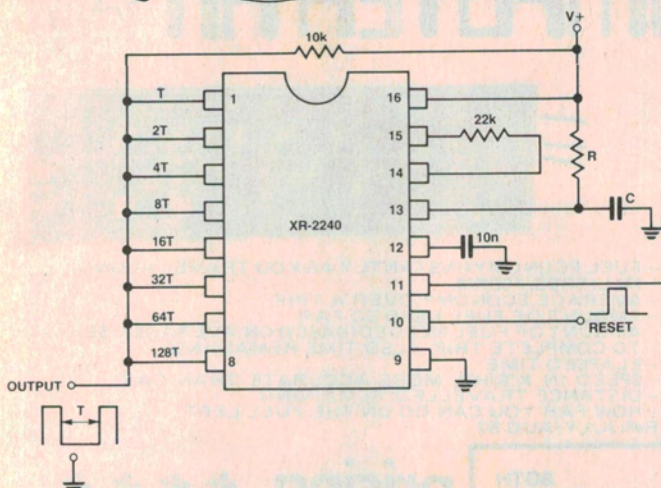


Figure 5. Astable operation under control of external trigger and reset controls.

Figure 5 shows an astable circuit under the control of the external trigger and reset signals. It will start timing when an external trigger pulse is applied, and will not stop until a reset pulse is applied.

Alternatively, the circuit can be made truly free running. The circuit in Figure 6 self-triggers automatically when the power is switched on, and continues to operate in its free running mode indefinitely.

When the timer is used in this mode, each counter output can be used individually as synchronised oscillators, or they can be connected together to provide complex pulse patterns.

Ultra-long delays

In some applications delays of four days may be required. This is particularly useful in electronic farming for controlling the rate of supplementary feeding. The timing components required can be calculated thus:

$$\begin{aligned} 4 \text{ days} &= 96 \text{ hours} \\ &= 5760 \text{ minutes} \\ &= 345\,600 \text{ secs.} \end{aligned}$$

Maximum number of T combinations = 255

$$\begin{aligned} \text{Therefore } T &= \frac{345600}{255} \\ &= 1355.3 \text{ secs} \\ &= 22.6 \text{ minutes} \end{aligned}$$

Incidentally, 20 minutes is about the longest time recommended for 1.CR as anything beyond this suffers from leakage problems.

$$\begin{aligned} T &= CR \\ \text{if } C &= 500 \text{ uF (low leakage)} \\ R &= \frac{T}{C} \end{aligned}$$

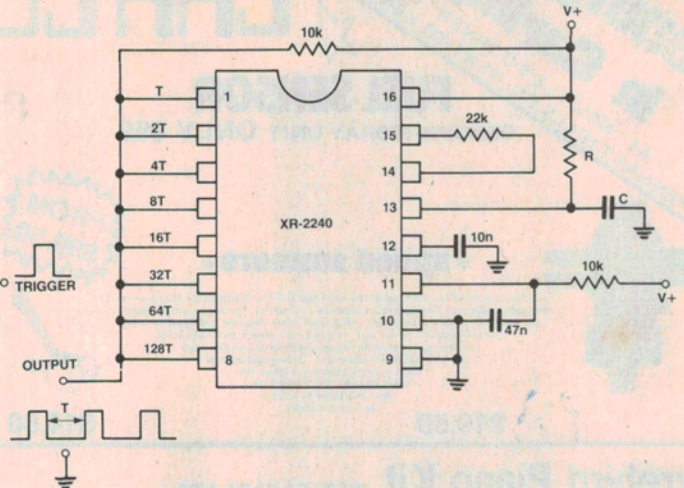


Figure 6. Free-running circuit.

$$\begin{aligned} &= \frac{1355.3}{500 \times 10^{-6}} \\ &= 2M7 \end{aligned}$$

Two XR-2240 ICs can be cascaded to generate extremely long time delays. When used in this format the reset and trigger terminals of the ICs are tied together and the timebase of unit 2 disabled as shown in Figure 7.

The output is normally high. When a positive-going trigger pulse is applied the output goes low and stays in the low state for $(256)^2 = 65\,536$ periods of the timebase oscillator. Therefore the total timing period of two cascaded units can be from $256.CR$ to $65\,536.CR$. The output is available in 256 discrete steps by selectively connecting one or a combination of the outputs from unit 2 to the output bus.

With $T = 20$ minutes an example of an ultra-long delay can be given.

$$CR = T = 20 \text{ mins.}$$

$$\begin{aligned} 65\,536T &= 1\,310\,720 \text{ min} \\ &= 21\,845 \text{ hours} \\ &= 910 \text{ days} \\ &= 2.5 \text{ years!} \end{aligned}$$

This article highlights the use of an XR-2240 as a precision timer. Other application suggestions are:

1. Sequential timing
2. Binary pattern generation
3. Frequency synthesis
4. Pulse counting or summing
5. A/D conversion
6. Digital sample and hold

Further information on the IC can be obtained from Exar Integrated Systems or their agents (Total Electronics).

This article was made possible by the courtesy of Exar Integrated Systems. Data was taken from their publication 'XR-2240/2340 Programmable Timer Counter'.

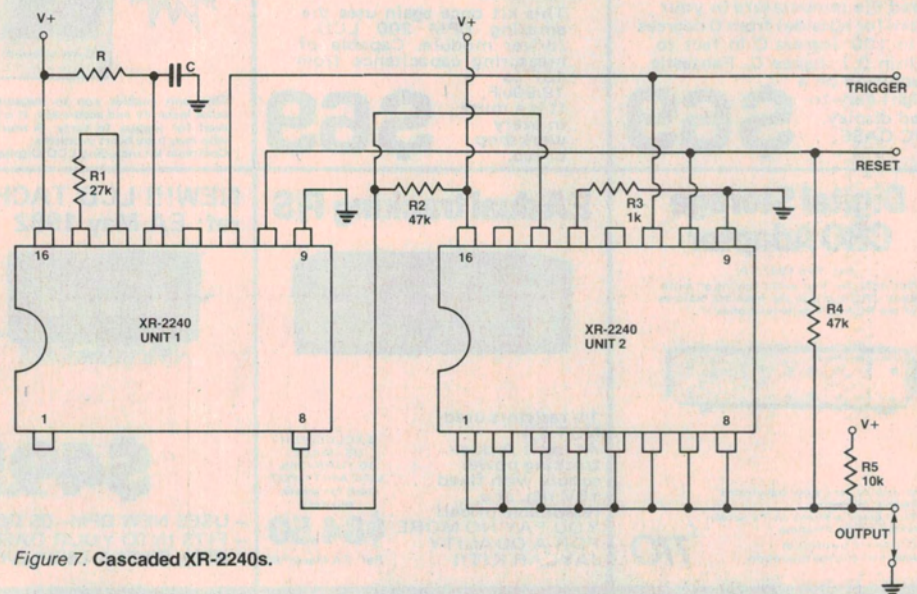


Figure 7. Cascaded XR-2240s.