Arc Welder Simulator

For model railways . . .

by
Ken Stone

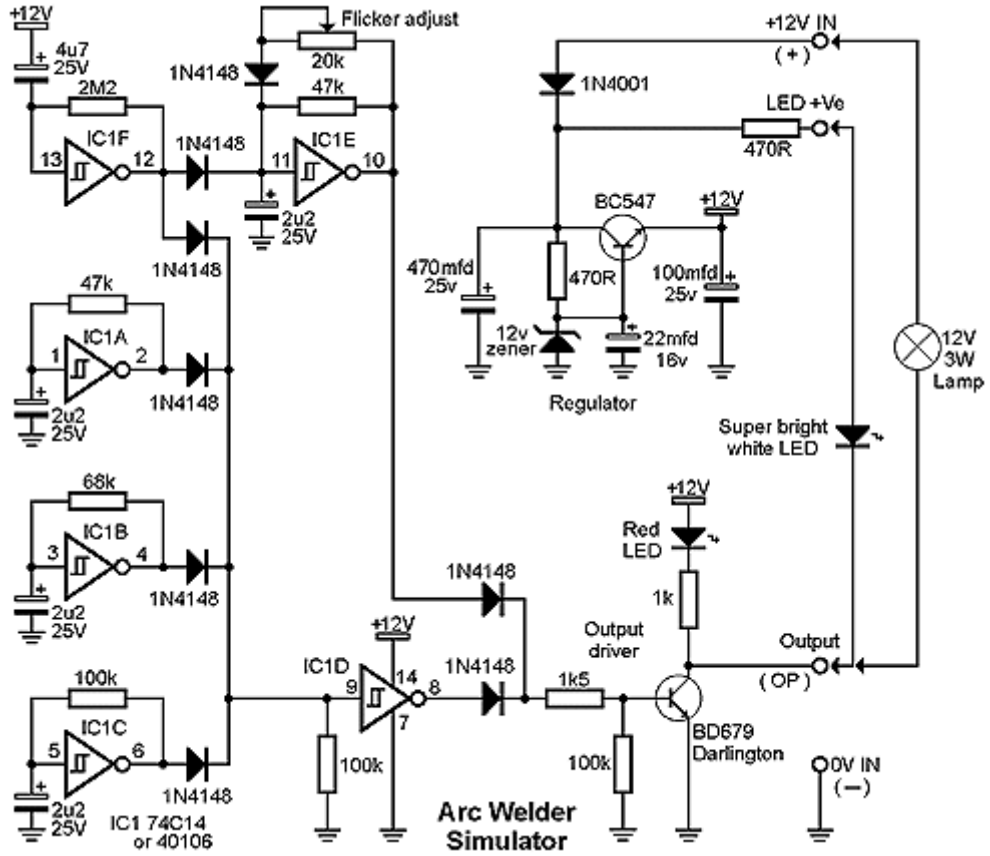
INTRODUCTION

Detailed workshops and maintenance yards can be the highlight of many model railways or dioramas. Unfortunately they usually suffer from one common problem. They are static. At the scale involved, it is not an easy problem to overcome either. Moving parts at this size present quite a challenge.

However making things move is not the only way to animate a scene. One classic sight in any industrial workshop or construction site is a man hunched over something he is welding, a fairly slow process that doesn't require much movement. None the less, anyone glancing in that direction is sure something is going on because of the flashes of light caused by the process.

Simulating such flickering is not difficult in electronics, and with the advances in LED technology, can be quite convincing.

HOW IT WORKS



The arc welder simulator is made up from several functional blocks: five oscillators, two gates and the output driver.

IC1A, IC1B and IC1C are all wired as square wave oscillators, each operating at a different frequency under 100 Hz. The three outputs of these oscillators are gated together by a NOR gate consisting of three 1N4148 diodes, a 100k resistor and IC1D. Only when the output of all three oscillators are LOW, is a HIGH present at the output from IC1D. This output is a pulse of semi-random duration and occurring at semi-random intervals. This is used to generate the occasional bright flashes associated with arc welding.

IC1E is also wired as an oscillator operating at a similar frequency to the previous three, though unlike them, its pulse length is adjustable from nearly 0 percent to 50 percent. This is used to generate the consistent flicker. The adjustment is provided to give some control over brightness, which is particularly important when using a lamp as the output. If a fixed mark space ratio was used, some lamp filaments would not achieve enough heat to glow during the short pulse.

The outputs of the NOR gate (IC1D) and the output of the flicker oscillator (IC1E) are gated together by an OR gate consisting of two diodes. This combines the flicker and flash, feeding them to the base of the Darlington driver transistor via a 1k5 resistor.

An onboard LED is provided to allow monitoring of the output.

The circuit as described above would result in a never-ending welding effect, and that would be as bad as not having any animation at all, so the remaining Schmitt inverter IC1F was added to the circuit to switch the effect on and off periodically. IC1F is wired as a square wave oscillator with a cycle of several seconds. Its output is fed to the same OR gate as the flash oscillators, and also to the flicker oscillator via 1N4148 diodes. When the output of IC1F is HIGH, the output of IC1D and IC1E are both forced LOW, preventing any output, thus darkening any LED or lamp connected to the output. When the output of IC1F is LOW the output of both the flicker and flash sections are enabled, giving the welding effect.

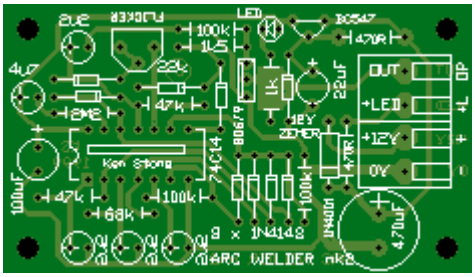
While this cycle is predictable because of its square wave nature, the period is long enough that is isn't that noticeable.

One other note about this oscillator: unlike the other oscillators in this circuit, the timing capacitor is between the input of the Schmitt inverter and the positive rail. This has been done so that when the unit is first powered, the discharged 4u7 capacitor will hold the output of IC1F LOW, allowing the effect to start immediately.

As the arc welder simulator is designed to be used with the uncontrolled DC output of model

railway transformers, a 1N4001 diode has been used to provide polarity protection, and a simple zener/transistor regulator has been included to limit the voltage to the chip to around 12 volts. Without this, the voltage of the model railway transformers could push the power to the chip to over 15 volts, destroying it. The uncontrolled DC output is usually rectified, but unsmoothed, and may be as high as 15 to 18 volts, despite being labelled as 12v on the transformer.

CONSTRUCTION



Arc Welder
PARTS LIST

2 - 470R
1 - 1k
1 - 1k5
2 - 47k
1 - 68k
3 - 100k
1 - 2M2
1 - 20k trim pot

4 - 2u2 25vw
1 - 4u7 25vw
1 - 22u 25vw
1 - 100u 25vw
1 - 470u 25vw

1 - 1N4001 or similar
8 - 1N4148 signal diodes
1 - 12v 400mW Zener>

1 - BC547 transistors
1 - BD679 power transistor
1 - 3mm red LED
1 - CD40106 Hex Schmitt Trigger IC
1 - 14 pin IC socket
2 - 2 way terminal blocks

1 - Arc Welder PCB PC board

Kits can be obtained from Talking Electronics:
http://www.talkingelectronics.com

Extra parts required (not included in kit)

LED version:
6000mcd High bright white LED

Lamp version:
12V to 18V 3 watt lamp

The arc welder simulator is built on a single sided PCB measuring about 5.5 cm by 4 cm. Before you start assembly, check the board for etching faults. Look for any shorts between tracks, or open circuits due to over etching. Take this opportunity to sand the edges of the board, removing any splinters or rough edges.
When you are happy with the printed circuit board, construction can proceed as normal, starting with the diodes and resistors first, followed by the IC socket, then moving onto the taller components.
Take particular care with the orientation of the polarized components, the diodes, LED, electrolytics and the transistor. The metal side of the transistor is indicated on the PCB by and extra line on that side of the component outline.
When inserting the IC in its socket, take care not to accidentally bend any of the pins under the chip. Also, make sure the notch on the chip is aligned with the notch marked on the PCB overlay.

USE

The four external connections to the circuit are all at one end of the board, via the terminal block. The two left most terminals, marked "-" and "+" on the overlay are connected to the power supply. This can be a regulated power supply providing 12V D.C., such as the Economy Power Supply presented in Electronics for Model Railways book 2, or the uncontrolled DC output of the model railway transformer. The kit for the Economy Power Supply is also available from Talking Electronics.
The right most connections on the board, marked "+L" and "OP", are the outputs for driving a LED or lamp respectively.
One of the relatively new high brightness 6000mcd white LEDs can be used. These put out a bright bluish-white light quite reminiscent of the output of an arc welder.
If you choose to use one of these LEDs, connect its anode (the long lead) to the terminal marked "+L" and its cathode (short lead) to the terminal marked "OP".
If you wish, a lamp may be connected here giving a reasonable effect. The lamp should be rated around 3 watts, giving enough brightness for the effect to work properly. The connections to the lamp are a little different, and there may be issues with its voltage. The lamp should be connected between the positive side of the power supply at the terminal marked "+", and the terminal marked "OP". Ideally a 12 volt lamp can be used, but depending on the actual output voltage of the uncontrolled DC output of the model railway transformer, you may find yourself needing to use a lamp that is rated as high as 18 volts. Be prepared to test the lamp *before* building it into your layout. If you notice and silvering occurring in the lamp after it has been running for a while, you will need to find a lamp with a higher voltage rating. An alternative would be to use several identical lower-voltage lamps in series. For example, three 6 volt lamps will give an overall rating of 18 volts.
By now you are probably wondering how a 5mm LED or 3 watt lamp are to be hidden on the layout, as neither is particularly small. The trick is to position them so that they throw light onto the scene around where the arc welding it taking place, possibly under, or in front of the welding scene. The source of the light (LED or lamp) should be hidden, for example in a crate that has one side open, facing away from the viewing angle. Clever use of reflective material can give the impression that an item is being welded. Alternately, you may chose to hide the job being welded with the body of the model welder, instead relying on the effect to show what is happening.
When mounting the arc welder PCB, if you use metal spacers, make sure they do not make contact with any of the PCB tracks, or short circuits may result.

ADJUSTMENT

There is only one adjustment on the circuit board, that for the flicker pulse width. Simply adjust it for the best effect. When driving a lamp from the arc welder simulator, a portion of this adjustment will have no visible effect as the pulse length is too short to heat the filament enough for it to glow.

Kits for this project are available from Talking Electronics.

Article, art & circuit design by Ken Stone.
