# ELM711
# Christmas LEDs Driver

## Description

The ELM711 is a sequencing circuit that is typically used to control strings of LEDs on Christmas trees. No external components are needed for its operation, as all timing and logic functions are performed internally.

Each high current output is capable of directly driving an LED, but in order to drive a string of LEDs, a higher voltage supply and an interface circuit (typically a transistor and two resistors) are required. See the Example Applications section for a short discussion on how you might typically build such a circuit.
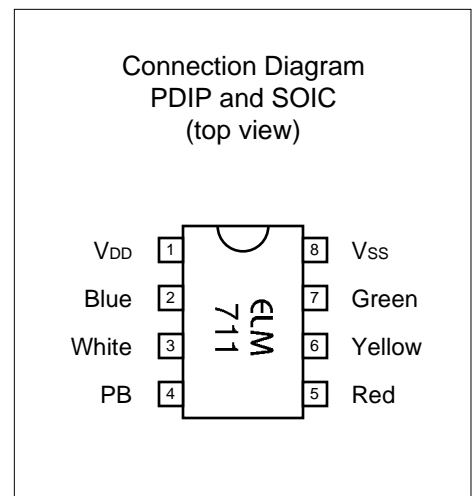
Note that this integrated circuit uses rapid PWM switching techniques to perform the LED dimming, so this device is not suitable for use with slow interface devices such as electro-mechanical relays.

## Applications

- Christmas LED lighting control
- Marquee lighting
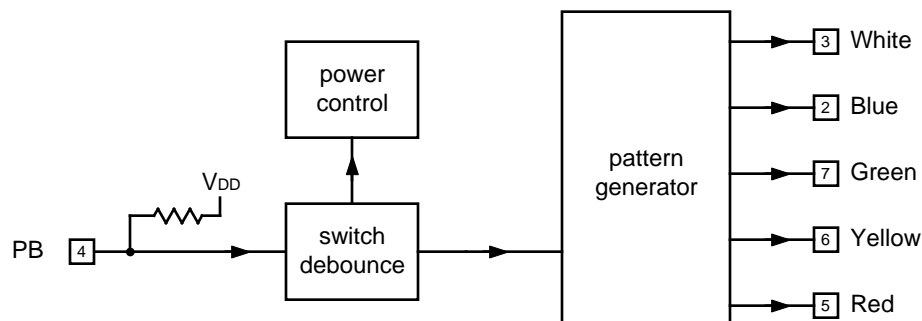- Display attention grabbers

## Features

- One button controls power and patterns
- Needs no external timing components
- Eight different patterns
- Debounced control switch input
- Wide supply range – 3.0 to 5.5 volts
- High current drive outputs
- Low power CMOS design

Connection Diagram
PDIP and SOIC
(top view)

| | | |
|---|---|---|
| $V_{DD}$ | 1 | 8 | $V_{SS}$ |
| Blue | 2 | 7 | Green |
| White | 3 | 6 | Yellow |
| PB | 4 | 5 | Red |

ELM
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## Block Diagram



power control

$V_{DD}$

PB  4

switch debounce

pattern generator

3  White
2  Blue
7  Green
6  Yellow
5  Red

## Pin Descriptions

VDD (pin 1)

This pin is the positive supply pin, and should always be the most positive point in the circuit. Internal circuitry connected to this pin is used to provide power-on reset of the internal microprocessor, so an external reset signal is not required. Refer to the Electrical Characteristics section (page 3) for further information.

Blue, Red, Yellow, and Green (pins 2, 5, 6, and 7)

These outputs are used to control four different groups of LEDs. The colours mentioned are only for pin identification, and you can connect the actual colours as you wish (none of the patterns require a specific colour).

Each pin outputs a high level (VDD) when 'active' or 'on'. Note that Pulse Width Modulation (PWM) techniques are used by a few patterns to control the intensity of the LEDs, with a minimum pulse width period of about 1 msec. For this reason, the ELM711 should not be used with mechanical relay circuits.

White (pin 3)

This output is identical to the others except that in many sequences, it is held continuously on. The intention was that this would control a special group of LEDs on the top of the tree (for a star or other ornament).

PB (pin 4)

This pin is for the connection of a momentary action pushbutton switch. Each press of the switch should connect this pin to circuit common (VSS).

If the outputs are on, a momentary pressing of the switch will change the LED pattern to the next available one (there are eight in total). If the button is pressed for more than 2 seconds, the circuit will turn off all of the outputs. If the outputs are off when the switch is pressed, the circuit will turn itself on with the pattern set to the one that was in effect when the circuit was turned off.

This input is internally 'debounced' and has an internal pullup resistor to simplify the direct connection to mechanical switches. Should you prefer to use a logic signal rather than a switch, this can be easily done, as the input will accept standard TTL and CMOS logic levels.

VSS (pin 8)

Circuit common is connected to this pin. This should be the most negative point in the circuit.

## Ordering Information

These integrated circuits are available in either the 300 mil plastic DIP format, or in the 208 mil SOIC surface mount type of package. To order, add the appropriate suffix to the part number:

300 mil Plastic DIP.............................. ELM711P          208 mil SOIC..................................... ELM711SM

## Absolute Maximum Ratings

Storage Temperature....................... -65°C to +150°C

Ambient Temperature with
 Power Applied...................................-40°C to +85°C

Voltage on $V_{DD}$ with respect to $V_{SS}$............ 0 to +7.0V

Voltage on any other pin with
 respect to $V_{SS}$........................... -0.6V to ($V_{DD}$ + 0.6V)

Note:

Stresses beyond those listed here will likely damage the device. These values are given as a design guideline only. The ability to operate to these levels is neither inferred nor recommended.

## Electrical Characteristics

All values are for operation at 25°C and a 5V supply, unless otherwise noted. For further information, refer to note 1 below.

| Characteristic | Minimum | Typical | Maximum | Units | Conditions |
|---|---|---|---|---|---|
| Supply Voltage, $V_{DD}$ | 3.0 | 5.0 | 5.5 | V | |
| $V_{DD}$ rate of rise | 0.05 | | | V/ms | see note 2 |
| Average Supply Current, $I_{DD}$ | | 0.8 | 1.4 | mA | see note 3 |
| Output low voltage | | 0.3 | | V | current (sink) = 10 mA |
| Output high voltage | | 4.2 | | V | current (source) = 10 mA |
| PB input debounce time | | 60 | | msec | |
| PB input pullup resistance | | 400 | | K | see note 4 |

Notes:

1. This integrated circuit is produced using one of the Microchip Technology Inc.'s PIC12C5XX products as the core embedded microcontroller. For further device specifications, and possibly clarification of those given, please refer to the appropriate Microchip documentation.

2. This spec must be met in order to ensure that a correct power on reset occurs. It is quite easily achieved using most common types of supplies, but may be violated if one uses a slowly varying supply voltage, as may be obtained through direct connection to solar cells, or some charge pump circuits.

3. Device only. Does not include any current supplied to external circuits.

4. This is typical – the value varies with temperature and voltage.

## ELM711 Operation

The ELM711 is a very simple sequencing circuit that uses one of eight preset patterns to control five output pins. When power is initially applied, the circuit will reset itself, and will display pattern 1, a traditional slow sequence, with the White LED on continuously.

While displaying an output pattern, the circuit continuously monitors the pushbutton (PB) input for signals from the user. If it sees a short pulse on this pin, it will switch to the next stored pattern (see Table 1 for a description of all 8 patterns). Should the circuit be displaying pattern 8 when the button is pressed, it will go to pattern 1.

If you wish to turn the circuit off, simply press the pushbutton for at least 2 seconds. When the ELM711 sees this special signal, it will force all 5 outputs to a low (off) level, and will keep them in that state until the next time that the pushbutton is pressed. Provided that the supply to the ELM711 was not interrupted, the next time that the pushbutton is pressed, the circuit will 'wake up' and display the last-selected pattern.

| Pattern | Description |
|---------|-------------|
| 1 | This one provides a slow twinkling of all of the coloured LEDs (the White one will stay on continuously). The rate will vary slightly with time to give a more natural appearance. |
| 2 | This pattern fades one colour out at a time (including the White one) with a fairly slow period. LEDs are faded in the order White, Red, Yellow, Green, and Blue. |
| 3 | The White LED stays on continuously, while the other colours fade in and out very slowly. A relaxing pattern. |
| 4 | A fast blinking pattern – all LEDs (including the White) are only on for a short time. Not a very relaxing pattern, but it does grab your attention. |
| 5 | Strings will light one at a time, with the White on throughout. Once per sequence, the White LED will blink. |
| 6 | One colour at a time is added until all LEDs are on, then all turn off and the pattern builds again. |
| 7 | Similar to pattern 6 with the strings building over time, but this pattern also turns them off one at a time, rather than all at once. |
| 8 | This pattern provides a rapid twinkling of all the LEDs (including the White one). |

Table 1. ELM711 LED Patterns

## Example Application

This section shows how the ELM711 might be typically used. Basically, all that needs to be done is apply power to the IC and it will create a sequence of outputs for you. There are some concerns over the external connections that should be discussed first, however.

Whenever interfacing to CMOS circuitry, you need to protect against a problem called 'latchup'. This may occur when excessive current is allowed to flow into one of the IC's pins, typically an input. This can happen at almost any time, but generally occurs if there are long wires connected directly to the IC, with no form of current limiting. Latchup will cause excessive currents to flow, which may damage components (such as the ELM711).

Figure 1 shows how a pushbutton will typically be connected to the input of the ELM711. This works well if the wires to the switch are short (less than about 12 inches long). If the wires are longer than that, currents can more easily be induced into the wires, and into the ELM711 pin. Since there is no current limiting, the currents can possibly be large enough to exceed the latchup threshold, and the IC may be damaged. Simply adding a series resistor such as that shown in Figure 2 is all that is generally needed to prevent latchup. Note that we also show a 4.7K pullup resistor connected to the switch as well. This pullup resistor helps to pass some of the induced currents around the ELM711 input, and also provides a lower impedance input so that the voltages caused by the induced currents are reduced, and less likely to provide false inputs. (The ELM711 input pin also uses a relatively long debounce time, so that it is less susceptible to noise.)

The ELM711 may be used to control other devices, but it was designed with LEDs in mind. When on, LEDs require a forward voltage of about 2 to 3 volts as shown in Table 2. These voltages will remain fairly constant over a wide range of currents, and can be used in calculations as if they are constant.

If the ELM711 is to use a 3 to 5 volt power supply, it is clear that it can only be directly connected to 1 or possibly 2 LEDs on each output, as there isn't enough voltage available to power a longer string of LEDs. This could result in a sparse Christmas tree unless something can be done.

The circuit of Figure 3 shows a transistor driving several LEDs from a power supply of Vp volts. As long as the sum of the LED voltages is less than Vp, the
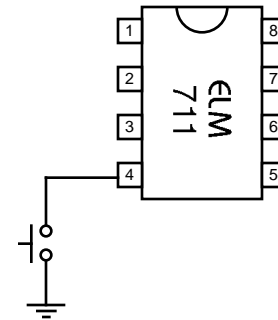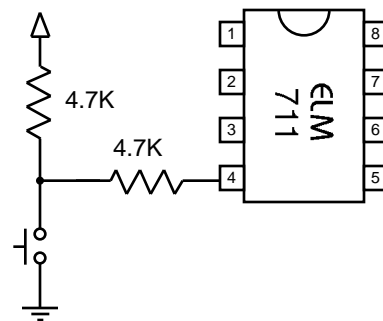

Figure 1. Typical Pushbutton Connection


Figure 2. Protection for very long PB leads

| Colour | Typical Vf |
|--------|-----------|
| Red | 1.8 |
| Yellow | 1.9 |
| Green | 2.0 |
| Blue | 3.0 |
| White | 2.9 |

Table 2. Typical LED Forward Voltage Drops

## Example Applications (continued)

resistor (R) will have a voltage across it, and the total current in the string will be determined by the voltage across the resistor, and the value of that resistance. Choosing a resistance value may require a little experimentation, but to get you started:

If you plan to use N LEDs in the string, each with a forward voltage drop of Vf, then choose Vp such that:

$$Vp \quad (N+1) \times Vf$$

Then, given the LED current (I), determine the value of R from:

$$R = (Vp - NxVf) \div I$$

For example, if you wish to have 4 green LEDs in a string, then you need to choose:

$$Vp \quad (4+1) \times 2.0$$
$$Vp \quad 10.0 \text{ volts}$$

Since 12V supplies are very common, we will use that. Then, you need to choose R, which requires a knowledge of the LED current. A good starting point is to use 9 or 10 mA for red, yellow and green leds, and a smaller current (4 or 5mA) for the blue and white LEDs. As this calculation is for a green LED, we choose I = 9 mA (or 0.009 A). R is then given by:

$$R = (12 - 4x2.0) \div 0.009$$
$$R = 444$$

While 444  is not a standard value, you could select either 430  or 470  for the resistor and the current would still be close to the desired 9mA. Continue in a similar fashion for the other colours. You may need to try a few resistor values for each colour in order to make all the LEDs appear to be of the same brightness, as your eye is more sensitive to some wavelengths, and some LEDs are simply more efficient than others.

In this way, all of the component values can be chosen and a circuit such as the one in Figure 4 can be designed. Note that Figure 4 does not show a transistor driving the white LED, as the wires to it are short, and the resistor helps to limit currents should some be induced. If you are considering very long wire runs, the White LED should also have a transistor buffer added in the same way as the others.

Figure 4 also shows a supply bypass capacitor connected across the ELM711 power supply pins. This is to prevent problems due to the transients, or 'spikes', that are inherent in all digital circuit's current flow (due to the internal switching process). By adding

a capacitor very close to the IC, much of the current for these spikes can be supplied by the capacitor rather than through the (inductive) leads of the supply. The net result is that there will be less noise generated at the supply by the ELM711. A value of 0.01µF works well.

We will leave the wiring details to you, but to get you started, we have found that the wires for a small (2 to 3 foot high) tree should be about 5 feet long. Space the LEDs about 12 inches apart, beginning at the end, and install them by cutting a 2 inch piece from one of the two conductors in the wire. When you bring the two ends of the cutout together to solder them to the LED, the other conductor is forced to form a loop, which allows it to hang from a tree branch.
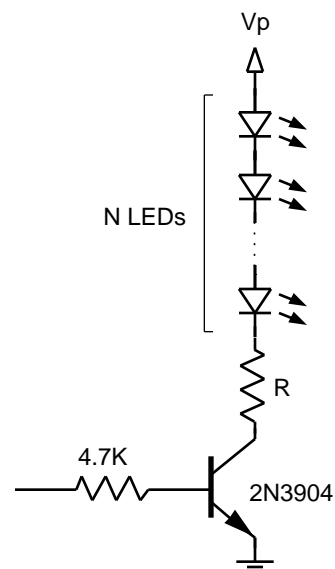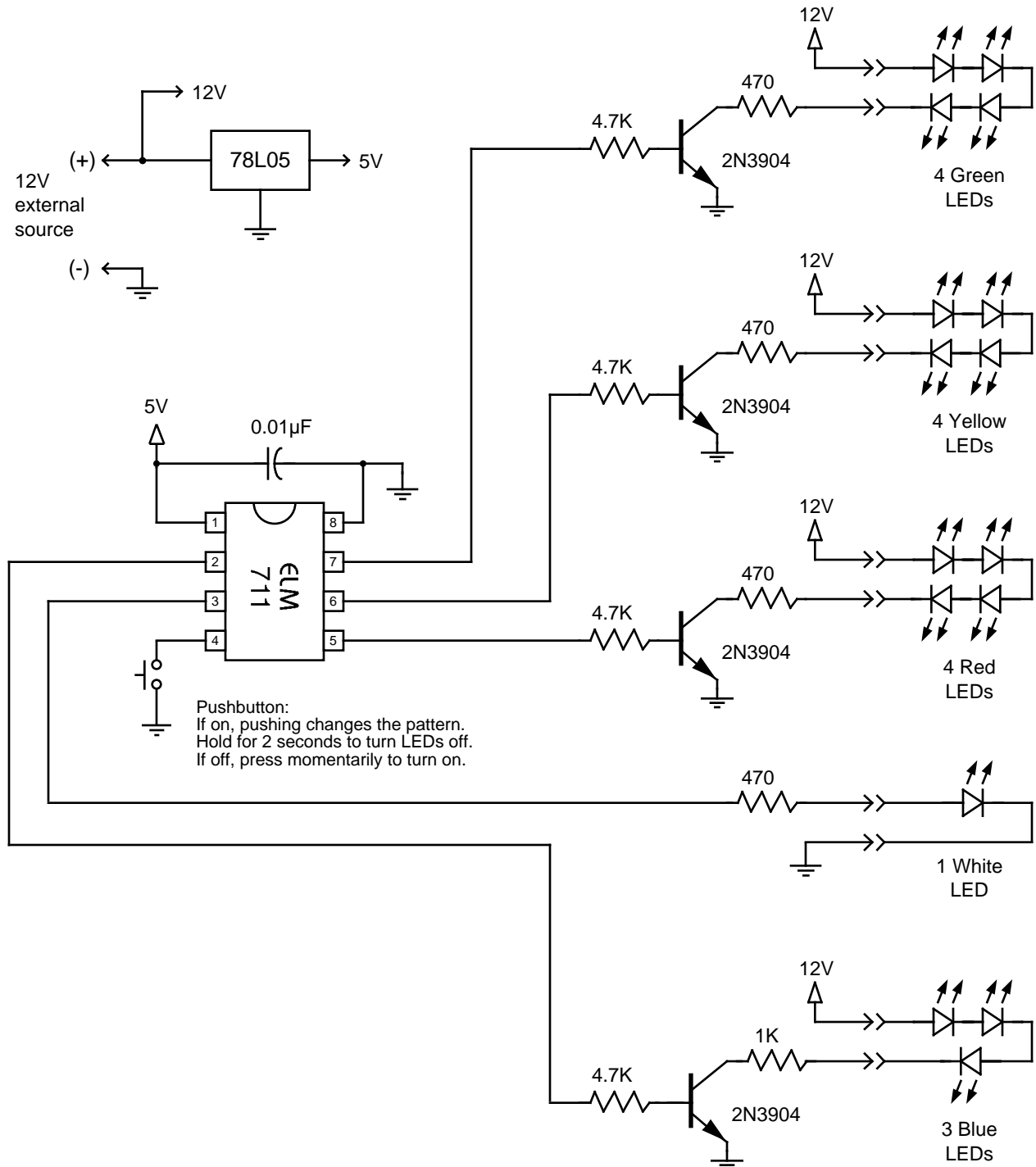
Enjoy the light show!



Figure 3. Driving LED Strings

Figure 4. Typical Connections for a Small Christmas Tree