More information from one port pin

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1. A special light emitting diode

It's always the same situation, the most applications with the BASIC-Tiger™ need more I/O pins than it has. If you want to show a digital (on or off) condition of a system you can use a simple LED with one port pin, if the condition is analog with more than two values, you need normally the LC display. But in many applications a PWM port is not needed so that we can use the capabilities of this PWM port to show an analog value with a simple LED too. The PWM pin switches on and off the LED very fast and the different on and off times make the LED brighter or darker (principle of a dimmer).
But there is a much better way to signalize analog values by using two-color LED's (for instance red and green). So you can show all variations from green over yellow to red. This can be an interesting alternative for any digital display, may be your application has no LC-display or may be you need a additional instrument to show the condition of battery for instant (green = full, yellow = nearly low, red = low).

2. The Circuit

Two-color LED's you can buy all over, mostly in combinations of red / green, green / yellow or yellow / red, may be you can get some new combinations with blue or white. Picture 1 shows such a LED, they all have three pins, the middle pin is the common electrode, the right and left pins are the other electrodes of each diode chip.

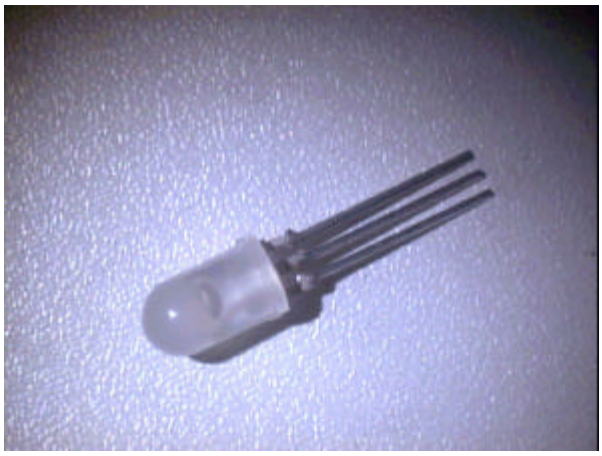

Fig. 1 a two-color LED

The used two-color LED in our project is one with common cathode, connected to GND. The both anodes have to be connected to Vcc via a resistor. If LEDs are lighting they have a nearly constant voltage so that you have to limit the diode current for preventing an overload. Every LED have its own "burning" voltage particularly at different colors. For this reason it is

necessary to select the resistor so that the both LEDs have the same light intensities. In our circuit we switch both LEDs with logic gates so that we have prevented overload automatically.
Some words to the basic principle. The BASIC-Tiger™ converts an analog value (A byte, that means numeric steps form 0 to 255) to a corresponding PWM value ("low" time and "high" times in a square wave signal). Fig. 2 shows the relations as a sample. The clock itself has a constant frequency but the "high" time (the LED's "burning" time) is changing its duration.

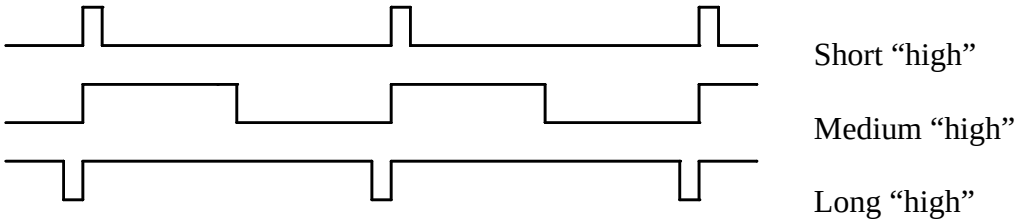

Fig. 2 The principle of pulse wide modulation

A high frequency (> 100 Hz) is necessary if you want to see no flickers. To switch on and off two LEDs mutual the signal for the second LED has to be inverted. This does a gate of a 74LS04 and so always only one diode is emitting light but their time share is depended from the PWM signal.

The both LEDs should have the same conditions and so we switch both with a gate output of the 74LS04 one LED has one gate (for inverting the signal), the other has two gates (two times inverting reconstruct the original signal). Fig. 3 shows the circuit.

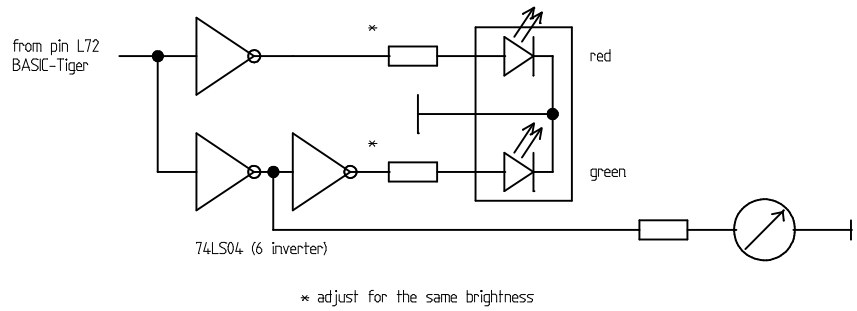

Fig. 3 PWM control of a two-color LED with additional moving coil indicator

The resistors of the both LEDs have to be adjusted to get the same brightness for each diode (some 10Ω till some 100 Ω). The 74LS04 has six single inverter, three of them we could used for a second indicator LED controlled by the second PWM output of the BASIC-Tiger™. If you need more brightness you can use a more powerful inverter IC.

The little BASIC-Tiger™ program 2LED01e.TIG demonstrates the possibilities of such a "analog" LED.

Some words to the applications of PWM controlled LED. A typical application are the mentioned above battery display or an amplitude meter in combination with an analog input of the BASIC-Tiger™. If you use a NAND instead of an inverter you can switch an “free colored” LED on and of. The PWM signal makes the color and another logic signal makes the LED blinking. Particularly if the application has no LC display such “analog” LED’s are interesting. You can show analog values and process steps static or blinking with different colors or different brightness.
By the way, the same effect is to use a small moving coil indicator at the PWM output of the BASIC-Tiger™. It should be an instrument with a full scale current of some 100 µA. The resistor can trimmed so that the value of 255 moves the arrow of the instrument to its maximum. With this method you can see tendencies and analog values too. The following pictures show some samples of the PWM driven LEDs and mechanical instruments “in action”. The instrument has the same value like the left LED, both are controlled by the PWM output L72.

Pic. 4 PWM value = 255 = green

Pic. 5 PWM value = 128 = yellow

Pic. 6 PWM value = 0 = red

3. Software

With the hardware above the program 2LED01e.TIG runs a demo. The LED goes continuously from green via yellow to red. After this the LED blinks in the two main colors. The moving coil instrument follows the values too. The sub program “Display” shows the actual numerical PWM values at the LC display.