
Appendix

For those who want to know more about timers

Microcontroller AT89C2051 has two identical timers, Timer0 and Timer1 (fig. 6). They are fairly complex circuits; they can be controlled from the program by entering specific values into the specific bits of the registers TMOD, TCON & IE. These registers are "shared" for both timers; only the hardware part is separated. Figure shows Timer0 so we will stick to it in the description, but everything we have to say for Timer0 is also valid for Timer1 (following rule applies: Counter0 = Counter1, TR0 = TR1, ET0 = ET1 etc.)...

The basic part of Timer0 is a 16-bit register **Counter0**. It can count the pulses on the input pin P3.4 (S1 in position 1) or machine cycles (S1 in position 0). Timer0 works as a counter in the first mode and as a timer in the second mode. Machine cycles are repeated at 1/12 of the frequency of the local oscillator; at $f_{osc} = 12 \text{ MHz}$, f_{sc} equals 1 MHz and measured time will be expressed in microseconds. The speed of counting external pulses also depends upon f_{osc} : at least two machine cycles are required to detect a change of state on the input pin P3.4. This is why the highest frequency of the pulse can't be more than 500 kHz for $f_{osc} = 12 \text{ MHz}$ (actually around 450 kHz).

Timer0 mode can be controlled from BASCOM with a simple command; **Config Timer0 = Counter/Timer**. What we actually do here is write specific value into the C/T-bit of the TM OD register.

Then we need to specify ways to activate Timer0. Schematic diagram shows that we need to close S2 to activate the timer, which can be accomplished by:

- if we selected the internal control (**Config... Gate = Internal**), then S2 will close as soon as we'll enter "1" to bit TR0 of the TCON register (**Start Timer0/Counter0**, in this case Timer0 and Counter0 mean the same thing).
- If we selected external control (**Config... Gate = External**), then the switch S2 will close, if "1" has been written to bit TR0 of the TCON register and if pin INT0 (P3.2) holds on logical "1" – this way makes it possible to control S2 (start and end of counting) by an external voltage.

In both cases we could also stop Timer0 by writing "0" to bit TR0 (**Stop Timer0/Counter0**).

Counter0 can count only in four different ways, definable by writing appropriate values to locations M1 and M0 of the register T MOD (**Config... Mode = 0/3**):

- Mode 0: Counter0 works as a 13-bit counter, configured as 8-bit counter (TH0) with 5-bit prescaler (lower 5 bits of TL0). As soon as the counter reaches the