Application Hints

for external Oscillator Circuitry

Topics:

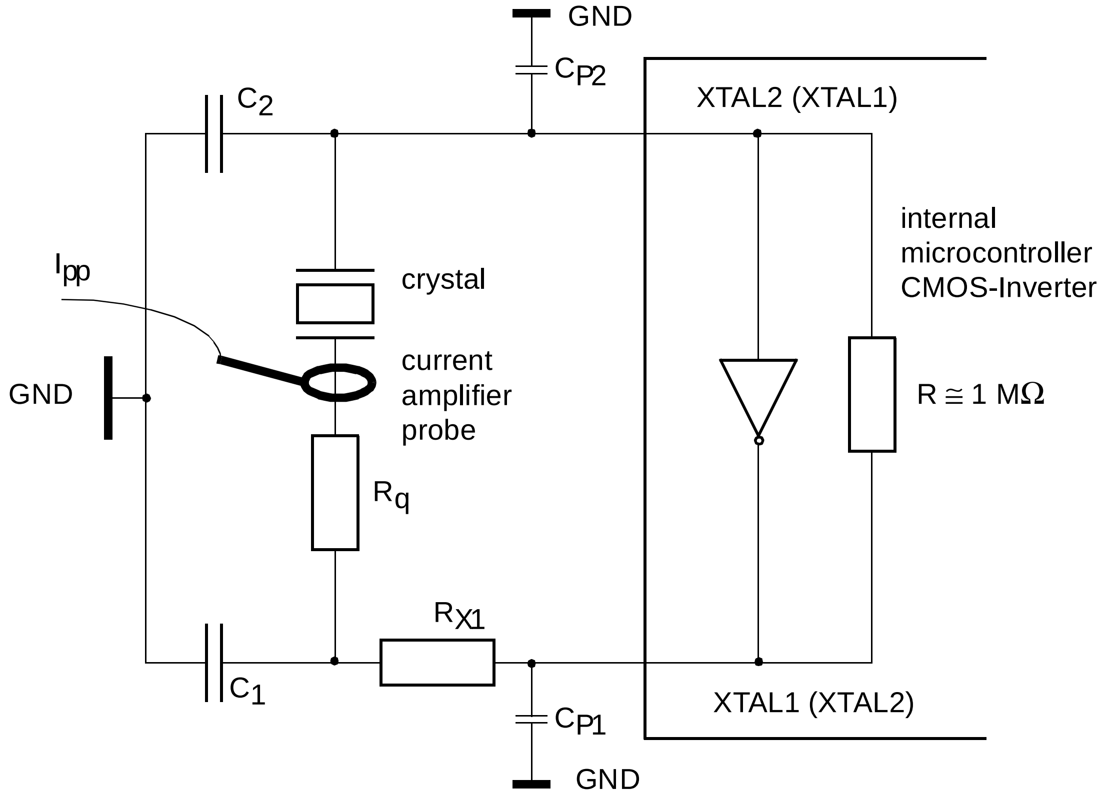
- influences of the oscillator circuitry
- external oscillator circuitry for measurements of fundamental crystals
- measurement characteristics for the drive level
- definition of the oscillator start time
- application hints for the fine tuning
- effect of circuit composition when tuning some dedicated parameters
- appendix (measurement protocols of the SAB 80C517A, ES-LA)

Influences of the Oscillator Circuitry

- components of the external circuitry
- stray capacitances and inductances
- crystal parameters
- board layout
- power supply rise time
- power supply quality
- temperature

Because of the above influences, Siemens as microcontroller manufacturer cannot give assured characteristics for the external oscillator circuitry . Therefore only recommend-ations can be given. The customer must proof in his application, whether his used external components for the oscillator circuitry correspond to his given demands.

External Oscillator Circuitry for Measurements of fundamental Crystals



C_1/C_2	...	capacitors which are parts of the load capacitance C_L
C_{P1}/C_{P2}	...	probe capacitance; probes are used for measuring XTAL1/2 amplitudes and oscillation start time ta
I_{pp}	...	measured drive current with current amplifier
R_{X1}	...	resistor is used for optional controlling of the drive current
R_q	...	resistor is used for checking the quality of the oscillation start up after power on (oscillation allowance)
GND	...	ground connection should be as close as possible to the controller GND pins (nearby XTAL pins)

Measurement Characteristics for the Drive Level

Drive Level: $$D_L = I^2 \times R_L$$

Drive Current: $$I = \frac{Ipp}{2 \times \sqrt{2}}$$ (for sine waveform)

Transformed equivalent series resistance with load capacitances:

$$R_L = R_1 \times \left(1 + \frac{Co}{C_L}\right)^2$$

Load Capacitance: $$C_L = \frac{C_{X1} \times C_{X2}}{C_{X1} + C_{X2}} + C_S$$ with: $$C_{X1} = C_1 + C_{P1}$$ $$C_{X2} = C_2 + C_{P2}$$

R_1 ... equivalent series resistance (see spec. from osc. crystal; typ. ≅ 50 Ω for crystals in the range from 8 to 20 MHz

C_0 ... shunt capacitance (see specification of oscillator crystal; ≅ 5 pF)

C_1/C_2 ... capacitors connected from ground to XTAL1/XTAL2 (C_1/C_2 should not be smaller than C_0)

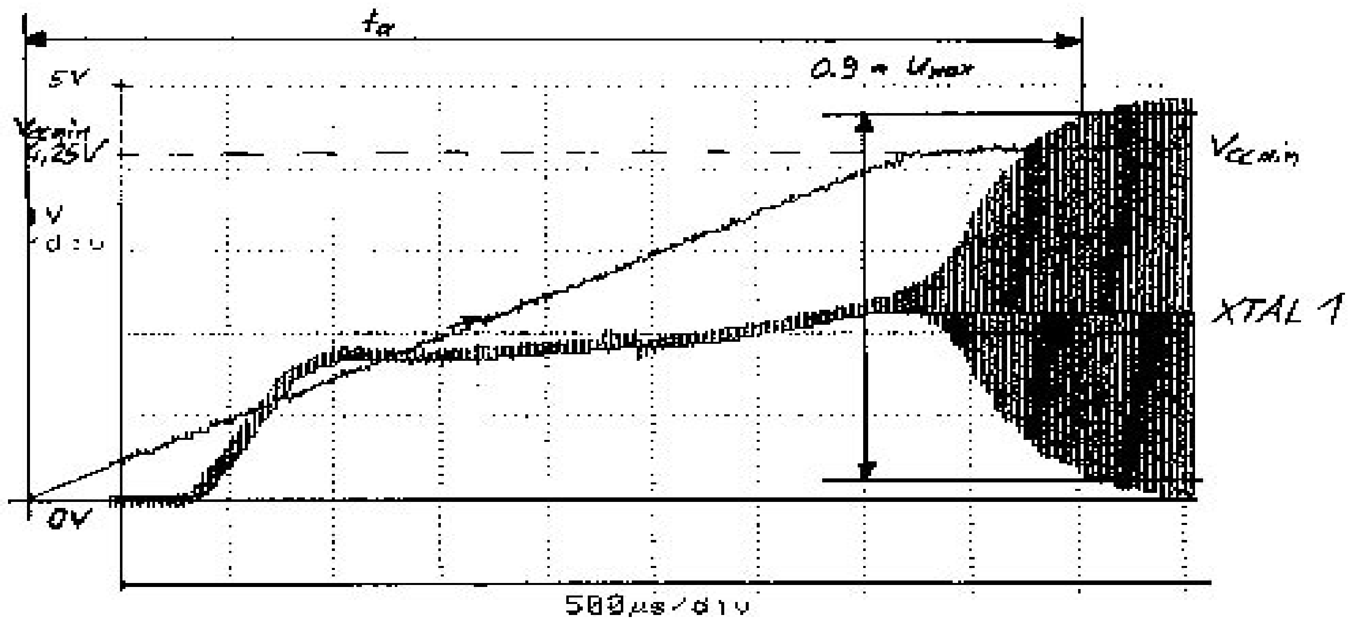
C_{P1}/C_{P2} ... probe capacitance; active probes ≅ 1 - 2 pF; passive probes 10 -15 pF

C_S ... stray capacitance, e.g. from the board layout; ≅ 0 - x pF (≅ 2 pF for a two layer board)

Definition of the Oscillator Start Up Time ta

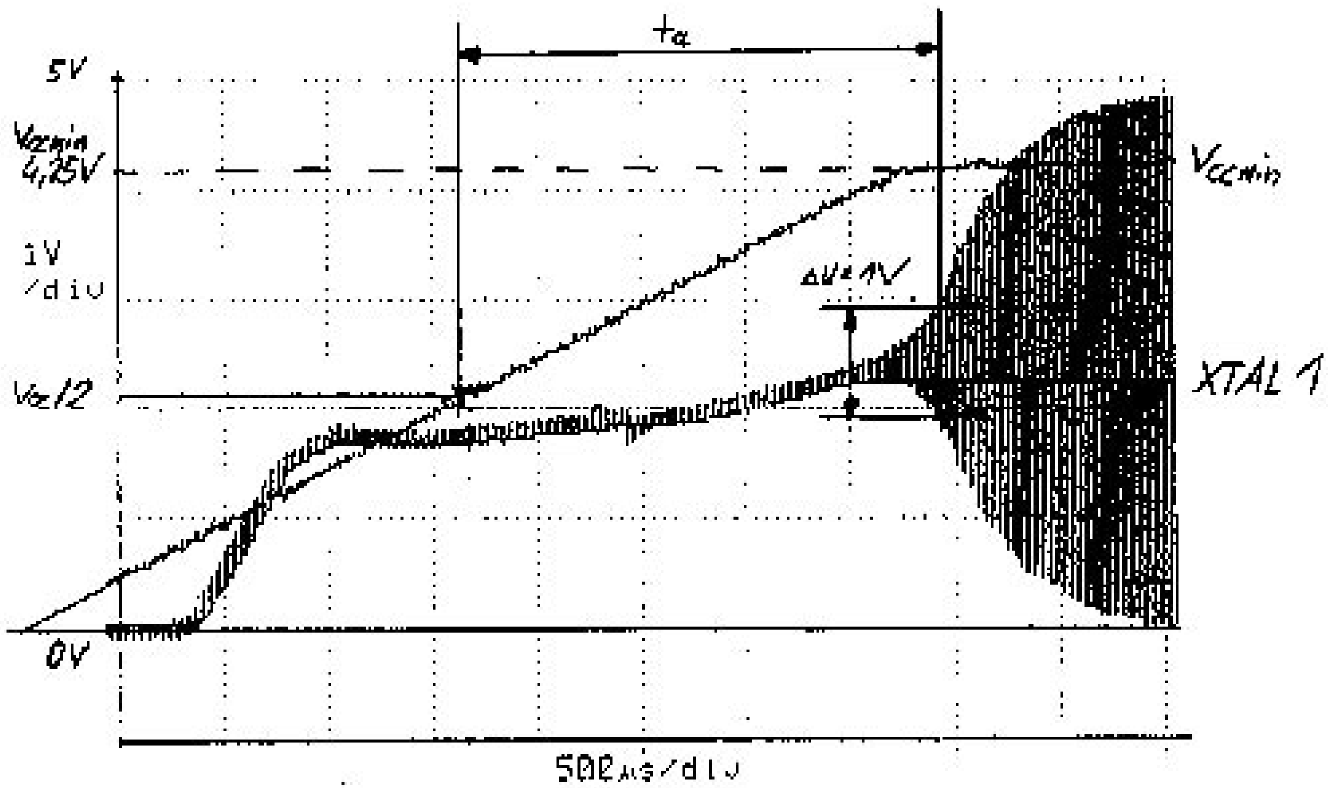
The definition of the oscillator start up time is not a well defined value in the literature. On principal it depends from the power supply rise time dVcc/dt at power on and the absolute Vcc level. For measurements the application specific power supply rise time dVcc/dt and the Vccmin level should be used. In the following two different definitions for ta are shown with dVcc/dt = 1 V/ms and Vccmin = 4.25 V.

- Figure 1: ta is measured between Vcc = 0 V and the point where the oscillation reaches 90% of the maximum amplitude.



Definition of the Oscillation Start Time ta

- Figure 2: ta is measured between Vcc = Vcc/2 and the point where the oscillation reaches an maximum peak to peak value of 1V.



Application Hints for the Fine Tuning

- Checking for Oscillation Allowance

Find out the maximum serial resistor Rq, where the oscillator circuit still starts up after power on. For this, vary Rq from low values to high values until the oscillator fails to start up. The last Rq value shows proper oscillation start up with its maximum value.
The quotient Rq/R1 is used for checking the oscillation allowance:

Demand: $\frac{Rq}{R1} \geq 5$ (the higher, the better)

Note: Rq is only used for checking the oscillation allowance and must be removed in the final application. Rq is often refered to as the negative resistance -R of the oscillator circuit.

- Drive current and life time:

For assuring the life time of the crystal unit, the used drive level in the application should be ten times lower than the specified maximum drive level for the oscillator crystal; e.g. with D_{LMAX} = 5 mW the drive level in the application should be limited with R_{X1} to 500 µW.

Effect of circuit composition when tuning some dedicated parameters

influenced parameters

		I	XTAL1	ta	Rq/R1	DL=I²*RL Rq=0	DL=I²*RL Rq>0	RL= R1*(1+C0/CL)²
variation	**C1=C2 ↑**	↑	↓	↑	/	*	↓	↓
of	**C1=C2 ↓**	↓	↑	↓	/	**	↑	↑

* (C1=C2) > 10 pF ---> ↑
* (C1=C2) < 10 pF ---> ↓
** (C1=C2) > 10 pF ---> ↓
** (C1=C2) < 10 pF ---> ↑

influenced parameters

		I	XTAL1	ta	Rq/R1	DL=I²*RL	RL= R1*(1+C0/CL)²
variation	**Rx1 ↑**	↓	↓	↑	↓	↓	/
of	**Rx1 ↓**	↑	↑	↓	↑	↑	/

not influenced	/
rising	↑
falling	↓

DL	drive level
I	drive current
XTAL1	amplitude of oscillation at XTAL1 pin
ta	oscillation start up time
Rq/R1	used for checking the oscillation allowence
RL	transformed equivalent series resistance

Effect of circuit composition when tuning some dedicated parameters

influenced parameters

			I	XTAL1	ta	Rq/R1	DL=I^2*RL	RL= R1*(1+C0/CL)^2
variation	Rq	↑	↓	↓	↑	/	↓	/
of	Rq	↓	↑	↑	↓	/	↑	/

influenced parameters

			I	XTAL1	ta	Rq/R1	DL=I^2*RL	RL= R1*(1+C0/CL)^2
variation	Vcc	↑	↑	↑	↓	↑	↑	/
of	Vcc	↓	↓	↓	↑	↓	↓	/

not influenced	/
rising	↑
falling	↓

DL	drive level
I	drive current
XTAL1	amplitude of oscillation at XTAL1 pin
ta	oscillation start up time
Rq/R1	used for checking the oscillation allowence
RL	transformed equivalent series resistance