How to Calculate the Capacitor of the Reset Input of a C51 Microcontroller

This application note explains how the reset of the 80C51 microcontroller works when the RST pin is a pure input pin and when the RST input is bi-directional. It gives rules to determine the extra components required to operate the reset function properly. The reset process can be active on low or high level depending on the product. In this application note only the high level case is discussed.

Introduction

The reset is used to start-up or to restart the 80C51 microcontroller activities. It forces the 80C51 in a known state by reinitializing all the internal registers needed to properly start the program execution. The reset must be kept active until all three of the following conditions are respected:

- The power supply must be in the specified range.
- The oscillator must reach a minimum oscillation level to ensure a good noise to signal ratio and a correct internal duty cycle generation.
- The reset pulse width duration must be at least two machine cycles.

If one of the conditions is not respected the microcontroller will not startup properly.

Theory of Reset Operation

To ensure a good startup, the reset pulse width has to be wide enough to cover the period of time where the electrical conditions are not met. Two parameters should be considered for a proper reset sequence to determine the reset pulse width (see Figure 1):

- $\mathbf{t_{osc}}$: time needed by the oscillator to reach the Vih1 or Vil1 level.
- $\mathbf{t_{vddrise}}$: rise time of the power-supply taken between 10 to 90% of V_{DD}.

When these two parameter conditions are met, the reset has to be maintained at least two machine cycles in order to synchronize the internal activity of the core. In normal mode, a machine cycle is 12-clock periods and in X2 mode is 6-clock periods.

80C51 Microcontrollers

Application Note

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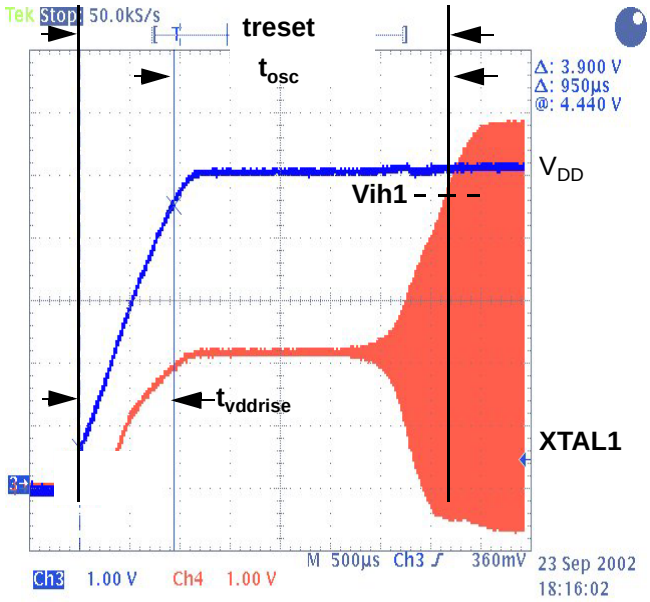
Figure 1. t_{osc} and $t_{vddrise}$ are the Two Parameters to Evaluate, Depending on the Application

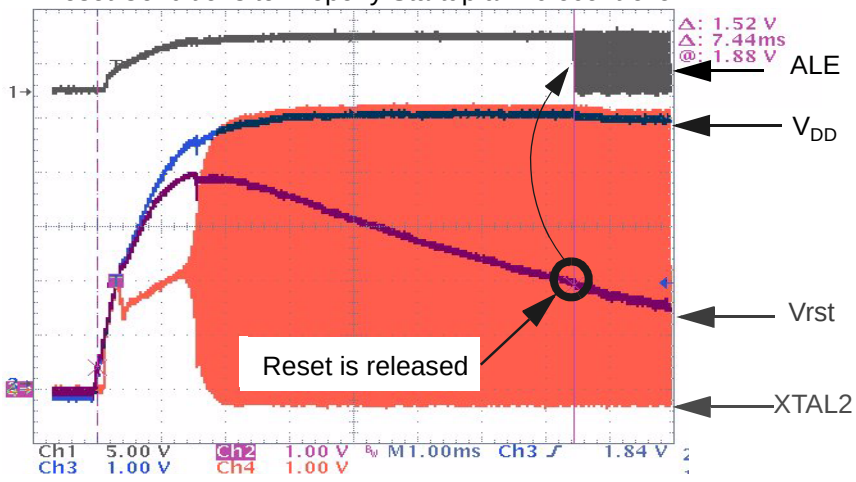


Vih1 is the reference parameter taken to calculate and determine the time constant of the reset. Indeed, normally the input is considered to be low when its level reaches **Vil1**. But in reality the trigger is somewhere between **Vih1** and **Vil1**. So, the worst case condition is considered at the **Vih1** level.

When the reset is released, the program execution starts and the ALE signal toggles as it is illustrated in Figure 2. and showing a proper startup condition:

- V_{DD} is within the voltage operating range,
- The level of Xtal1 is greater than the Vih1 level specification,
- The reset reached its active level (Vih1) and is maintained at least two machine cycles.

Figure 2. Reset Conditions to Properly Startup a Microcontroller

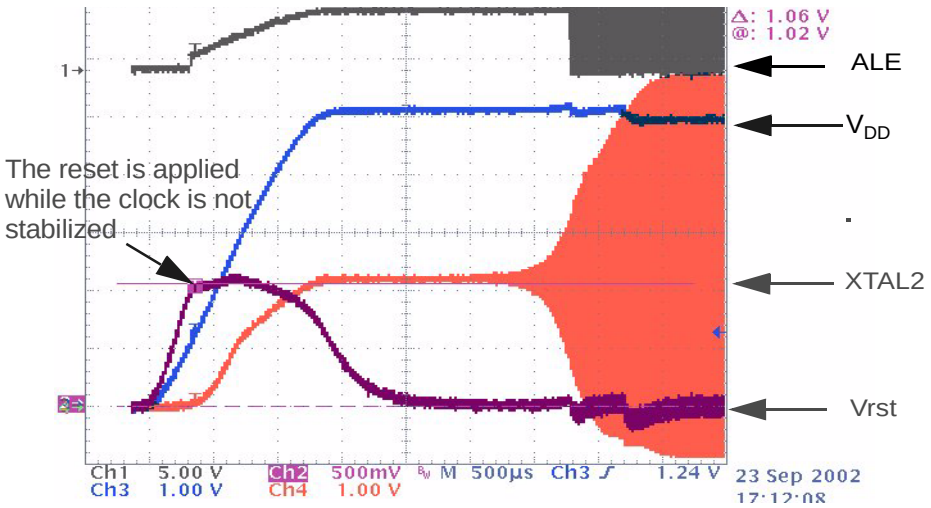


Why Does the Reset Does Not Properly Start the Microcontroller?

The Oscillator is not Stabilized

Figure 3 shows the case where the RST signal is applied while the oscillator is not stabilized and there is no clock to reset the internal registers of the CPU. Due to this bad reset, the first address fetched can be anywhere in the program space except address 0000h.

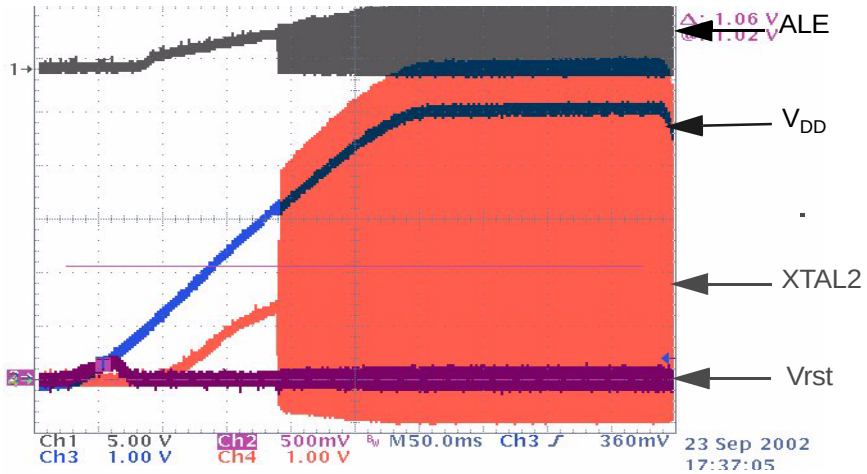
Figure 3. If electrical Conditions are not Met, the Reset Signal is Applied but without the Clock



Reset is Released before V_{DD} is Stable

Figure 4 shows the case where the reset is released before the V_{DD} is stable. The microcontroller will never see the reset and can start anywhere in the program space and with a bad register initialization.

Figure 4. The Reset is Released before the Clock and the V_{DD} are Stable



Reset Input Circuitry Description

At least two kinds of reset input structure exist in C51 products. The first one is a pure input which allows an external device to reset the microcontroller. The second one is bi-directional. The microcontroller can be reset by an external device. The microcontroller can reset an external device when, for example the internal watchdog expires. Table 1 lists some C51 Atmel products which have uni-directional or bi-directional reset.

Table 1. Examples of Products Using Uni-directional and Bi-directional Reset

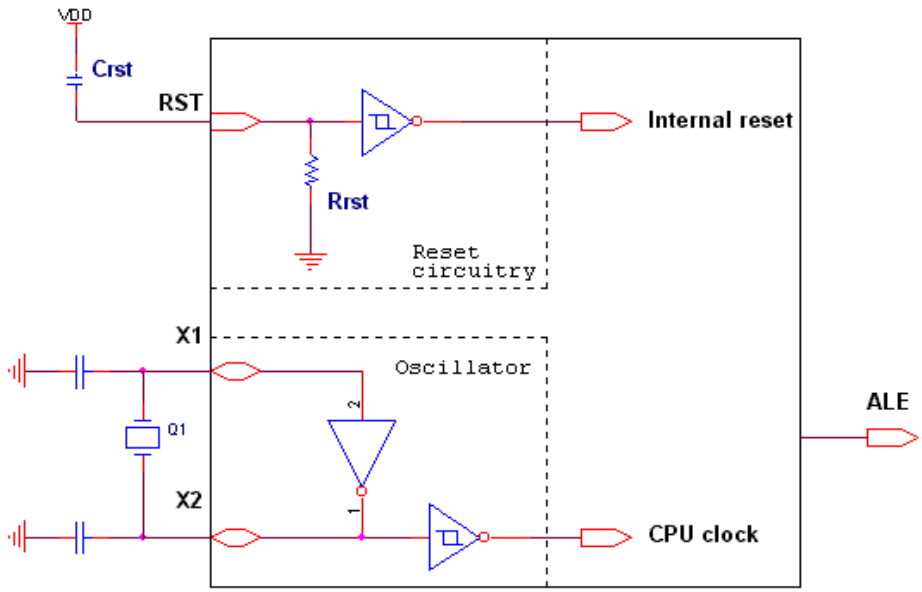
Product	Main Features	Uni/Bidir
T83C51RB2	16 KB of ROM, Watchdog	B
T89C51RD2	64 KB of Flash, Watchdog	B
AT89C51CC01	10-bit ADC, CAN controller	B
AT89C51SND1	MP3 decoder, TWI, MMC, USB	U

uni-directional Reset Input

Description

The uni-directional reset input circuitry is shown in Figure 5. A pull-down resistor, **Rrst**, is connected between the RST input and the ground. An external capacitor, **Crst**, is connected between the RST input and the V_{DD}. The value of **Crst** determines the reset time duration. The calculation of **Crst** is explained in the next chapter.

Figure 5. Reset Structure for an uni-directional Circuitry



Theory of Operation

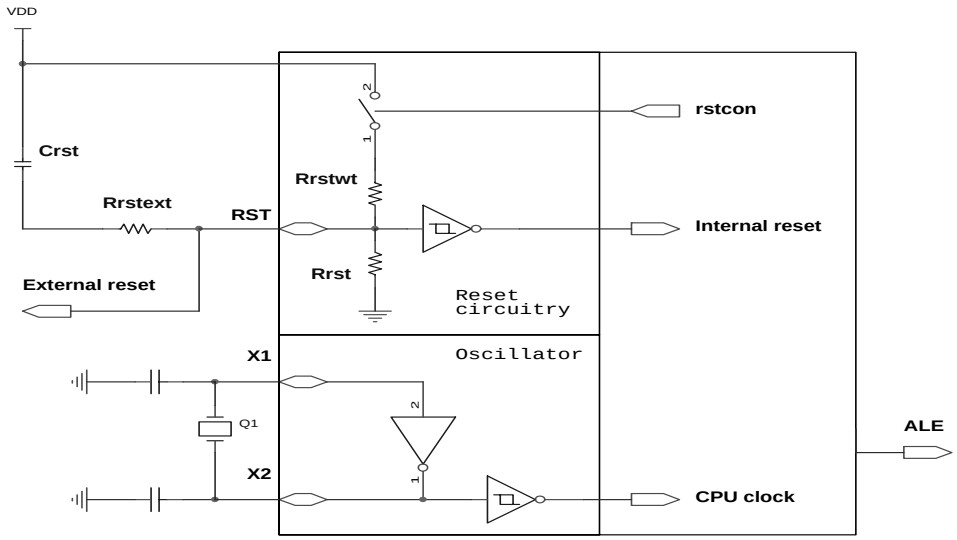
When a reset is applied on the RST input, **Crst** is discharged and then charged through **Rrst**. The reset is active until the level applied on the RST pin is below **Vih1**. **Crst** determines the reset pulse width duration.

Bi-directional Reset Input

Description

The bi-directional reset circuitry is shown in Figure 6. In addition to the uni-directional structure, the RST pin is able to drive an external reset for example when a watchdog expires. To do this, a pull-up resistor (**Rrstwt**) controlled by the **rstcon** signal drives a high level on the RST pin. An extra resistor (**Rrstext)** must be added between the RST input and **Crst** (Figure 6.).

Figure 6. Reset Structure in a Bi-directional Mode



Theory of Operation

External Reset

During a power-up or when an external reset is applied to the RST input, the **Crst** capacitor is charged through the two resistors **Rrstext** and **Rrst**. The reset is active until the level applied on the RST pin is below **Vih1**. The **Rsrtext** resistor is required when an internal reset is applied by the microcontroller and will be explained in the next session.

Internal Reset

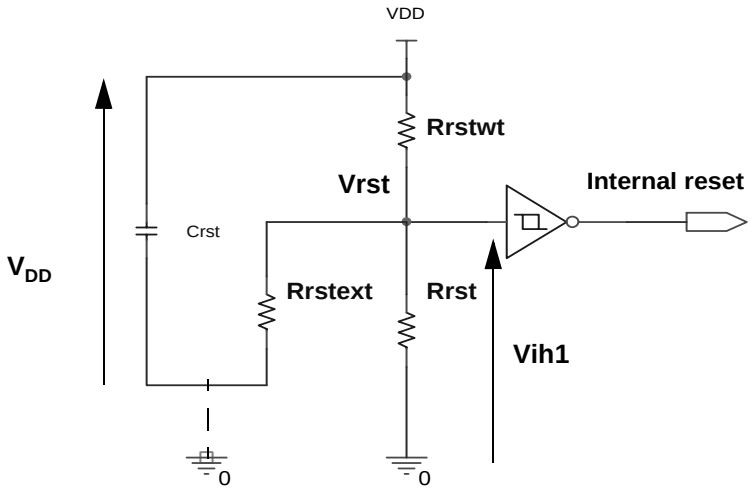
In some cases, such as a watchdog reset, the microcontroller generates an internal reset by driving the **rstcon** signal and consequently by applying a high level on the RST pin. The pulse duration depends on the product and is typically equal to 96 clock periods (see the product datasheet).

The **Rrstext** allows a reset pulse to occur on the RST pin. The reset time constant (several ms) is large in comparison to the reset pulse duration (96 clock periods). In that condition, **Crst** maintains its charge (V_{DD}) for all the duration of the reset pulse even if **Rrstwt** is active (see Figure 7). V_{DD} is applied across the **Rrst** and **Rrstwt** resistors and expression of **Vrst** is given below:

$$Vrst = VDD \times \frac{Rrstext}{Rrstext + Rstwt}$$

For a given **Rrstwt** resistance, **Rrstext** determines the active level of the reset pin. To take into account on the external and internal reset constraints, **Rrstext** must be chosen in the 1 kΩ and 10 kΩ range.

Figure 7. Reset Circuitry When an Internal Reset is Applied



Without **Rrstext** no external reset signal will be generated.

Use Excel File to Determine Crst

To determine **Crst,** the reset pulse width needs to be calculated using the following equation:

$$\mathbf{treset = t_{vddrise} + t_{osc}}$$

- $\mathbf{t_{vddrise}}$ (typically 1 ms to 100 ms), is the rise time of the V_{DD} (10% and 90% of the V_{DD}). It depends on the power supply and the decoupling capacitors used.
- $\mathbf{t_{osc}}$ (typically 1 ms to 50 ms), time taken by the oscillator at startup. It depends on the crystal characteristics and the capacitors connected to the crystal.

Because the power supply has a finite transition time (several hundreds of microseconds to several milliseconds), **Crst** is not so easy to compute by hand. Excel tool is used to calculate **Crst** versus $\mathbf{t_{vddrise}}$ and $\mathbf{t_{osc}}$ parameters. A spreadsheet can be downloaded from the Atmel Web site to compute **Crst**.

Four parameters have to be entered and **Crst** is directly computed by the spreadsheet while 1kΩ is chosen for **Rrst**. Here is how to do it:

- $\mathbf{V_{DD}}$, the power supply voltage, is entered in the cell F3
- $\mathbf{t_{vddrise}}$, the rise time of the power-supply, is entered in the cell F4
- $\mathbf{t_{osc}}$, the oscillator startup time, is entered in cell F8
- **Rrstmin**, the minimum pull-down resistor, is entered in the cell F13

After these steps, the cell E31 has to be clicked to compute the **Crst** and the minimum reset pulse width.

Table 2. Excel Spreadsheet Use to Calculate **Crst**

Power Supply Characteristics			
Power Supply Voltage	V_{DD} =	5	V
Power Supply Rise Time (10% to 90%)	tvddrs =	1	ms
Oscillator			
Oscillator Startup Time time, measured at VIH1	tosct =	10	ms
Electrical Characteristics of the Reset Input			
Minimum pull-down resistance	Rrstmin =	100	kΩ
Minimum Pulse Width			
Calculation of the reset pulse width	trstmin =	22, 726	ms
Evaluation of Reset Capacitor: C			
Minimum reset pulse width	Trst =	65, 545	ms
Value of reset capacitor C	C =	0.649	µF

Table 3 gives the **Crst** value computed from the Excel file for different values of $\mathbf{t_{vddrise}}$ and $\mathbf{t_{osc}}$ parameters.

Table 3. Minimum Reset Capacitor Value for a 50kΩ Pull-down Resistor (**Rrstmin**)

	$\mathbf{t_{vddrise}}$		
$\mathbf{t_{osc}}$	**1 ms**	**10 ms**	**100 ms**
5 ms	820 nF	1.2 µF	12 µF
20 ms	2.7 µF	3.9 µF	12 µF

Table 4. Minimum Reset Capacitor Value for a 100KΩ Pull-down Resistor

	$\mathbf{t_{vddrise}}$		
$\mathbf{t_{osc}}$	**1 ms**	**10 ms**	**100 ms**
5 ms	390 nF	0.56 µF	5.6 µF
20 ms	1.2 µF	2 µF	5.6 µF

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