AVR190: Power Up Considerations

8-Bit AVR Microcontroller

Application Note

Introduction

This application note describes how to ensure proper operation of an AVR Microcontroller after power-up. All AVR microcontrollers are equipped with Power-Up Reset circuitry that helps ensure stable power-up conditions. In the case of a slowly rising V_{CC}, however, special consideration must be taken.

Power-Up Reset Circuit

When a microcontroller is powered up from any power supply, the voltage will traverse from zero to the final voltage. The different parts in a MCU usually starts working at different voltages. The Power-On Reset (POR) circuit that will ensure that the device is held reset until V_{CC} has reached a safe level.

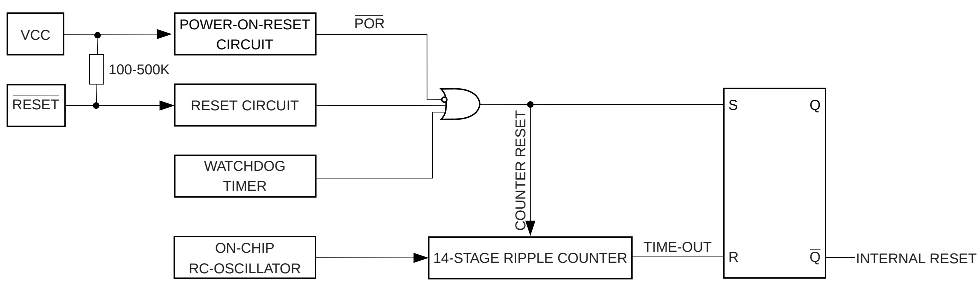

Figure 1. AT90S1200 Power Up Circuit

As shown in Figure 1, an internal timer clocked from the Watchdog timer oscillator prevents the MCU from starting until after a certain period after V_{CC} has reached the Power-On Threshold voltage - V_{POT}. When V_{CC} has reached the V_{POT} voltage, the internal reset will be activated with the $\overline{POR}$ -signal. This signal is active in a short period (Power-On Reset Period - t_{POR}) typ. 3 ms. After this period, the 14-Stage Ripple Counter is started. This delay generated by the counter is called the Reset Delay Time-Out Period (t_{TOUT}). When this counter times out (typ. 16 ms @V_{CC} = 5V), the internal reset is deactivated and the MCU starts program execution.

The two following figures show the power-up sequence in the case that the RESET is tied to V_{CC}, and when it is controlled externally.

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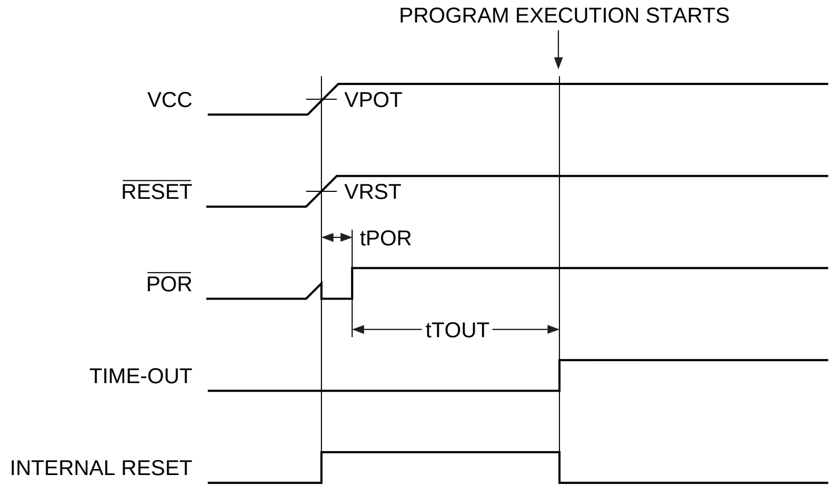

Figure 2. Power-Up Sequence. $\overline{\text{RESET}}$ tied to V_{CC}

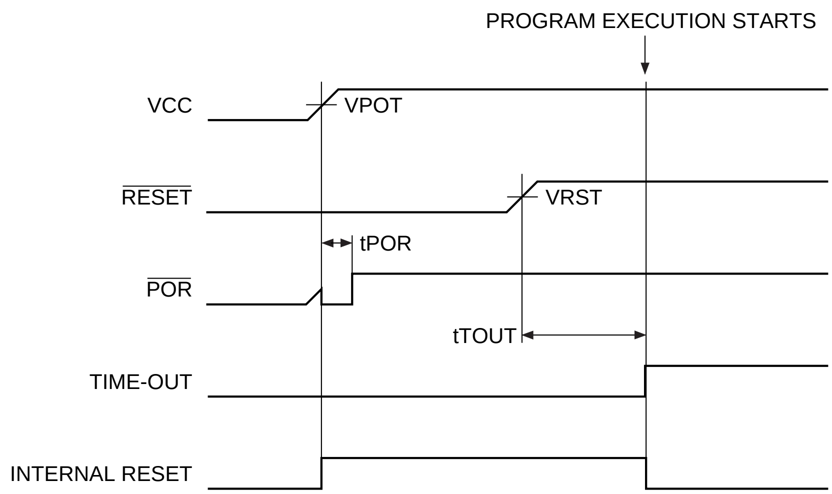

Figure 3. Power-Up Sequence. $\overline{\text{RESET}}$ Controlled Externally

Typical time figures are shown in the following table.

Table 1. Reset Characteristics (V_{CC} - 5V)

Symbol	Parameter	Min	Typ	Max	Units
V_{POT}	Power-On Reset Threshold Voltage	1.8	2	2.2	V
V_{RST}	Pin Threshold Voltage		V_{CC} / 2	0.7 V_{CC}	V
T_{POR}	Power-On Reset Period	2	3	4	ms
T_{TOUT}	Reset Delay Time-Out Period	11	16	21	ms

Timing intervals are generated by the internal RC oscillator which runs at 1 MHz at 5V V_{CC}. As the frequency of this oscillator depends on V_{CC}, use Figure 4 to calculate typical times for other V_{CC} voltages.

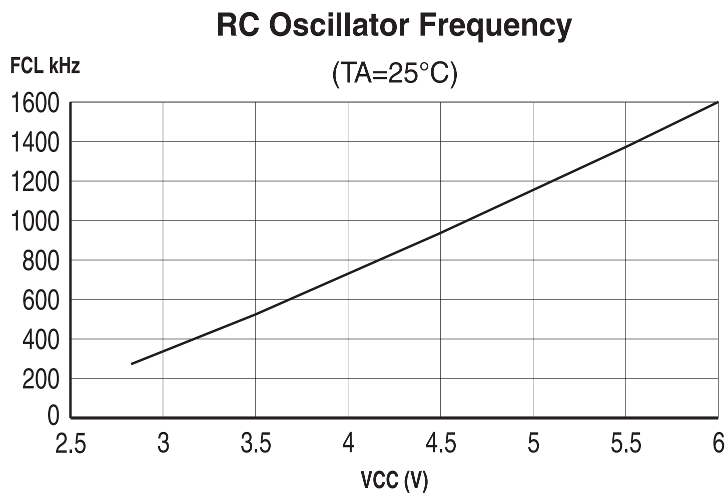

Figure 4. RC Oscillator Frequency vs. V_{CC} Voltage

Power-Up Considerations

The following precautions must be taken to ensure stable power-up conditions:

1. If V_{CC} is guaranteed to reach the operating voltage *before* MCU execution starts (i.e. V_{CC} rise time < $T_{POR} + T_{TOUT}$), the $\overline{RESET}$ pin can be connected to V_{CC} directly or via a pull-up resistor. No external Power-On Reset is required.
2. If V_{CC} is *not* guaranteed to reach the operating voltage before MCU execution starts (i.e. V_{CC} rise time > $T_{POR} + T_{TOUT}$), an external Power-On Reset circuit must be applied. This circuit must hold $\overline{RESET}$ low until the time T_{TOUT} before V_{CC} is guaranteed to reach the operating voltage. See the next section on how to implement a Power-On Reset circuit.
3. IMPORTANT! For the AT90S1200 and AT90S8515, the following applies:
   V_{CC} must, in any case, rise from 0 to 2.2V in at least 100 ms. Also during operation, if the V_{CC} voltage drops below 1.0V, it must be brought back to 2.2V within 100 ms. This requirement applies even if an external reset circuit is used. If the rise time to 2.2V exceeds 100 ms, the MCU will not operate, and can only be reset by bringing V_{CC} down to 0V.

External Power-On Reset Circuit

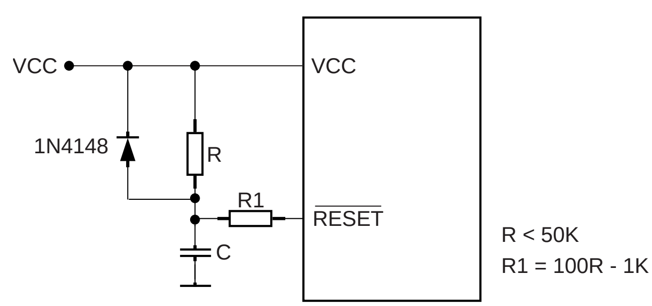

Figure 5. External Power-On Reset Circuit

When using power-supplies with long rise times, an external reset circuit must be applied. An example is shown in Figure 5. This circuit uses an external RC filter to generate the reset pulse. The time constant of the RC filter should be long enough to ensure that the reset pulse is held until T_{TOUT} milliseconds before V_{CC} has reached the operating voltage level. The resistor R and the capacitor C comprise the RC filter. The delay at startup can be calculated from:

$$\tau = R \cdot C$$

τ is the time-constant (the time to reach approx. 63% of V_{CC}). If the value of R is too large (>50kΩ), the voltage at the $\overline{\text{RESET}}$ pin will be too low. This will cause the MCU to see the $\overline{\text{RESET}}$ pin as constantly low, and it will not start. The diode D is used to discharge the capacitor during power down. This is important to ensure a power-up reset pulse after a power-down period shorter than τ. The resistor R1 protects against high currents flowing into the $\overline{\text{RESET}}$ pin from a fully charged capacitor. The circuit does however, not protect against brown-out situations where the power does not drop to zero, but merely dips below V_{CC} min. In such a situation the voltage at the $\overline{\text{RESET}}$ pin will not go low enough to ensure proper reset pulse.

For applications where V_{CC} is guaranteed to rise from 0 to 2.2V in less than 100 ms, the two following connections of the pin are recommended.

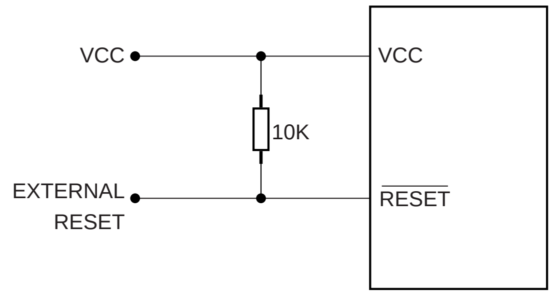

Figure 6. Reset Connection, In-System Programming Required

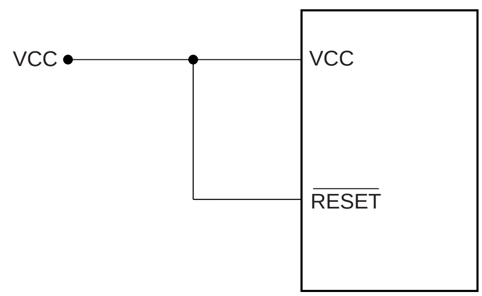

Figure 7. Reset Connection. No In-System Programming Required