DS18B20 – Characterization Tests

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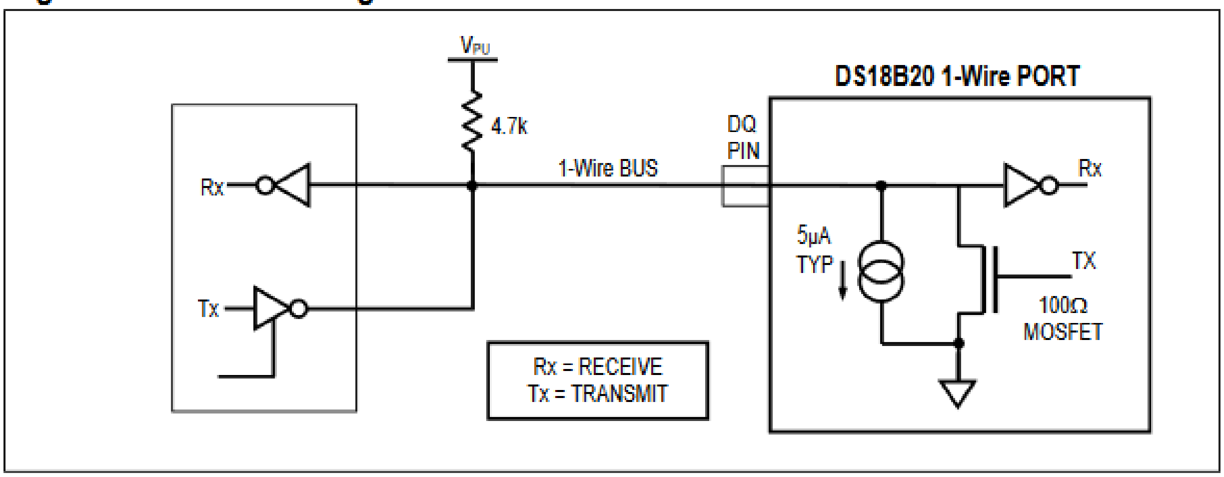
Test 1 – 30 feet length cable:

The goal of this test is to characterize the impact of two different types of cables on the degradation of the signal sent using the 'One-Wire' protocol from Maxim Integrated. It is the protocol used for the temperature sensors DS18B20 from the same company.

Typical configuration (from datasheet):

Figure 10. Hardware Configuration



Key Characteristics from One Wire Protocols:

- Two power modes (Parasitic power from Data line or using External power)
- Rate is 16.3kbps

If the master sends information:

- The master holds the bus low for more than 480us for all components on the bus to be reset.
- To send a logical "1", the bus master sends a very brief low pulse (1-15us).
- To send a logical "0", the master sends a 60us low pulse.

If the master wants to receive data:

- The master sends a 1-15us 0-volt pulse to start each bit.
- To send a logical "1", the slave does nothing. The bus will go to the pulled-up voltage.
- To send a logical "0", the slave pulls the data line to ground for 60us.

The voltages to respect are presented below (from datasheet):

Input Logic-Low	V_{IL}		-0.3		+0.8	V	1,4,5
Input Logic-High	V_{IH}	Local Power	+2.2		The lower of 5.5 or V_{DD} + 0.3	V	1, 6
		Parasite Power	+3.0				

Conclusions from literature review:

- There is no specification on the rising and falling edge to respect, if the timings are respected. Therefore, there is a big margin for parasitic capacitance (see figure below).
- Each device interfaces to the data line via an open-drain or 3-states ports. Therefore, the voltage drop of the cable will probably be negligible.

Figure 15. Detailed Master Read 1 Timing

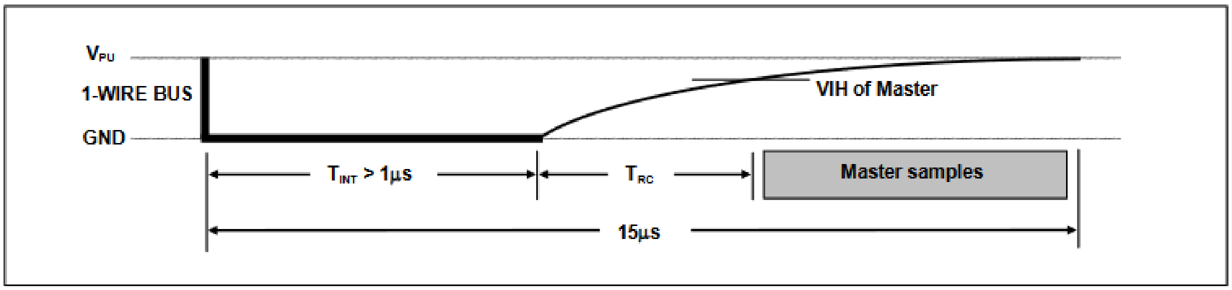
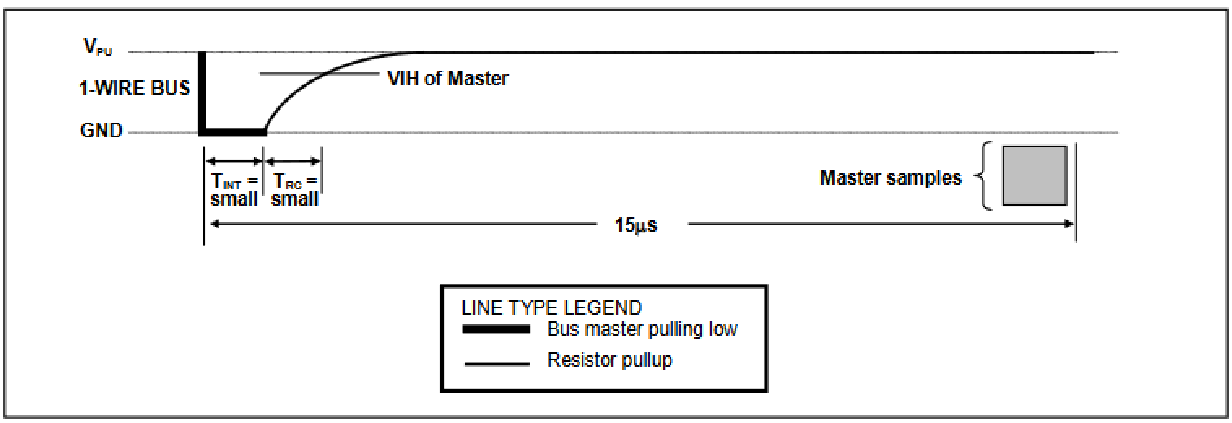


Figure 16. Recommended Master Read 1 Timing



Setup:

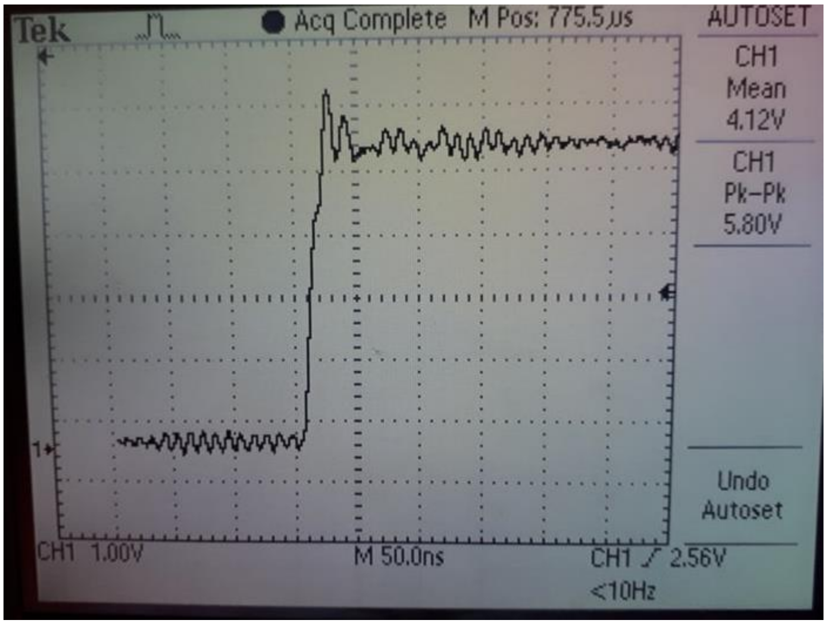
Arduino Uno runs a basic script that requests the temperature from a single DS18B20 every 5 seconds. The DS18B20 is powered using VDD (i.e. there are three cables from the Arduino to the DS18B20). There are three configurations tested:

1- The DS18B20 is connected directly to the Arduino. See test 1.1 reference signals.
2- The DS18B20 is connected to the Arduino through 30 feet AWG22. See test 1.2 – 30 ft of AWG22.
3- The DS18B20 is connected to the Arduino through 30 feet of CAT6. See test 1.3 – 30 ft of CAT6.

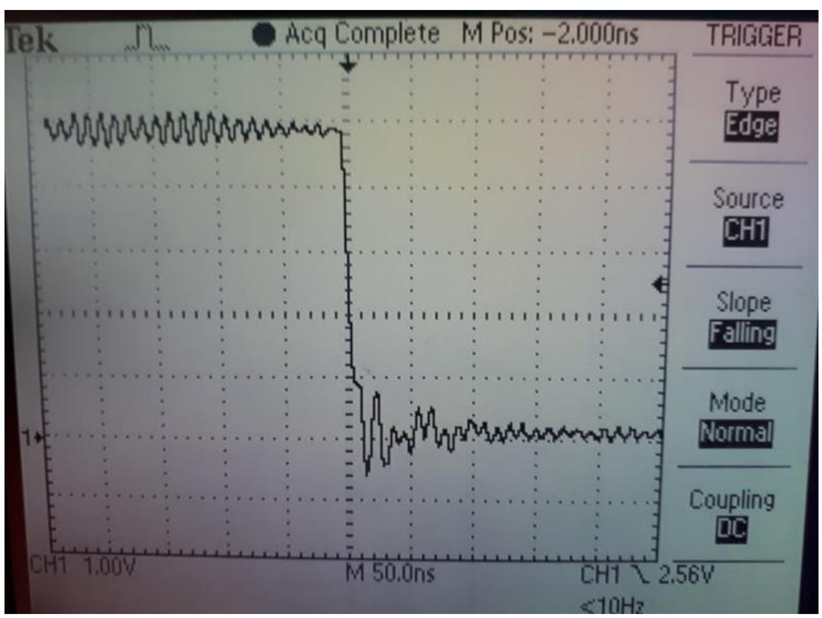
Test 1.1 – Reference signals.

The DS18B20 is connected directly on the Arduino. These are considered as the reference signals to compare the effects of the cables.

Rising edge:



Falling edge:



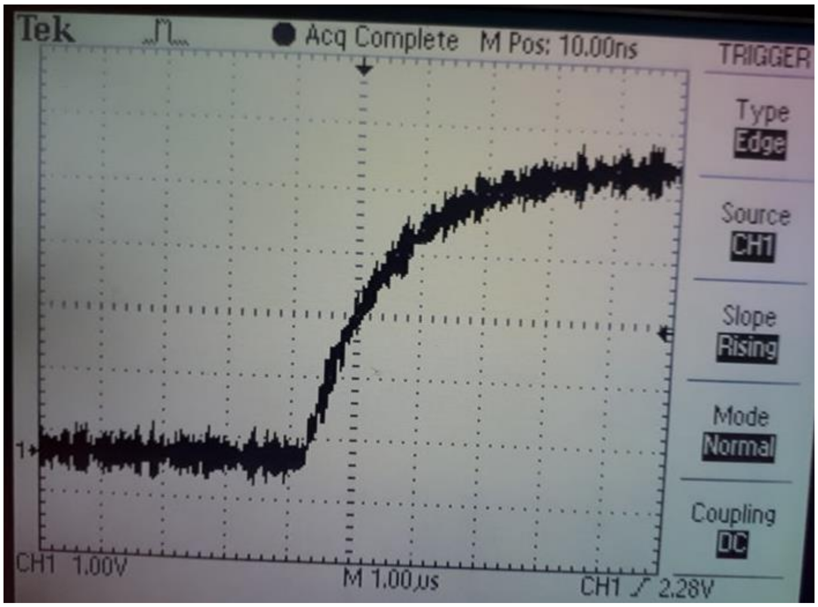
Conclusions:

Slew rate is extremely quick for both rising and falling edges (< 5V/50ns). The voltages are clear 0 and 5V for the low and high voltages. There are some oscillations, but they are probably due to the accuracy of the oscilloscope itself.

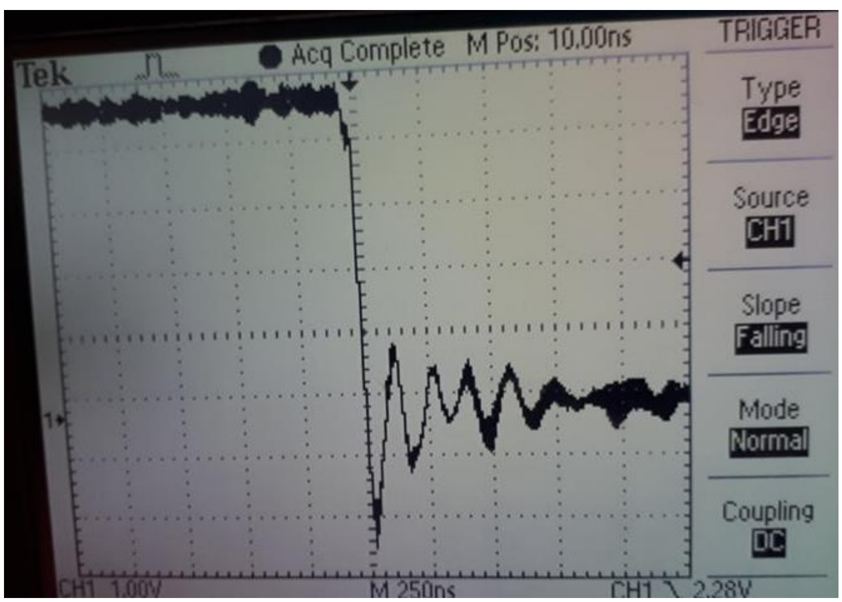
Test 1.2 - 30 ft of AWG22.

The DS18B20 is connected to the Arduino through 30 ft of AWG22 cables (three cables).

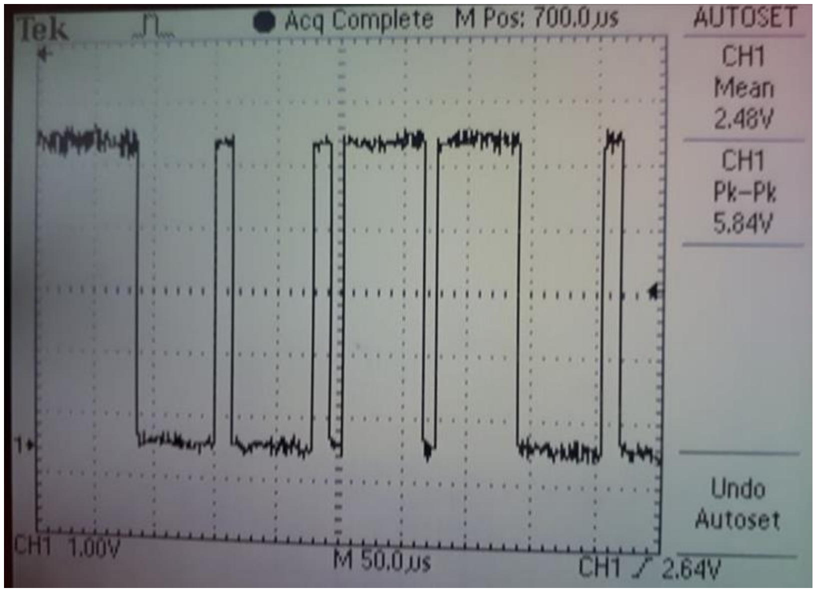
Rising edge:



Falling edge:



Overall:



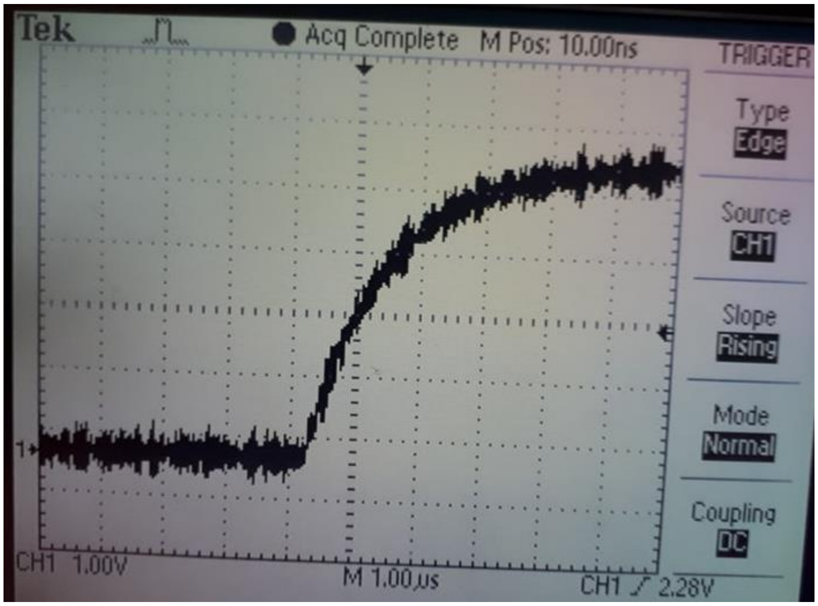
Conclusions:

- The Arduino receives 100% of the information.
- We can definitely see the impact of the capacitance of the line on the rising edge of the signal. However, it is well within the limits of the protocol (takes 4us to charge but needs to do it in less than 14us).
- In the falling edge, we can see that there is an ‘undershoot’ of roughly 1V. This one might be problematic because the tolerance of the pins is -0.5V to +6V for the DS18BB20. It is probably due to the inductance effect of the cable. Furthermore, we do not see those spike in the overall picture.
- The voltages are properly respected (a good 5V and a good 0V).

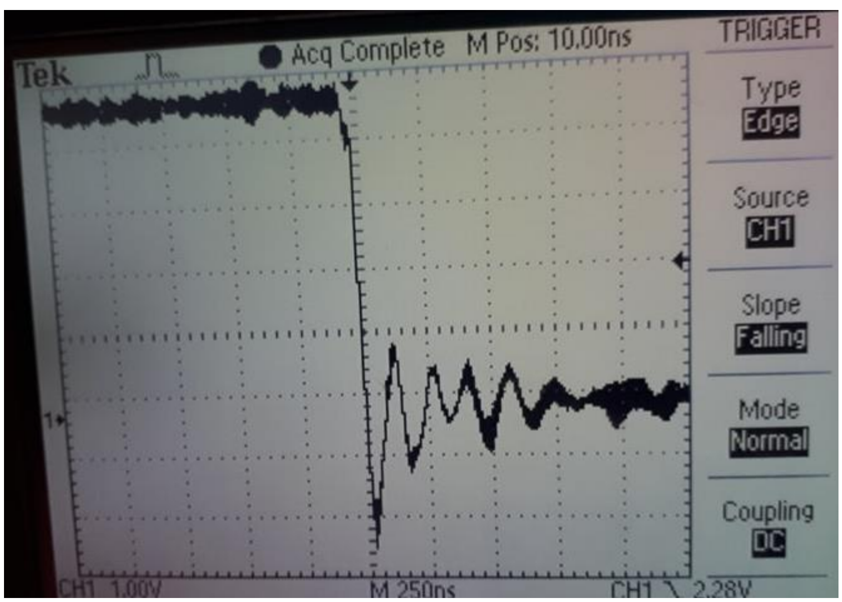
Test 1.3 - 30 ft of Cat6 Cable.

The DS18B20 is connected to the Arduino through 30 ft of Cat6 cables (three cables).

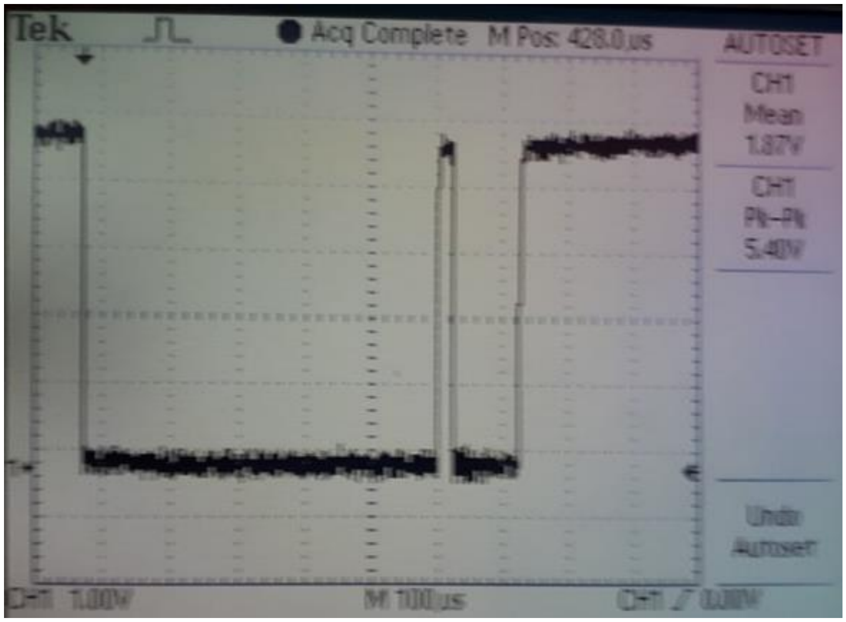
Rising edge:



Falling edge:



Overall:



Conclusions:

- The Arduino receives 100% of the information.
- We can definitely see the impact of the capacitance of the line on the rising edge of the signal. However, it is well within the limits of the protocol (takes 4us to charge but needs to do it in less than 14us). (R is bigger; therefore the RC is bigger too).
- In the falling edge, we can see that there is an 'undershoot' of roughly 1V. It is probably due to the inductance effect of the cable.
- The voltages are properly respected (a good 5V and a good 0V).

Overall Conclusions:

- The 1-One Wire protocol is quite tolerant.
- The length of the cable does affect the quality of the signal. A cable can be represented by a resistor and an inductance in series.
- Surprisingly, we get the same results with both cables: the voltages are well within of the logical levels, there is a charging effect visible in the rising edge (bigger resistance, bigger RC), but it is well within the tolerance, and. Lastly, there is an undershoot that is outside the absolute rating (bigger inductance).
- For the undershoot, the duration of the spike is so short that it might explain why it seems not affect the DS18B20.

Recommendation:

We can proceed and install a DS18B20 with 30 feet cables. If we need longer and it does not seem to work, we can try to add a capacitance near the DS18B20 to cancel the inductive effect and but a smaller pull-up.