Keywords: 1-wire power, EEPROM, temperature, SHA-1, Rpup, Vpup

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APPLICATION NOTE 4255

How to Power the Extended Features of 1-Wire® Devices

Abstract: A 1-Wire bus provides both communication and power between a host and slave devices on a single line. Some 1-Wire devices offer extended features, which include EEPROM, temperature measurement, and a SHA-1 engine. Operation of these special features can require additional power, so the 1-Wire device's pull-up resistor (R_{PUP}) must be sized accordingly.

Introduction

The 1-Wire bus is a simple signaling scheme that performs half-duplex bidirectional communications between a master controller and one or more slaves, all sharing a common data line. Both power delivery and data communication take place over this single line. Most 1-Wire devices use very little power, on the order of tens of microamps, to operate and communicate. Some 1-Wire devices, however, need more power during specific operations, such as an EEPROM write or a device-specific calculation or measurement. During these periods of increased power demand, it is important that the voltage on the 1-Wire bus does not fall below the device's minimum operating pullup voltage (V_{PUP}). For most parasitic-powered 1-Wire devices, the minimum operating voltage (V_{PUP}) is 2.8V.

1-Wire Devices that Need Extra Power

Table 1 is a partial list of 1-Wire devices with special features that require extra power.

Table 1. Devices that Need Extra Power

Part	EEPROM	SHA-1	Temperature	ADC
DS18B20	√		√	
DS1920	√		√	
DS1961S	√	√		
DS1971	√			
DS1972	√			
DS1973	√			
DS1977	√			
DS2431	√			
DS2432	√	√		
DS2433	√			
DS2450				√
DS28E01-100	√	√		
DS28E04-100	√			
DS28EA00	√		√	
DS28EC20	√			

How to Identify Extra Power Requirements in the EC Table

Any additional power requirements for a device are listed in the data sheet's electrical characteristics (EC) table under a variety of terms (**Table 2**). The pullup resistor's specification (R_{PUP}) in the EC table is for 1-Wire communication only and does not include additional power requirements for the special operations.

Table 2. EC Table Parameters Specifying Extra Power Demands

Parameter Description	Symbol	1-Wire Device
Programming Current	I_{PROG}	DS1961S, DS1972, DS2431, DS28E01, DS28E04, DS28E00
Programming Current	I_{LPROG}	DS1973, DS2433, DS1977, DS2432
Programming Current	I_P	DS1971 (DS2430A)
SHA Computation Current	I_{LCSHA}	DS1961S, DS28E01
Active Current	I_{DD}, I_{DQA}	DS1920, DS18B20, DS18B20-PAR
Conversion Current	I_{CONV}	DS28EA00
Operating Current	I_{CC}	DS2450

Parameter	Symbol	Conditions	Min	Typ	Max	Units
EEPROM						
Programming Current	I_{PROG}	(Notes 5, 20)			1.5	mA
Programming Time	t_{PROG}	(Note 21)			10	ms
Write/Erase Cycles (Endurance) (Notes 22, 23)	N_{CY}	At +25°C	200k			—
		-40°C to +85°C	50k			
Data Retention (Notes 24, 25)	t_{DR}	At +85°C (worst case)	10			years
Temperature Converter						
Conversion Current	I_{CONV}	(Notes 5, 20)			1.5	mA

Figure 1. Example of the EC table for the DS28EA00.

Available Power

For a given V_{PUP} and R_{PUP}, the voltage difference between V_{PUP} and the 1-Wire device's V_{PUPmin} determines the current available for special functions. The available current can be calculated as $I_{AVAIL} = (V_{PUP} - V_{PUPmin})/R_{PUP}$. An example calculation follows:

$V_{PUP} = 5V$
$R_{PUP} = 2k\Omega$
$V_{PUPmin} = 2.8V$, resulting in $I_{AVAIL} = 1.1mA$

So for this example, there are 1.1mA available before the 1-Wire voltage drops below the minimum V_{PUP}. If the available current is not sufficient for the application, then a lower pullup resistor or a low-impedance bypass to the pullup resistor will be necessary.

Finding the Right Pullup (R_{PUP})

The available current can be calculated by dividing the potential voltage drop from nominal V_{PUP} to the minimum V_{PUP} by the pullup resistor (R_{PUP}). **Figure 2** graphs this calculation based on a V_{PUP} of 5V with a device that has a minimum V_{PUP} of 2.8V. A pullup resistor of 2.2kΩ or less supports at least 1mA at 5V pullup voltage.

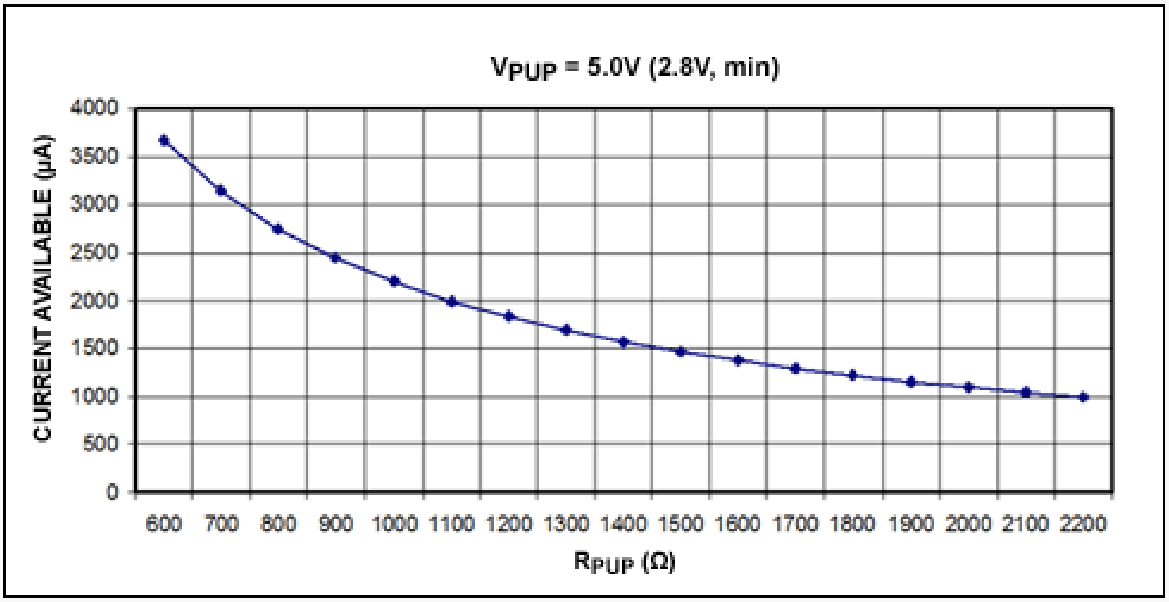

Figure 2. Available current for V_{PUP} = 5V.

Similarly, **Figure 3** shows the available current based on a V_{PUP} of 3.3V. With only 0.5V as the permissible voltage drop on the pullup resistor, very little current is available. Other means of providing the extra current are probably required (see **Low-Impedance Bypass** section below).

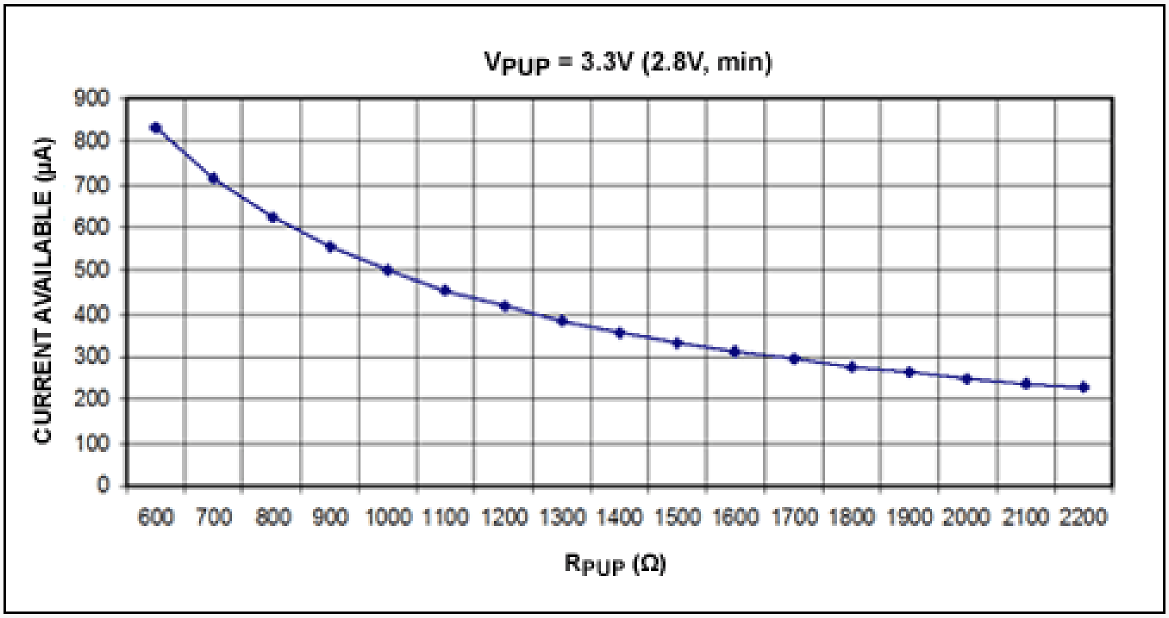

Figure 3. Available current for V_{PUP} = 3.3V.

Advanced Considerations

Choosing a very-low pullup resistor value delivers the desired power to run the special function. However, this configuration raises the voltage representing logic 0 on the 1-Wire bus. If V_{OL} levels do not meet the minimum-voltage input low (V_{IL}) specified for the 1-Wire slave or the 1-Wire master, then reliable communication will not be possible. The most common V_{OL} specification for 1-Wire devices is 0.4V at 4mA, maximum. This value is equivalent to an impedance of 100Ω, maximum, when the 1-Wire device is responding with a logic 0. V_{IL} varies from 0.3V to 0.8V, depending on the 1-Wire device. With multiple 1-Wire devices on the bus, the lowest V_{IL} sets the limit. The pullup resistor value that meets the logic 0 requirement can be calculated as: $R_{PUPmin} = 100\Omega \times (V_{PUP}/V_{ILmax} - 1)$.

(**Note**: Instead of starting the equation with 100Ω, one could write V_{OL}/4mA.)

Therefore, assuming a V_{IL} maximum of 0.4V, the results are

For a V_{PUP} = 5V: 1150Ω

For V_{PUP} = 3.3V: 725Ω

Assuming a V_{IL} maximum of 0.3V, the results are

For a V_{PUP} = 5V: 1567Ω

For V_{PUP} = 3.3V: 1000Ω

The tolerances for the pullup resistor and the power supply must also be considered when selecting the proper pullup. These tolerances are not correlated, i.e., they can add up to either (positive, negative) side or cancel each other. Always check the worst combinations: voltage at upper limit with resistor at lower limit (i.e., highest V_{OL}), and voltage lower limit with resistor at upper limit (i.e., lowest available extra current).

Low-Impedance Bypass

If meeting the V_{OL} and V_{IL} requirements requires a pullup resistor that cannot deliver the necessary current, then the extra current must be supplied by other means. There are two ways to do this:

1. Implement a discrete low impedance bypass (also called a strong pullup) that is engaged only during high current demand.
2. Utilize a 1-Wire interface device that incorporates a strong pullup.

Examples of a 1-Wire master with a discrete strong pullup can be found in application note 4206, "Choosing the Right 1-Wire® Master for Embedded Applications," or application note 244, "Advanced 1-Wire Network Driver." **Figure 4** shows a strong pullup controlled with an extra IO pin.

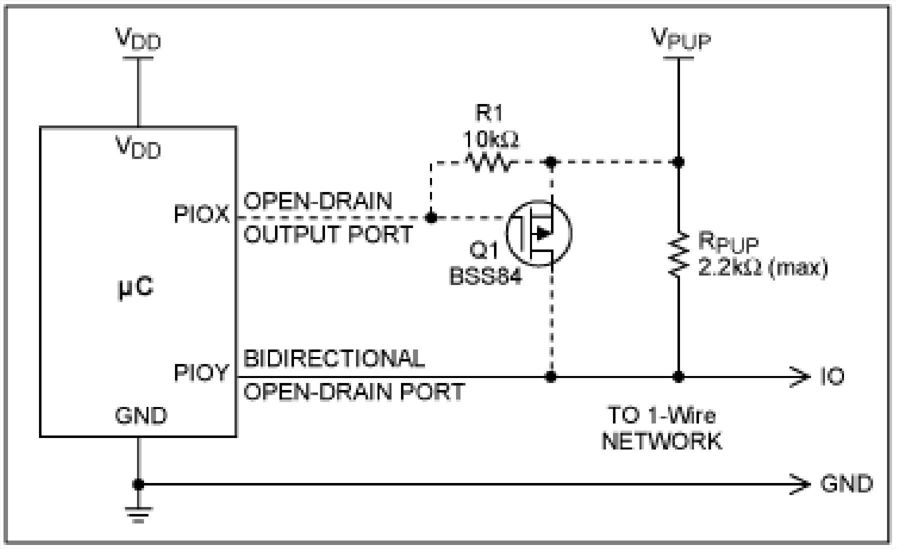

Figure 4. Bidirectional port pin with optional circuit for strong pullup (dashed lines).

There are three 1-Wire interface chips that incorporate a strong pullup feature (**Table 3**). The DS2482-100 also has an external control signal that can be used to drive an additional discrete, extra-strong pullup.

Table 3. 1-Wire Master Interface Devices

Device	Interface	Features
DS2480B	Serial	Strong pullup, active pullup
DS2482-100	I²C	Single 1-Wire channel with built in strong pullup, optional active pullup, control signal for extra-strong pullup
DS2482-800	I²C	Eight 1-Wire channels with built in strong pullup, optional active pullup

Conclusion

For extended features like temperature conversion, EEPROM, or a SHA-1 engine to operate properly in 1-Wire devices, those devices must be provided with sufficient current from the 1-Wire master without allowing the 1-Wire to drop below the minimum-voltage pullup (V_{PUP}). The 1-Wire pullup resistor (R_{PUP}) must, therefore, be sized to provide this current in accordance with application demands. If application requirements do not permit a pullup resistor of the correct size, then the current can be supplied with a discrete strong pullup circuit or a 1-Wire interface chip such as the DS2480B or DS2482.

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Application note 4255: www.maxim-ic.com/an4255

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Related Parts

DS18B20:	QuickView -- Full (PDF) Data Sheet -- Free Samples
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DS1973:	QuickView -- Full (PDF) Data Sheet -- Free Samples
DS1977:	QuickView -- Full (PDF) Data Sheet
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