AN1199

1-Wire® Communication with PIC® Microcontroller

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INTRODUCTION

This application note introduces the user to the 1-Wire® communication protocol and describes how a 1-Wire device can be interfaced to the PIC® microcontrollers.

1-Wire protocol is a registered trade mark of Maxim/ Dallas Semiconductor.

A software stack for the basic, standard speed, 1-Wire master communication is provided with this application note along with an example application.

Note:	1-Wire is not related to the UNI/O™ bus. The UNI/O serial EEPROM family uses a single wire communication protocol developed by Microchip. For UNI/O protocol related application notes, visit the Microchip web site: http://www.microchip.com.

OVERVIEW OF THE 1-Wire BUS

The PIC microcontrollers have multiple General Purpose Input/Output (GPIO) pins, and can be easily configured to implement Maxim/Dallas Semiconductor's 1-Wire protocol.

The 1-Wire protocol allows interaction with many Maxim/Dallas Semiconductor parts, including battery and thermal management devices, memory, iButtons®, etc.

1-Wire devices provide solutions for identification, memory, timekeeping, measurement and control. The 1-Wire data interface is reduced to the absolute minimum (single data line with a ground reference). As most 1-Wire devices provide a relatively small amount of data, the typical data rate of 16 kbps is sufficient for the intended tasks. It is often convenient to use a GPIO pin of an 8-bit or 16-bit microcontroller in a "bit banging" manner to act as the bus master. 1-Wire devices communicate using a single data line and well-defined, time tested protocols.

Note:	The Idle state for the 1-Wire bus is high. If, for any reason, a transaction needs to be suspended, the bus must be left in the Idle state. If this does not occur and the bus is left low for more than 120 µs, one or more of the devices on the bus may be reset.

1-Wire Protocol

- The protocol is called 1-Wire because it uses 1 wire to transfer data. 1-Wire architecture uses a pull-up resistor to pull voltage off the data line at the master side.
- 1-Wire protocol uses CMOS/TTL logic and operates at a supply voltage ranging from 2.8V to 6V.
- Master and slave can be receivers and transmitters, but transfer only one direction at a time (half duplex). The master initiates and controls all 1-Wire operations.
- It is a bit-oriented operation with data read and write, Least Significant bit (LSb) first, and is transferred in time slots.
- The system clock is not required as each part is self-clocked and synchronized by the falling edge of the master.

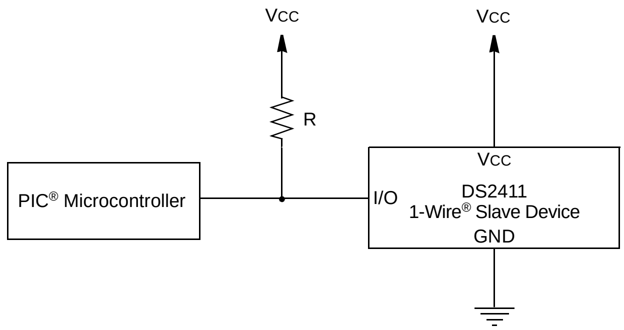
Prerequisites

The requirements of any 1-Wire bus are:

- The system must be capable of generating an accurate and repeatable 1 µs delay for standard speed and 0.25 µs delay for overdrive speed.
- The communication port must be bidirectional; its output must be open-drain and there should be a weak pull-up on the line.
- The communication operations should not be interrupted while being generated.

Note:	Most PIC microcontrollers allow the user to configure any I/O pin to open-drain as it is one of the prerequisites. For recommended pull-up resistance value, refer to the specific slave device data sheet

FIGURE 1: HARDWARE INTERFACE



OPERATIONS OF THE 1-Wire BUS

The four basic operations of a 1-Wire bus are Reset, Write 0 bit, Write 1 bit and Read bit.

Using these bit operations, one has to derive a byte or a frame of bytes.

The bus master initiates and controls all of the 1-Wire communication. Figure 2 illustrates the 1-Wire communication timing diagram. It is similar to Pulse-Width Modulation (PWM) because, the data is transmitted by wide (logic '0') and narrow (logic '1') pulse widths during data bit time periods or time slots. The timing diagram also contains the recommended time values for robust communication across various line conditions.

Table 1 provides a list of operations with descriptions and also implementation steps; this is for standard speed.

A communication sequence starts when the bus master drives a defined length "Reset" pulse that synchronizes the entire bus. Every slave responds to the "Reset" pulse with a logic-low "Presence" pulse.

To write the data, the master first initiates a time slot by driving the 1-Wire line low, and then, either holds the line low (wide pulse) to transmit a logic '0' or releases the line (short pulse) to allow the bus to return to the logic '1' state. To read the data, the master again initiates a time slot by driving the line with a narrow low pulse. A slave can then either return a logic '0' by turning on its open-drain output and holding the line low to extend the pulse, or return a logic '1' by leaving its open-drain output off to allow the line to recover.

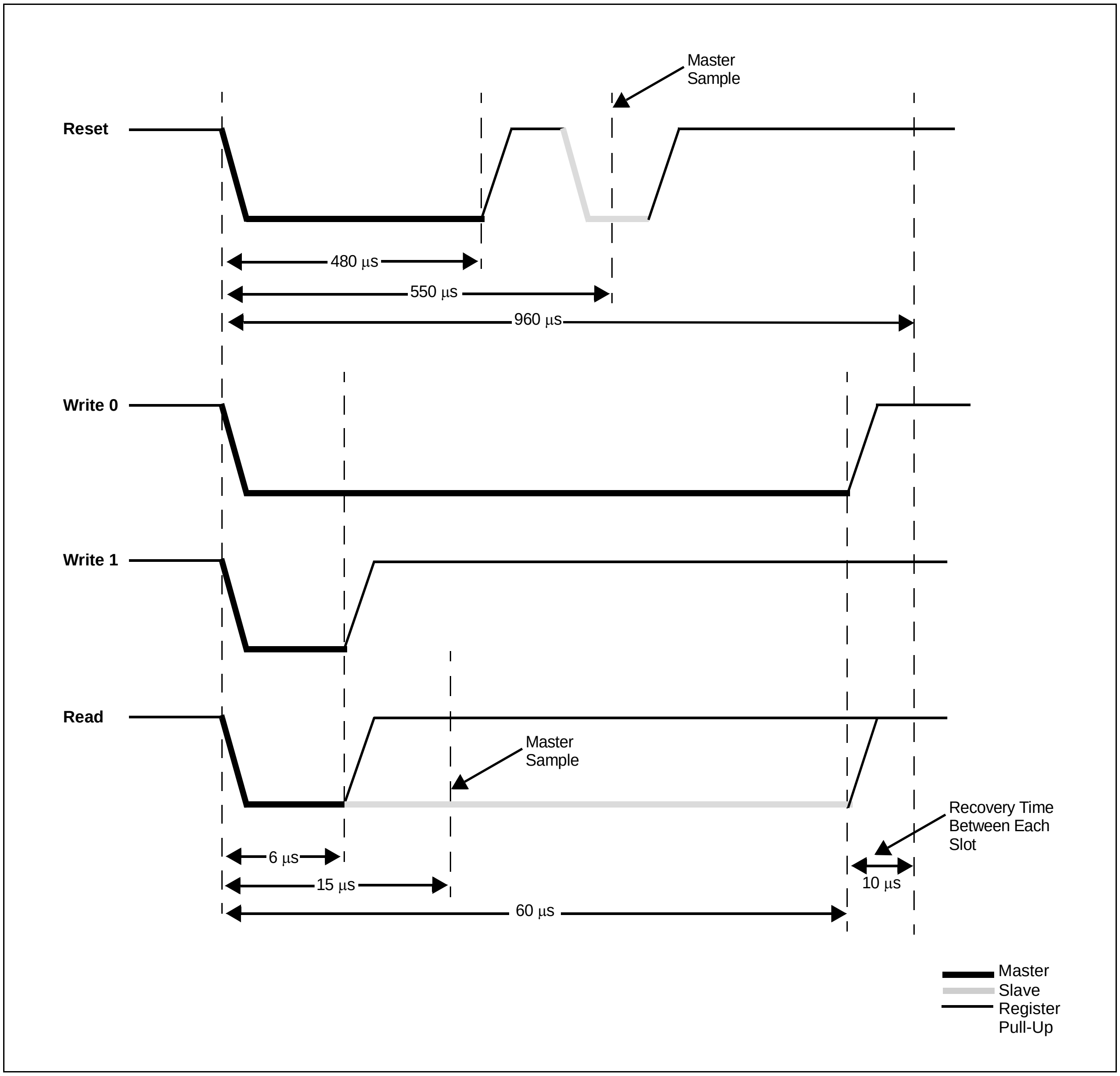
- Most 1-Wire devices support two data rates: standard speed of about 15 kbps and overdrive speed of about 111 kbps.

The protocol is self-clocking and tolerates long inter-bit delays, which ensures smooth operation in interrupted software environments.

TABLE 1: 1-Wire® OPERATIONS

Operation	Description	Implementation
Reset	Reset the 1-Wire bus slave devices and get them ready for a command.	Drive bus low, delay 480 µs. Release bus, delay 70 µs. Sample bus: 0 = device(s) present, 1 = no device present Delay 410 µs.
Write 0 bit	Send '0' bit to the 1-Wire slaves (Write 0 slot time).	Drive bus low, delay 60 µs. Release bus, delay 10 µs.
Write 1 bit	Send '1' bit to the 1-Wire slaves (Write 1 slot time).	Drive bus low, delay 6 µs. Release bus, delay 64 µs.
Read bit	Read a bit from the 1-Wire slaves (Read time slot).	Drive bus low, delay 6 µs. Release bus, delay 9 µs. Sample bus to read bit from slave. Delay 55 µs.

FIGURE 2: 1-Wire® TIMING DIAGRAM



1-Wire APIs FOR PIC MICROCONTROLLERS

Table 2 provides the 1-Wire functions.

TABLE 2: 1-Wire® API FUNCTIONS

Function Name	Description
`drive_OW_low`	This function configures the 1-Wire port pin as an output and drives the port pin to LOW.
`drive_OW_high`	This function configures the 1-Wire port pin as an output and drives the port pin to HIGH.
`read_OW`	This function configures the 1-Wire port pin as an input and reads the status of the port pin.
`OW_write_byte`	This function is used to transmit a byte of data to a slave device.
`OW_read_byte`	This function is used for reading a complete byte from the slave device.
`OW_reset_pulse`	This function describes the protocol to produce a Reset pulse to a slave device and also to detect the presence pulse from the slave device. The 1-Wire slave device is identified using this function.
`OW_write_bit`	This function describes the protocol to write bit information to a slave device.
`OW_read_bit`	This function describes the protocol to read bit information from a slave device.

CONCLUSION

This application note provides an overview of a 1-Wire protocol and also can be used as a building block to develop a sophisticated 1-Wire application using API developed on PIC microcontrollers.

REFERENCES

- http://www.maxim-ic.com/1-Wire
- http://www.maxim-ic.com/appnotes.cfm?appnote_number=126
- http://www.maxim-ic.com/quick_view2.cfm/qv_pk/3711/t/al

APPENDIX A: 1-Wire FUNCTIONS

drive_OW_low

Configures the 1-Wire port pin as an output and drives the port pin to LOW.

Syntax

`void drive_OW_low (void)`

Parameter

None

Return Values

None

Precondition

None

Side Effects

None

Example

```
// Driving the 1-Wire bus low
drive_OW_low();
```

drive_OW_high

Configures the 1-Wire port pin as an output and drives the port pin to HIGH.

Syntax

`void drive_OW_high (void)`

Parameter

None

Return Values

None

Precondition

None

Side Effects

None

Example

```
// Driving the 1-Wire bus High
drive_OW_high();
```

read_OW

Configures the 1-Wire port pin as an input and reads the status of the port pin.

Syntax

```
unsigned char read_OW (void)
```

Parameters

None

Return Values

Return the status of OW pin.

Precondition

None

Side Effects

None

Example

```
unsigned char presence_detect ;

// Return the status of OW pin.
presence_detect = read_OW();      // Get the presence pulse from 1-Wire slave device.
```

OW_write_byte

Transmits 8-bit data to the 1-Wire slave device.

Syntax

```
void OW_write_byte (unsigned char write_data)
```

Parameters

Send byte to the 1-Wire slave device.

Return Values

None

Precondition

None

Side Effects

None

Example

```
#define READ_COMMAND_DS2411 0x33

//Send read command to 1-Wire Device DS2411 to get serial number.
OW_write_byte (READ_COMMAND_DS2411);
```

OW_read_byte

Reads the 8-bit information from the 1-Wire slave device.

Syntax

`unsigned char OW_read_byte (void)`

Parameters

None

Return Values

Returns the read byte from the slave device.

Precondition

None

Side Effects

None

Example

```
// To receive 64-bit registration number  ( 8-bit CRC Code, 48-bit Serial
//Number, 8-bit family code) from the 1-Wire slave device.

 unsigned char serial_number [8];
 unsigned char temp;

  for(temp = 0; temp<8; temp++)
  serial_number[temp] = OW_read_byte();
```

OW_reset_pulse

Describes 1-Wire protocol to generate Reset pulse to detect the presence of the 1-Wire slave device.

Syntax

`unsigned char OW_reset_pulse(void)`

Parameters

None

Return Values

Return '0' if the slave device presence pulse is detected, return '1' otherwise.

Precondition

None

Side Effects

None

Example

```
// OW_reset_pulse function return the presence pulse from the slave device

       if (!OW_reset_pulse())
              return HIGH;         //  Slave Device is detected
       else
             return LOW;           //  Slave Device is not detected
```

OW_write_bit

Describes 1-Wire protocol to write 1 bit of information to the 1-Wire slave device.

Syntax

```
void OW_write_bit (unsigned char write_bit)
```

Parameters

Send one bit to the 1-Wire slave device.

Return Values

None

Precondition

None

Side Effects

None

Example

```
unsigned char loop;

for (loop = 0; loop < 8; loop++)
{
    OW_write_bit(write_data & 0x01);  //Sending LS-bit first
    write_data >>= 1;                 // shift the data byte for the next bit to send
}
```

OW_read_bit

Describes 1-Wire protocol to read 1 bit of information from the 1-Wire slave device.

Syntax

`unsigned char OW_read_bit (void)`

Parameters

None

Return Values

Return the read bit transmitted by a slave device.

Precondition

None

Side Effects

None

Example

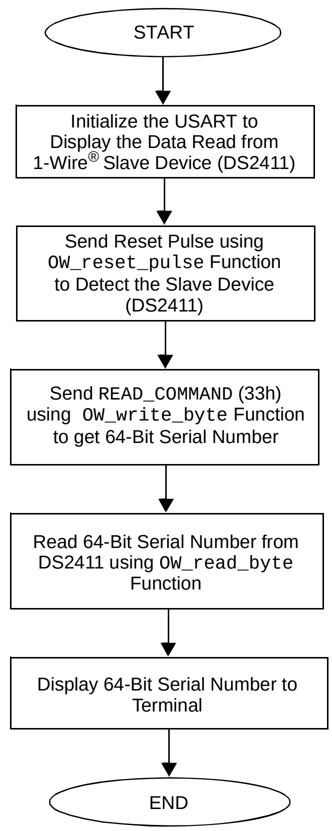
```
unsigned char loop;
unsigned char result = 0;

for (loop = 0; loop < 8; loop++)
{
    result >>= 1;     // shift the result to get it ready for the next bit to receive
    if (OW_read_bit())
    result |= 0x80;   // if result is one, then set MS-bit
}
return (result);
```

APPENDIX B: APPLICATION FLOWCHART

This flowchart illustrates how to use the library functions.

FIGURE B-1: LIBRARY USE FLOWCHART



Note: The source code provided with this application note contains an implementation of this flowchart which can be customized to your needs.

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