Abstract: A microprocessor can easily generate 1-Wire® timing signals if a true bus master is not present (e.g., DS2480B, the family of DS2482 parts). This application note provides an example, written in 'C', of the basic standard-speed 1-Wire master communication routines. The four basic operations of a 1-Wire bus are Reset, Write 1 bit, Write 0 bit, and Read bit. Byte functions can then be derived from multiple calls to the bit operations. The time values provided produce the most robust 1-Wire master for communication with all 1-Wire devices over various line conditions.

Introduction

A microprocessor can easily generate 1-Wire timing signals if a dedicated bus master is not present. This application note provides an example, written in 'C', of the basic standard-speed 1-Wire master communication routines. Overdrive communication speed is also covered by this document. There are several system requirements for proper operation of the code examples:

1. The communication port must be bidirectional, its output is open-drain, and there is a weak pullup on the line. This is a requirement of any 1-Wire bus. See Category 1 in application note 4206, "Choosing the Right 1-Wire® Master for Embedded Application" for a simple example of a 1-Wire master microprocessor circuit.
2. The system must be capable of generating an accurate and repeatable 1µs delay for standard speed and 0.25µs delay for overdrive speed.
3. The communication operations must not be interrupted while being generated.

The four basic operations of a 1-Wire bus are Reset, Write 1 bit, Write 0 bit, and Read bit. The time it takes to perform one bit of communication is called a time slot in the device data sheets. Byte functions can then be derived from multiple calls to the bit operations. See Table 1 below for a brief description of each operation and a list of the steps necessary to generate it. Figure 1 illustrates the waveforms graphically. Table 2 shows the recommended timings for the 1-Wire master to communicate with 1-Wire devices over the most common line conditions. Alternate values can be used when restricting the 1-Wire master to a particular set of devices and line conditions. See the downloadable worksheet to enter system and device parameters to determine minimum and maximum values.
<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
<th>Implementation</th>
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<tbody>
<tr>
<td>Write 1 bit</td>
<td>Send a '1' bit to the 1-Wire slaves (Write 1 time slot)</td>
<td>Drive bus low, delay A&lt;br&gt;Release bus, delay B</td>
</tr>
<tr>
<td>Write 0 bit</td>
<td>Send a '0' bit to the 1-Wire slaves (Write 0 time slot)</td>
<td>Drive bus low, delay C&lt;br&gt;Release bus, delay D</td>
</tr>
<tr>
<td>Read bit</td>
<td>Read a bit from the 1-Wire slaves (Read time slot)</td>
<td>Drive bus low, delay A&lt;br&gt;Release bus, delay E&lt;br&gt;Sample bus to read bit from slave&lt;br&gt;Delay F</td>
</tr>
<tr>
<td>Reset</td>
<td>Reset the 1-Wire bus slave devices and ready them for a command</td>
<td>Delay G&lt;br&gt;Drive bus low, delay H&lt;br&gt;Release bus, delay I&lt;br&gt;Sample bus, 0 = device(s) present, 1 = no device present&lt;br&gt;Delay J</td>
</tr>
</tbody>
</table>

Figure 1. 1-Wire waveforms.
### Table 2. 1-Wire Master Timing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Speed</th>
<th>Recommended (µs)</th>
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<tr>
<td>A</td>
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<td>6</td>
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<tr>
<td></td>
<td>Overdrive</td>
<td>1.0</td>
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<tr>
<td>B</td>
<td>Standard</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>7.5</td>
</tr>
<tr>
<td>C</td>
<td>Standard</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>7.5</td>
</tr>
<tr>
<td>D</td>
<td>Standard</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>2.5</td>
</tr>
<tr>
<td>E</td>
<td>Standard</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>1.0</td>
</tr>
<tr>
<td>F</td>
<td>Standard</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>7</td>
</tr>
<tr>
<td>G</td>
<td>Standard</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>2.5</td>
</tr>
<tr>
<td>H</td>
<td>Standard</td>
<td>480</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>70</td>
</tr>
<tr>
<td>I</td>
<td>Standard</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>8.5</td>
</tr>
<tr>
<td>J</td>
<td>Standard</td>
<td>410</td>
</tr>
<tr>
<td></td>
<td>Overdrive</td>
<td>40</td>
</tr>
</tbody>
</table>

Worksheet to calculate these values is available for [download](#).

### Code Examples

This following code samples rely on two common 'C' functions outp and inp to write and read bytes of data to input/output (I/O) port locations. They are typically located in the `<conio.h>` standard library. These functions can be replaced by platform appropriate functions.

```c
// send 'databyte' to 'port'
int outp(unsigned port, int databyte);

// read byte from 'port'
```
int inp(unsigned port);

The constant PORTADDRESS in the code (Figure 3) is defined as the location of the communication port. The code assumes bit 0 of this location controls the 1-Wire bus. Setting this bit to 0 drives the 1-Wire line low. Setting this bit to 1 releases the 1-Wire to be pulled up by the resistor pullup or pulled down by a 1-Wire slave device.

The function *tickDelay* in the code is a user-generated routine to wait a variable number of 1/4 microseconds. This function varies for each unique hardware platform running so it is not implemented here. Below is the function declaration for the *tickDelay* along with a function *SetSpeed* to set the recommended standard and overdrive speed tick values.

**Example 1. 1-Wire Timing Generation**

```c
// Pause for exactly 'tick' number of ticks = 0.25us
void tickDelay(int tick); // Implementation is platform specific

// 'tick' values
int A,B,C,D,E,F,G,H,I,J;

VENTORY(53,279),(814,896)
Example 2 below shows the code examples for the basic 1-Wire operations.

Example 2. 1-Wire Basic Functions

```c
// Generate a 1-Wire reset, return 1 if no presence detect was found, // return 0 otherwise.
// (NOTE: Does not handle alarm presence from DS2404/DS1994)
//
int OWTouchReset(void)
{
    int result;

    tickDelay(G);
    outp(PORTADDRESS,0x00); // Drives DQ low
    tickDelay(H);
    outp(PORTADDRESS,0x01); // Releases the bus
    tickDelay(I);
    result = inp(PORTADDRESS) ^ 0x01; // Sample for presence pulse from slave
    tickDelay(J); // Complete the reset sequence recovery
    return result; // Return sample presence pulse result
}
```

```c
// Send a 1-Wire write bit. Provide 10us recovery time.
//
void OWWriteBit(int bit)
{
    if (bit)
    {
        // Write '1' bit
        outp(PORTADDRESS,0x00); // Drives DQ low
        tickDelay(A);
        outp(PORTADDRESS,0x01); // Releases the bus
        tickDelay(B); // Complete the time slot and 10us recovery
    }
    else
```
{  
    // Write '0' bit  
    outp(PORTADDRESS,0x00); // Drives DQ low  
    tickDelay(C);  
    outp(PORTADDRESS,0x01); // Releases the bus  
    tickDelay(D);  
}

// Read a bit from the 1-Wire bus and return it. Provide 10us recovery time.  
//  
int OWReadBit(void)  
{
    int result;
    
    outp(PORTADDRESS,0x00); // Drives DQ low  
    tickDelay(A);  
    outp(PORTADDRESS,0x01); // Releases the bus  
    tickDelay(E);  
    result = inp(PORTADDRESS) & 0x01; // Sample the bit value from the slave  
    tickDelay(F); // Complete the time slot and 10us recovery  
    return result;  
}

This is all for bit-wise manipulation of the 1-Wire bus. The above routines can be built upon to create byte-wise manipulator functions as seen in Example 3.

Example 3. Derived 1-Wire Functions

// Write 1-Wire data byte  
//  
void OWWriteByte(int data)  
{
    int loop;
    
    // Loop to write each bit in the byte, LS-bit first  
    for (loop = 0; loop < 8; loop++)  
    {
        OWWriteBit(data & 0x01);  
        
        // shift the data byte for the next bit  
        data >>= 1;  
    }
// Read 1-Wire data byte and return it
//
int OWReadByte(void)
{
    int loop, result=0;
    for (loop = 0; loop < 8; loop++)
    {
        // shift the result to get it ready for the next bit
        result >>= 1;

        // if result is one, then set MS bit
        if (OWReadBit())
            result |= 0x80;
    }
    return result;
}

// Write a 1-Wire data byte and return the sampled result.
//
int OWTouchByte(int data)
{
    int loop, result=0;
    for (loop = 0; loop < 8; loop++)
    {
        // shift the result to get it ready for the next bit
        result >>= 1;

        // If sending a '1' then read a bit else write a '0'
        if (data & 0x01)
        {
            if (OWReadBit())
                result |= 0x80;
        }
        else
            OWWriteBit(0);

        // shift the data byte for the next bit
        data >>= 1;
    }
    return result;
}
// Write a block 1-Wire data bytes and return the sampled result in the same // buffer.
//
// void OWBlock(unsigned char *data, int data_len)
//
//     int loop;
//
//     for (loop = 0; loop < data_len; loop++)
//     {
//         data[loop] = OWTouchByte(data[loop]);
//     }
//
//     return 0;
//
// Set all devices on 1-Wire to overdrive speed. Return '1' if at least one // overdrive capable device is detected.
//
// int OWOverdriveSkip(unsigned char *data, int data_len)
//
//     // set the speed to 'standard'
//     SetSpeed(1);
//
//     // reset all devices
//     if (OWTouchReset()) // Reset the 1-Wire bus
//         return 0; // Return if no devices found
//
//     // overdrive skip command
//     OWWriteByte(0x3C);
//
//     // set the speed to 'overdrive'
//     SetSpeed(0);
//
//     // do a 1-Wire reset in 'overdrive' and return presence result
//     return OWTouchReset();
//

The `owTouchByte` operation is a simultaneous write and read from the 1-Wire bus. This function was derived so that a block of both writes and reads could be constructed. This is more efficient on some platforms and is commonly used in API's provided by Maxim. The `OWBlock` function simply sends and receives a block of data to the 1-Wire using the `OWTouchByte` function. Note that `OWTouchByte(0xFF)` is equivalent to `OWReadByte()` and `OWTouchByte(data)` is equivalent to `OWWriteByte(data)`.

These functions plus `tickDelay` are all that are required for basic control of the 1-Wire bus at the bit, byte, and block level. The following example in Example 4 shows how these functions can be used together to read a SHA-1 authenticated page of the DS2432.
Example 4. Read DS2432 Example

```c
// Read and return the page data and SHA-1 message authentication code (MAC)
// from a DS2432.

int ReadPageMAC(int page, unsigned char *page_data, unsigned char *mac)
{
    int i;
    unsigned short data_crc16, mac_crc16;

    // set the speed to 'standard'
    SetSpeed(1);

    // select the device
    if (OWTouchReset()) // Reset the 1-Wire bus
        return 0; // Return if no devices found

    OWWriteByte(0xCC); // Send Skip ROM command to select single device

    // read the page
    OWWriteByte(0xA5); // Read Authentication command
    OWWriteByte((page << 5) & 0xFF); // TA1
    OWWriteByte(0); // TA2 (always zero for DS2432)

    // read the page data
    for (i = 0; i < 32; i++)
        page_data[i] = OWReadByte();
    OWWriteByte(0xFF);

    // read the CRC16 of command, address, and data
    data_crc16 = OWReadByte();
    data_crc16 |= (OWReadByte() << 8);

    // delay 2ms for the device MAC computation
    // read the MAC
    for (i = 0; i < 20; i++)
        mac[i] = OWReadByte();

    // read CRC16 of the MAC
    mac_crc16 = OWReadByte();
    mac_crc16 |= (OWReadByte() << 8);

    // check CRC16...
    return 1;
}
```
Additional Software

The basic 1-Wire functions provided in this application note can be used as a foundation to build sophisticated 1-Wire applications. One important operation omitted in this document is the 1-Wire search. The search is a method to discover the unique ID's of multiple 1-Wire slaves connected to the bus. Application note 187, "1-Wire Search Algorithm" describes this method in detail and provides 'C' code that can be used with these basic 1-Wire functions.

The 1-Wire Public Domain Kit contains a large amount of device-specific code that builds upon what has been provided here.

www.ibutton.com/software/1wire/wirekit.html

For details on other resources see application note 155, "1-Wire® Software Resource Guide Device Description."

Alternatives

If a software solution is not feasible for a specific application, then a 1-Wire master chip or a synthesized 1-Wire master block can be used as an alternative.

Maxim provides a predefined 1-Wire master in Verilog and VHDL.

DS1WM

To obtain the 1-Wire master Verilog/VHDL code, please submit a tech support request.

Operation of the synthesizable 1-Wire Master is described in application note 119, "Embedding the 1-Wire® Master in FPGAs or ASICs."

There are several 1-Wire master chips that can be used as a peripheral to a microprocessor. The DS2480B Serial 1-Wire Line Driver provides easy connectivity to a standard serial port. Similarly the DS2482-100, DS2482-101, and DS2482-800 can connect to the I²C port.

Operation of the DS2480B is described in application note 192, "Using the DS2480B Serial 1-Wire Line Driver."

Operation of the DS2482 is described in application note 3684, "How to Use the DS2482 I²C 1-Wire® Master."

A more sophisticated 1-Wire line driver designed specifically for long lines is presented in application note 244, "Advanced 1-Wire Network Driver."

Revision History

07/06/00: Version 1.0—Initial release.
05/28/02: Version 2.0—Correct 1-Wire reset sample time. Add wave figure, links, and more code examples.
02/02/04: Version 2.1—Add overdrive support, provided min/max on timings, and update example.
09/06/05: Version 2.2—Correct polarity of PIO in Code Examples description.
1-Wire is a registered trademark of Maxim Integrated Products, Inc.

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<tr>
<th>Related Parts</th>
<th>Description</th>
<th>Free Samples</th>
</tr>
</thead>
<tbody>
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<td>Programmable Resolution 1-Wire Digital Thermometer</td>
<td>Free Samples</td>
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<tr>
<td>DS18S20</td>
<td>1-Wire Parasite-Power Digital Thermometer</td>
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<td>DS1904</td>
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<td>iButton Temperature Logger</td>
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<td>1-Wire Digital Temperature Sensor with 1Kb Lockable EEPROM</td>
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More Information
For Technical Support: [http://www.maximintegrated.com/support](http://www.maximintegrated.com/support)
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Other Questions and Comments: [http://www.maximintegrated.com/contact](http://www.maximintegrated.com/contact)

Application Note 126: [http://www.maximintegrated.com/an126](http://www.maximintegrated.com/an126)
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