Keywords: 1-Wire master, 1-Wire communication, C-code implementation

APPLICATION NOTE 126

1-Wire Communication Through Software

May 30, 2002

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 1. 1-Wire Operations

Operation	Description	Implementation
Write 1 bit	Send a '1' bit to the 1-Wire slaves (Write 1 time slot)	Drive bus low, delay A Release bus, delay B
Write 0 bit	Send a '0' bit to the 1-Wire slaves (Write 0 time slot)	Drive bus low, delay C Release bus, delay D
Read bit	Read a bit from the 1-Wire slaves (Read time slot)	Drive bus low, delay A Release bus, delay E Sample bus to read bit from slave Delay F
Reset	Reset the 1-Wire bus slave devices and ready them for a command	Delay G Drive bus low, delay H Release bus, delay I Sample bus, 0 = device(s) present, 1 = no device present Delay J

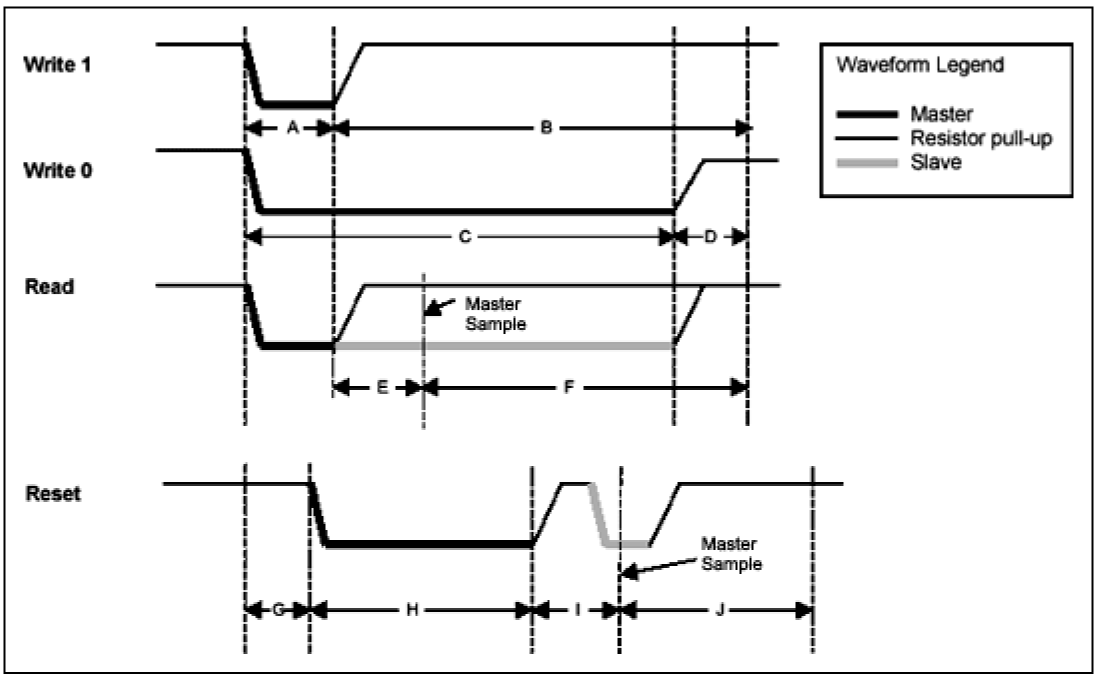

Figure 1. 1-Wire waveforms.

Table 2. 1-Wire Master Timing		
Parameter	**Speed**	**Recommended (µs)**
A	Standard	6
	Overdrive	1.0
B	Standard	64
	Overdrive	7.5
C	Standard	60
	Overdrive	7.5
D	Standard	10
	Overdrive	2.5
E	Standard	9
	Overdrive	1.0
F	Standard	55
	Overdrive	7
G	Standard	0
	Overdrive	2.5
H	Standard	480
	Overdrive	70
I	Standard	70
	Overdrive	8.5
J	Standard	410
	Overdrive	40

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.

```
// 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

```
// 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;

//-----------------------------------------------------------------------------
--
// Set the 1-Wire timing to 'standard' (standard=1) or 'overdrive'
(standard=0).
//
void SetSpeed(int standard)
{
        // Adjust tick values depending on speed
        if (standard)
        {
                // Standard Speed
                A = 6 * 4;
                B = 64 * 4;
                C = 60 * 4;
                D = 10 * 4;
                E = 9 * 4;
                F = 55 * 4;
                G = 0;
                H = 480 * 4;
                I = 70 * 4;
                J = 410 * 4;
        }
        else
        {
                // Overdrive Speed
                A = 1.5 * 4;
                B = 7.5 * 4;
                C = 7.5 * 4;
                D = 2.5 * 4;
```

```
                E = 0.75 * 4;
                F = 7 * 4;
                G = 2.5 * 4;
                H = 70 * 4;
                I = 8.5 * 4;
                J = 40 * 4;
        }
}
```

Example 2 below shows the code examples for the basic 1-Wire operations.

Example 2. 1-Wire Basic Functions

```
//-----------------------------------------------------------------------------
--
// 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
}

//-----------------------------------------------------------------------------
--
// 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]);
        }
}

//-----------------------------------------------------------------------------
--
// 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

```
//----------------------------------------------------------------------------
--
// 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.
08/04/09: Version 2.3—Add AN4206 reference. Change recommended overdrive E value. Correct OWTouchReset sample. Move min/max calculated fields in 1-Wire master timing to worksheet. Add DS2482 reference.

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Related Parts		
DS18B20	Programmable Resolution 1-Wire Digital Thermometer	Free Samples
DS18S20	1-Wire Parasite-Power Digital Thermometer	Free Samples
DS1904	iButton RTC	Free Samples
DS1920	iButton Temperature Logger	
DS1921G	Thermochron iButton Device	
DS1921K	Thermochron iButton Starter Kit	
DS1922L	iButton Temperature Loggers with 8KB Data-Log Memory	
DS1922T	iButton Temperature Loggers with 8KB Data-Log Memory	
DS1923	iButton Hygrochron Temperature/Humidity Logger with 8KB Data-Log Memory	
DS1963S	iButton Monetary Device with SHA-1 Function	
DS1971	iButton 256-Bit EEPROM	
DS1973	iButton 4Kb EEPROM	Free Samples
DS1982	iButton 1Kb Add-Only	Free Samples
DS1985	iButton 16Kb Add-Only	Free Samples
DS1990A	iButton Serial Number	Free Samples
DS1992	iButton 1Kb/4Kb Memory	Free Samples
DS1993	iButton 1Kb/4Kb Memory	Free Samples
DS1995	iButton 16Kb Memory	Free Samples
DS1996	iButton 64Kb Memory	Free Samples
DS2401	Silicon Serial Number	Free Samples
DS2406	Dual Addressable Switch Plus 1Kb Memory	Free Samples
DS2411	Silicon Serial Number with V_{CC} Input	Free Samples
DS2413	1-Wire Dual Channel Addressable Switch	Free Samples
DS2417	1-Wire Time Chip With Interrupt	Free Samples
DS2422	1-Wire Temperature/Data Logger with 8KB Datalog Memory	

DS2431	1024-Bit 1-Wire EEPROM	Free Samples
DS2432	1Kb Protected 1-Wire EEPROM with SHA-1 Engine	Free Samples
DS2433	4Kb 1-Wire EEPROM	
DS2438	Smart Battery Monitor	Free Samples
DS2450	1-Wire Quad A/D Converter	
DS2480B	Serial to 1-Wire Line Driver	Free Samples
DS2482-100	Single-Channel 1-Wire Master	Free Samples
DS2482-101	Single-Channel 1-Wire® Master with Sleep Mode	Free Samples
DS2482-800	8-Channel 1-Wire Master	Free Samples
DS2502	1Kb Add-Only Memory	Free Samples
DS2502-E48	48-Bit Node Address Chip	Free Samples
DS2505	16Kb Add-Only Memory	Free Samples
DS2762	High-Precision Li+ Battery Monitor with Alerts	Free Samples
DS28E02	1-Wire SHA-1 Authenticated 1Kb EEPROM with 1.8V Operation	Free Samples
DS28E04-100	4096-Bit Addressable 1-Wire EEPROM with PIO	
DS28E10	1-Wire SHA-1 Authenticator	Free Samples
MAX31826	1-Wire Digital Temperature Sensor with 1Kb Lockable EEPROM	Free Samples

More Information
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Application Note 126: http://www.maximintegrated.com/an126
APPLICATION NOTE 126, AN126, AN 126, APP126, Appnote126, Appnote 126