# AN926: Reading and Writing Registers with SPI and $I^2C$ for Si534x/8x Devices

The Si534x/8x timing devices use either SPI or $I^2C$ as the communication protocol for changing internal register settings in the chip. This application note clarifies how to access the Si534x/8x registers with examples using these two protocols.

While a microcontroller is often used to read/write registers on the device, an SPI or $I^2C$ bus analyzer can also be used. Companies, such as Corelis (www.corelis.com) or Total Phase/Ardvark (http://www.totalphase.com), sell both $I^2C$ and SPI bus analyzers that connect through USB to the PC and have GUI interfaces. The user simply connects the wires (GND, CS, MISO, MOSI, and SCLK pins for SPI or SDA, SCLK, and GND pins for $I^2C$) of the hardware (slave). The bus analyzer handles the low-level control of the bus. The commands and data are sent through a GUI on the PC. This is often a quick way to evaluate a chip requiring one of these serial interfaces when the driver code is not easily available. It is always important to make sure the hardware is connected and configured correctly for proper operation.

The examples provided in this application note can be followed regardless of the hardware chosen to connect to the Si534x/8x device.

**KEY POINTS**

- SPI and $I^2C$ communication available
- SPI command protocol provided
- Step-by-step code examples provided for SPI and $I^2C$

# 1. Introduction

In the Si538x/4x, a register is 1 byte (8-bits) wide, and an address is 2 bytes (16-bits) wide. Due to single byte addressing used on the I$^2$C and SPI interfaces, a special PAGE register is used to specify the 2 byte address. The first byte in the 2 byte address is always the PAGE, and the PAGE is always located at register 0x01. It is copied on every address page. Therefore, address 0001= Page; 0101= Page; 0201=Page, etc. A named setting, such as "MXAXB_NUM", is a contiguous range of bits within one or more registers. A named setting will never span a page boundary. For example:

| Named Setting | Location | |
|---|---|---|
| DEVICE_GRADE | 0x0004[7:0] | A full byte at page 0x00, serial interface address 0x04 |
| MXAXB_NUM | 0x0235[0:43]<br>0x0235[7:0]<br>0x0236[7:0]<br>0x0237[7:0]<br>0x0238[7:0]<br>0x0239[7:0]<br>0x023A[3:0] | 5 full bytes, 1 partial byte located at page 0x02 interface address 0x35 through 0x3A |

The Register Map section of the device Family Reference Manual has more information on registers and addressing.

## 2. SPI Protocol

The Si5348x/4x devices can operate in 4-wire or 3-wire SPI mode. There is a configuration bit called "SPI_3WIRE", which must be set when in 3-wire mode and cleared when in 4-wire mode. The hardware connections for both SPI configurations are shown in the following figure.

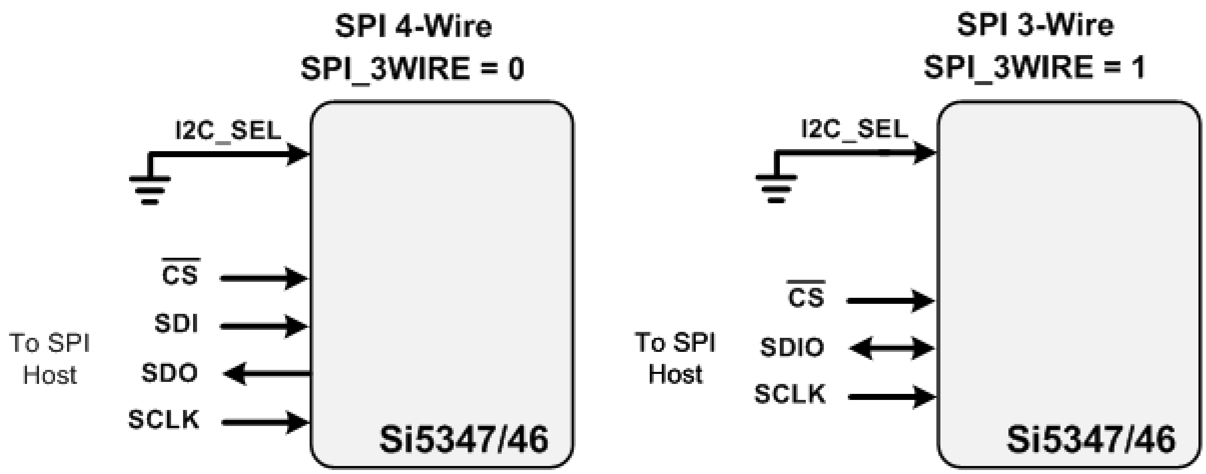



**Figure 2.1. SPI Connections Diagram**

The I2C_SEL pin must be low for SPI. The SPI protocol has a command format that must be followed for reading and writing transactions.

The SPI commands that the Si534x/8x devices support are defined in the following table:

**Table 2.1. SPI Commands and Expected Command Format**

| Instruction | 1st Byte[1] | 2nd Byte | 3rd Byte | Nth Byte[2,3] |
|---|---|---|---|---|
| Set Address | 000x xxxx | 8-bit Address | — | — |
| Write Data | 010x xxxx | 8-bit Data | — | — |
| Read Data | 100x xxxx | 8-bit Data | — | — |
| Write Data + Address Increment | 011x xxxx | 8-bit Data | — | — |
| Read Data + Address Increment | 101x xxxx | 8-bit Data | — | — |
| Burst Write Data | 1110 0000 | 8-bit Address | 8-bit Data | 8-bit Data |

**Note:**
1. X = don't care (1 or 0).
2. The Burst Write Command is terminated by deasserting /CS (/CS = high).
3. There is no limit to the number of data bytes that follow the Burst Write Command, but the address will wrap around to zero in the byte after address 255 is written.

The following transactions can be performed from SPI with the Si534x/8x devices:
1. Read Single Register
2. Write Single Register
3. Auto-Increment Read Single Register
4. Burst Write Data

Note that, in all the examples that follow, the registers chosen are completely arbitrary. Please take care and understand the purpose of the regiseters in the Si534x/8x products before simply writing to them.

The following examples use the "SPI_Run" function, which is written for an 8051 Silicon Labs MCU, as follows:

```
U8 SPI_Run(U8 command, U8 val)
          {
                 P0_3 = 0;                              // Set Chip Select line low
                 SPI0CN |= 0x01                         // Enable the SPI Port
                 SPI0DAT = command                      // send the command byte to the DUT
                 while (SPIF == 0 ) {}                  // Wait for transfer to complete
                 SPIF = 0;                              // Clear the SPI interrupt flag
                 spi _read_data = SPI0DAT;              // Clear the SPI receive buffer

                 SPI0DAT = val;                         // Send the value or data to the DUT
                 while (SPIF == 0 ) {}                  // Wait for transfer to complete
                 SPIF = 0;                              // Clear the SPI interrupt flag
                 P0_3 = 1;                              // Set Chip Select line high
                 spi_read_data=SPI0DAT;
                 return spi_read_data;                  // return the data from the receive buffer
           }
```

### 2.1 Example 1: Read from Register 0x052A

1. Run the SPI bus to send out 0x00 for the “Set Address” command followed by the PAGE register location (0x01). This sets the address to point to 0x01, which is the register for changing the page value:

```
SPI_Run (0x00, 0x01) // Set Address to Register 0x01 (PAGE register)
```

2. Run the SPI bus to write the page value of 0x05, since the address is pointing at the PAGE register. First send out the “write” command 0x40, followed by the value 0x05:

```
SPI_Run (0x40, 0x05) // Write Value 0x05
```

3. Run the SPI bus to point to the register 0x2A. This is done by using the “Set Address” command followed by the register 0x2A:

```
SPI_Run (0x00, 0x2A) //Set Address to Register 0x2A
```

4. Send the Read Command followed by a dummy write. The dummy write is needed because the SPI bus sends data out to receive data in:

```
Data = SPI_Run (0x80, 0xFF) //Send the read command and receive data from register 0x052A
```

At this point, the SPI bus value from register 0x052A is returned into “Data”:

```
//Full Example 1

          PAGE = 0x01;
          Byte SPI_Reg_Read(u16 Reg)
          {
                  Byte page_byte;
                  Byte reg_byte;
                  page_byte =  Reg>>8;
                  reg_byte=Reg;
                  SPI_Run(0x00, PAGE);
                  SPI_Run(0x40, page_byte);
                  SPI_Run(0x00, reg_byte);
                  Return SPI_Run (0x80, 0xFF);
          }
```

## 2.2 Example 2: Write 0x23 to Register 0x03B9

1. Run the SPI bus to send the “Set Address” command, followed by the PAGE register:

```
SPI_Run (0x00, 0x01) // Set Address to Register 0x01 PAGE
```

2. Run the SPI bus to write in the page value:

```
SPI_Run (0x40, 0x03) // Write Value 0x03 to set the page to 3
```

3. Run the SPI bus to point to register address 0xB9:

```
SPI_Run (0x00, 0xB9) // Set the register address to 0xB9
```

4. Run the SPI bus write the value (0x23 in this example) into that register location:

```
SPI_Run (0x40, 0x23) // Write Value 0x23
```

A value of 0x23 has been written to register 0x03B9:

```
//Full Example 2

          PAGE = 0x01;
          void SPI_Reg_Write(u16 Reg, byte value)
          {
                  Byte page_byte;
                  Byte reg_byte;
                  page_byte =  Reg>>8;
                  reg_byte=Reg;
                  SPI_Run(0x00, PAGE);
                  SPI_Run(0x40, page_byte);
                  SPI_Run(0x00, reg_byte);
                  SPI_Run (0x40, value);
          }
```

### 2.3 Example 3: Read 3 Consecutive Values Starting at Register 0x0130

In this example, the purpose is to read from registers 0x0130, 0x0131, and 0x0132 consecutively.

1. Set the Address to point to the PAGE register:

```
SPI_Run (0x00, PAGE);
```

2. Set the page value to 0x01:

```
SPI_Run (0x40, 0x01);
```

3. Set the address of the register to 0x30:

```
SPI_Run (0x00, 0x30);
```

4. Send the read increment command. This will read out the value from the current register address and automatically point to the next consecutive address. A dummy byte is sent after the read increment command. Data is clocked out and in during the read transaction.

```
Data[0]= SPI_Run (0xAA, 0xFF);
Data[1]= SPI_Run (0xAA, 0xFF);
Data[2]= SPI_Run (0xAA, 0xFF);
```

```
// Full Example 3
PAGE = 0x01;
U8 Data [] = {0,0,0};
U8 SPI_Reg_Read(U16 Reg, U8 num_bytes)
{
      U8 page_byte, reg_byte, i;
      page_byte = Reg>>8;
      reg_byte= Reg;
      Run_SPI(0x00, PAGE);
      Run_SPI(0x40, page_byte);
      Run_SPI(0x00, reg_byte);
      for (i=0; i < num_bytes; i++)
      {
       Data[i] = Run_SPI (0xAA, 0xFF);
      }
      return Data;
}
```

### 2.4 Example 4: Write 3 Consecutive Values Starting at Register 0x0711

In this example, the purpose is to read from registers 0x0711, 0x0712, and 0x0713 consecutively.

1. Step 1: Set the Address to point to the PAGE register:

```
SPI_Run (0x00, PAGE);
```

2. Set the page value to 0x07:

```
SPI_Run (0x40, 0x07);
```

3. Set the address of the register to 0x11:

```
SPI_Run (0x00, 0x11);
```

4. Send the write increment command. This will write the value to the current register address and automatically point to the next consecutive address.

```
        SPI_Run (0x60, Data[0]);
        SPI_Run (0x60, Data[1]);
        SPI_Run (0x60, Data[2]);
```

```
        //Full Example 4
        PAGE = 0x01;U8 Data [] = {0xA3, 0xB5, 0x2C};SPI_Reg_Write(U16 Reg, U8 num_bytes)
        {
              U8 page_byte, reg_byte, i;
              page_byte =  Reg>>8;
              reg_byte= Reg;
              Run_SPI(0x00, PAGE);
              Run_SPI(0x40, page_byte);
              Run_SPI(0x00, reg_byte);
              for (i=0; i < num_bytes; i++)
              {
                      Run_SPI (0x60, Data[i]);
              }
  }
```

### 2.5 Example 5: Burst Write Values 0x01 through 0x0F Starting at Register 0x002B

There is a burst command that will write data consecutively into the part auto incrementing between each data byte.

The command for a Burst Write is 0xE0.

1. Set the Address to point to the PAGE register:

```
SPI_Run (0x00, PAGE); //Set the Address to point to the PAGE register
```

2. Set the page value to 0x00:

```
SPI_Run (0x40, 0x00); //Write 0x00 into the PAGE register
```

3. Send the Burst Command 0xE0, followed by the Register, then the Data:

```
Unsigned char src_data [] = {0x2B, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06,0x07, 0x08, 0x09, 0x0A, 0x0B, 0x0C, 0
x0D, 0x0E,0x0F};
```

This function points to the data array above. The length “len” would be 16, for 15 bytes of data plus one byte for the register in this example. This code is specific to the Silicon Labs 8051 MCU architecture, but the concept is similar for other MCUs.

```
SPI_write_burst(unsigned char* src_data, int len)
{
       P0_3 = 0;                       //Set Chip Select line low
       SPI0DAT= 0xE0;                  // Send the burst command byte to the DUT
       while (SPIF == 0 ) {}           // Wait for transfer to complete
       SPIF = 0;                       // Clear the SPI interrupt flag
       While ( (i<len) || (i == len))
       {
               SPI0DAT = src_data[i]; //send the register and data to the DUT
               While (SPIF == 0) {}   // wait for the transfer to complete
               SPIF = 0;              // clear the interrupt flag
               i++;
       }
       P0_3 = 1;
}
```

There is no Burst Read command for the Si534x/8x devices.

# 3. I$^2$C Hardware Connections

For I$^2$C communication, the I2C_SEL pin must be set high. Please review the following hardware connection diagrams. They can also be found in in the reference manual.

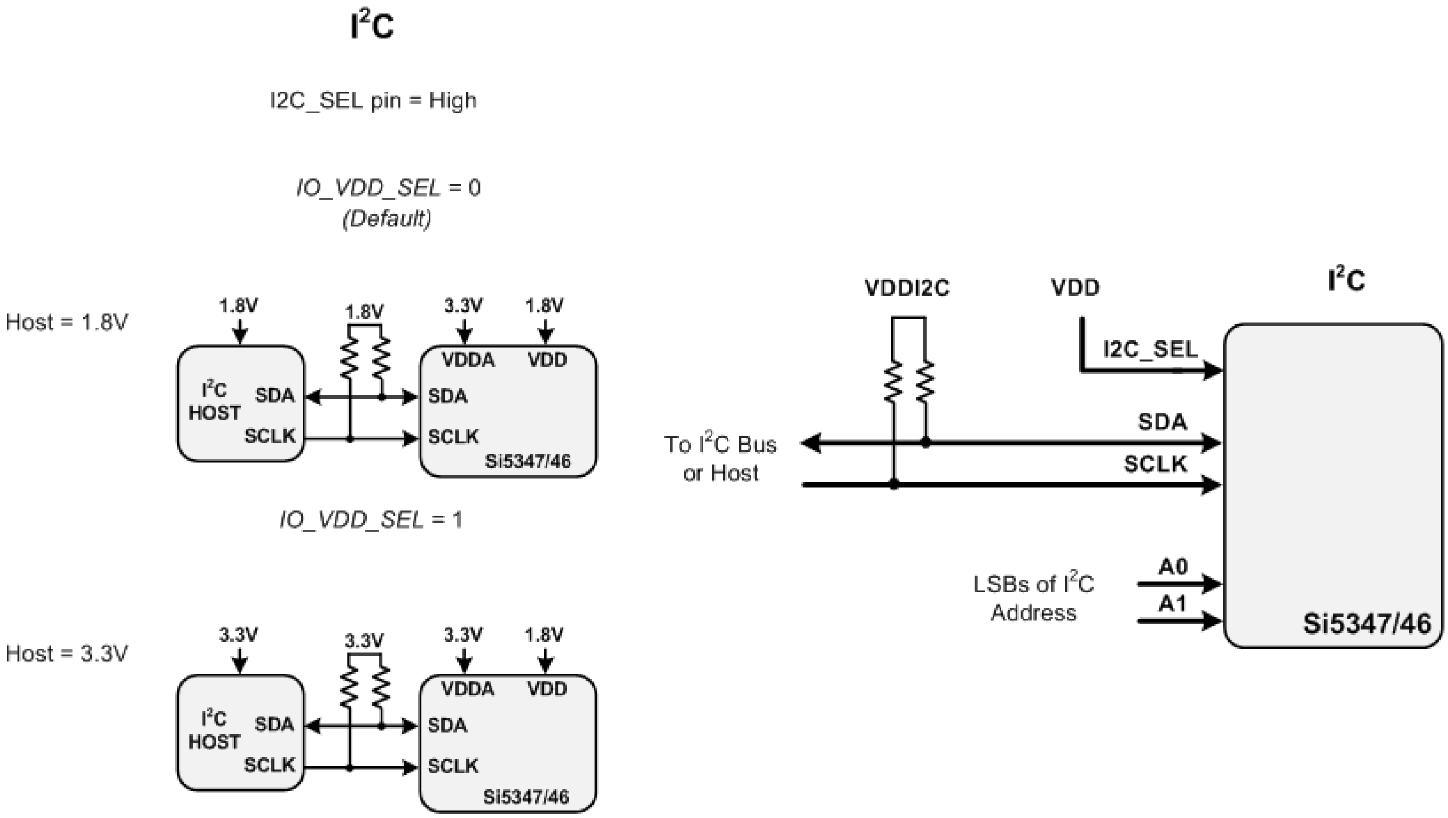



**Figure 3.1. Hardware Connections I$^2$C Communication**

The I$^2$C protocols used with the Si534x/8x devices are shown in the figures below. When reading and writing registers, it is important to remember that the PAGE register address must be set correctly each time. Also, pay attention to the Slave I$^2$C Address. The first 5 bits starting from MSB of the slave I$^2$C address are fixed, while A1 and A0 can be high or low. The eighth bit of the I$^2$C address implies reading (1) or writing (0).

The 7-bit slave device address of the Si5347/46 consists of a 5-bit fixed address plus 2 pins that are selectable for the last two bits, as shown in the figure below.

| | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| **Slave Address** | 1 | 1 | 0 | 1 | 1 | A1 | A0 |

**Figure 3.2. 7-Bit I$^2$C Slave Address Bit-Configuration**

Data is transferred MSB-first in 8-bit words as specified by the I$^2$C specification. A write command consists of a 7-bit device (slave) address + a write bit, an 8-bit register address, and 8 bits of data as shown in the following figure. A write burst operation is also shown in which subsequent data words are written using an auto-incremented address:

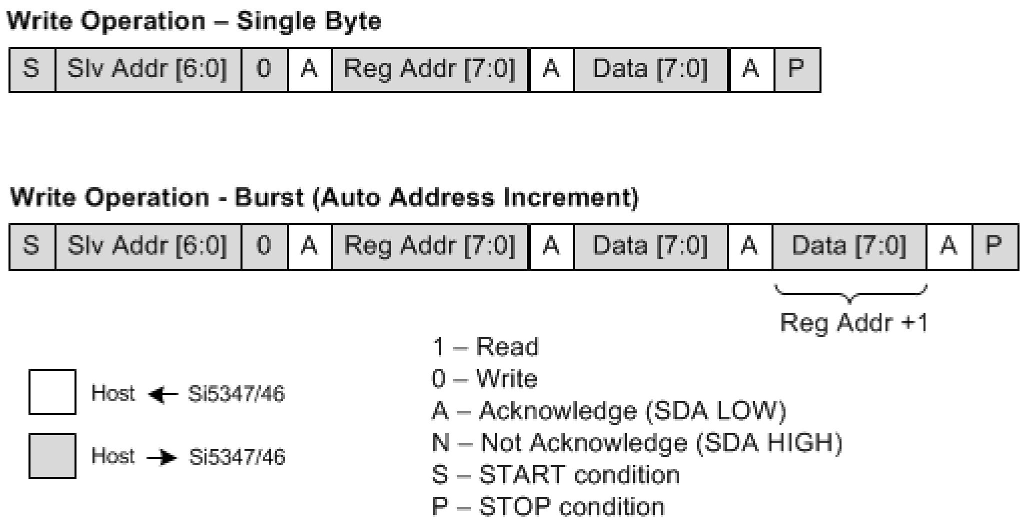



**Figure 3.3. I$^2$C Write Operation**

A read operation is performed in two stages. A data write is used to set the register address; then, a data read is performed to retrieve the data from the set address. A read burst operation is also supported. This is shown in the figure below.

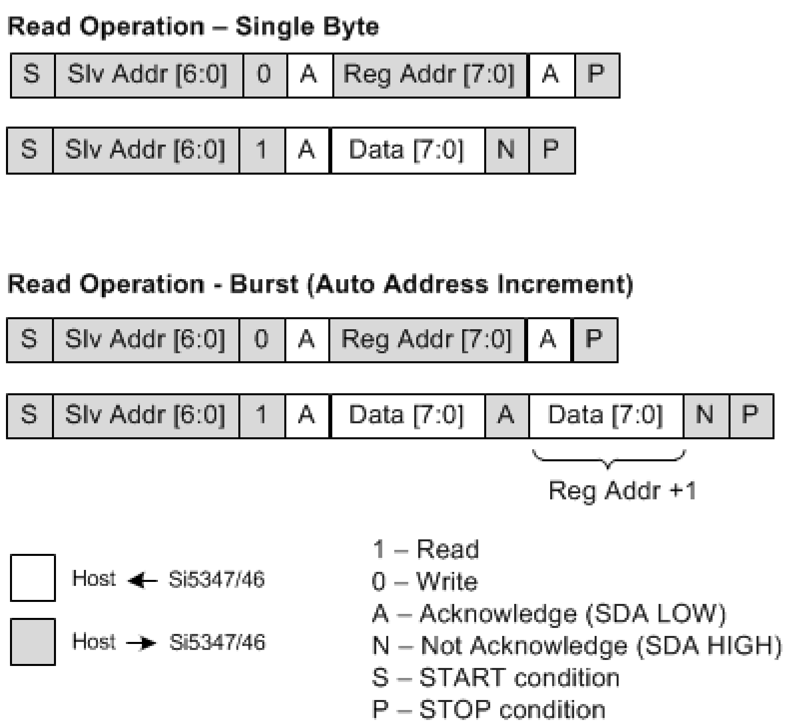



**Figure 3.4. I$^2$C Read Operation**

The following sections describe the basic operations that can be performed using I$^2$C:

1. Read a single register
2. Write a single register
3. Read increment
4. Write increment

### 3.1 Example 1: Read from Register 0x052A

In order to read register 0x052A, the first step is to write the PAGE register to 0x05. Then, write Register 0x2A, and, finally, read the data out. Note that a read sequence always consists of first writing the register and then reading the data.

1. Write the Page Address (0x01) to a value of 0x05:

```
S/SlaveAddress/0/Ack/Reg_Address=0x01/Ack/Data=0x05/Ack/P
```

2. Read Address 0x2A.

   The read sequence requires first writing the register, then reading out the data.

```
S/Slave Address/0/Ack/Reg_Address=0x2A/Ack/P  //First Write the Register Address
```

```
S/Slave Address/1/Ack/DATA_RETURNED/N/P  //Then Read out the Data
```

When reading a single byte from the device, the data length of 1 is passed to the I2C firmware to tell it to read one byte of data and then stop.

### 3.2 Example 2: Write a Value of 0x23 to Register 0x03B9

The first step is to set the PAGE register to a value of 3, and then write a value of 23 into register 0xB9.

1. Write the Page Address (0x01) to a value of 0x03:

```
S/SlaveAddress/0/Ack/Reg_Address=0x01/Ack/Data=0x03/Ack/P
```

2. Write a value of 0x23 into register 0xB9:

```
S/SlaveAddress/0/Ack/Reg_Address=0xB9/Ack/Data=0x23/Ack/P
```

When writing one byte of data, the firmware receives a data length instruction telling it to write in a single byte from the data passed in.

### 3.3 Example 3: Read 7 Values Starting from Register 0x0130

The first step is to set the PAGE register to 1; then, write the register address, and then read out the data, incrementing based on the length passed in.

1. Write the Page Address (0x01) to a value of 0x01:

```
S/SlaveAddress/0/Ack/Reg_Address=0x01/Ack/Data=0x01/Ack/P
```

2. Read Address 0x30:

```
S/Slave Address/0/Ack/Reg_Address=0x30/Ack/P
```

```
S/Slave Address/1/Ack/DATA_RETURNED[0]/Ack/ DATA_RETURNED[1]/Ack/…DATA_RETURNED[6]/N/P
```

When reading multiple bytes from the device, the data length is passed to the I2C firmware to tell it to read the number of bytes of data and then stop. The register address auto-increments as the data is incrementally read out.

### 3.4 Example 4: Write 8 Values Starting from Register 0x021C

After the page address is written, a multi-byte write is done by writing the register followed by all the data. The I2C driver will need to know the length expected to continue incrementing and writing in all the values passed in.

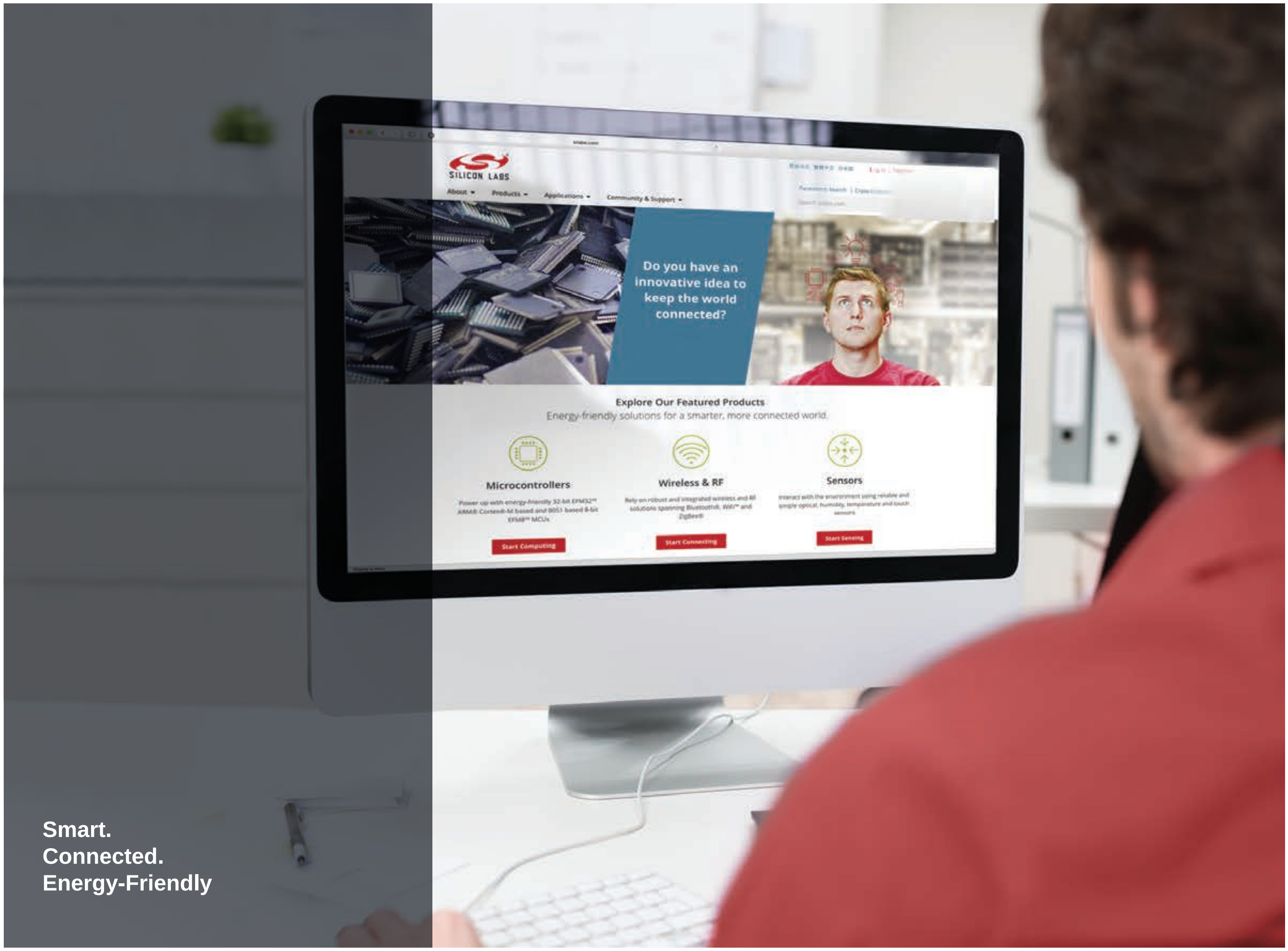
1. Write the Page Address (0x01) to a value of 0x02:

```
S/SlaveAddress/0/Ack/Reg_Address=0x01/Ack/Data=0x03/Ack/P
```

2. Write a data value data[0],data[1],…data[7] starting at register 0x1C:

```
S/SlaveAddress/0/Ack/Reg_Address=0x1C/Ack/data[0]/Ack/data[1]/Ack/…data[7]/Ack/P
```

When writing multiple bytes from the device, the data length is passed to the I2C firmware to tell it to write the number of bytes of data and then stop. The register address auto-increments as the data is incrementally written in.

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