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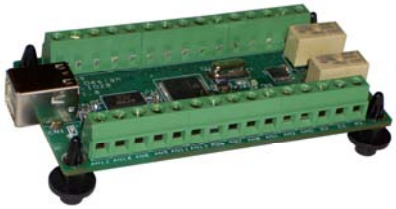
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DLP-IO20

LEAD-FREE

USB-Based 20-Channel Data-Acquisition Module

FEATURES:

- 20 Channels: 14 Analog Inputs 0-5V, Up to 20Ksps Sample Rate, 2 Latching Relays, Digital I/O
- Two Relay Driver Outputs (5V Coil)
- Digital Temperature Sensor Feature Supported on All Digital I/O's
- Two 32-Bit Interrupt-Driven Event Counters
- USB Port Powered
- USB 1.1- and 2.0-Compatible Interface
- Small Footprint; Easily Fits On a Desktop
- Easy-To-Use Programming Interface

APPLICATIONS:

- Robotics Control
- Motion Control/Presentation
- Data Acquisition
- Industrial/Process Control
- Process Monitoring
- Relay Control
- Audio Analysis

1.0 INTRODUCTION

The DLP-IO20 Data-Acquisition Module is a low-cost, easy-to-use data-acquisition system for analyzing AC voltages, driving 5-volt relays, controlling and monitoring processes and measuring DC voltages in the range of 0-5 volts. This module provides topside wire terminal blocks for the wiring connections.

The 20 channels on the DLP-IO20 are broken down as follows: 3 outputs with high current relay/LED drivers and 17 digital I/O; 14 of which can be set to analog input mode. The DLP-IO20 also provides two latching relay contacts. Each of the channels and relay contacts can be controlled via simple, multi-byte commands. All operational power is taken from the host PC via the USB port.

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The mode of each I/O is automatically changed with each command sent. For example, if an I/O is set to Digital Output-High and then the Digital Input Mode is selected, the I/O is first changed to Input Mode and then the high/low state is read and returned to the host.

2.0 SPECIFICATIONS

The DLP-IO20 is an all 5-volt system that derives its power from the host USB port. Channels have the following capabilities:

Relay Contacts: There are two sets of relay contacts on the board. These contacts are latching and are capable of handling resistive loads of up to 4A @ 30 VDC, 0.6A @ 110 VDC and 1A @ 125 VAC. Each of the two on-board relays has two sets of SPDT contacts that have been connected in parallel to increase the current carrying capability. (These are detailed in Section 6 under the table describing K1 and K2.)

Relay Drivers: There are three relay driver outputs on the board. These outputs connect to one side of a 5V relay coil, and the side of the coil is connected to the +5V terminal.

Analog In: Fourteen inputs can read and return the voltage on the analog inputs using a 10-bit ADC. The maximum sample rate is 20Ksps. The input voltage range is 0-5 Volts. (Refer to Section 7 of this document for more details.)

Digital Output: Set high, or clear low; configurable as digital outputs (5V). (The actual high/low voltage depends upon sink/source current.)

Digital Input: Read the input's high/low state.

3.0 ABSOLUTE MAXIMUM RATINGS

Stresses beyond the ranges listed below may cause permanent damage to the DLP-IO20:

Operating Temperature: 0-70°C

Voltage on Digital Inputs with Respect to Ground: -0.3V to +5.3V

Voltage on Analog Inputs with Respect to Ground: -0.3V to +5.3V

Voltage on Relay Contacts with Respect to Ground/Return: 110VDC, 125VAC

Sink/Source Current on Any I/O: 25mA

Sink/Source Current on All I/O Combined: 90mA

4.0 WARNINGS

- Unplug from the host PC before connecting to the I/O terminals on the DLP-IO20.
- Isolate the bottom of the board from all conductive surfaces.
- Observe static precautions to prevent damage to the DLP-IO20 module.

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5.0 USB DRIVERS

USB drivers for the following operating systems are available for download from the DLP Design website:

Windows XP x64	Mac OSX
Windows Server 2003	Mac OS9
Windows 2000	Mac OS8
Windows 98, ME	Linux

These drivers are available for download from the following page: http://www.dlpdesign.com/DNLD8/.

Note: If you are utilizing the dual-mode drivers from FTDI (CDM2.x.x) and you want to use the Virtual COM Port (VCP) drivers, then it may be necessary to disable the D2XX drivers first via Device Manager. To do so, right click on the entry under USB Controllers that appears when the DLP-IO20 is connected, select Properties, select the Advanced tab, put a check in the option for "Load VCP" and click OK. Then unplug and replug the DLP-IO20, and a COM port should appear in Device Manager under Ports (COM & LPT).

6.0 TERMINAL BLOCK PIN DEFINITIONS

The wiring terminals on the DLP-IO20 are explained in the following table:

TABLE 1	
J1 Prototyping Terminal Block Pin Definitions	
PIN NAME	**DESCRIPTION**
R1	Latching Relay 1 Reset Contact (see Note 3)
C1	Latching Relay 1 Common Contact (see Note 3)
S1	Latching Relay 1 Set Contact (see Note 3)
GND	Ground
P7	Relay Driver Output P7. Driven by Darlington pair transistors powered by 5V from the USB port (see Note 4).
P6	Relay Driver Output P6. Driven by Darlington pair transistors powered by 5V from the USB port (see Note 4).
P5	Relay Driver Output P5. Driven by Darlington pair transistors powered by 5V from the USB port (see Note 4).
+5V	VCC Output +5.0V. Limit current drawn from this pin to 100mA to avoid exceeding the available current from the host USB port.
AN7	Analog Input AN7. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN7; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN6	Analog Input AN6. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN6; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN5	Analog Input AN5. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN5; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN4	Analog Input AN4. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN4; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
RA4	Digital I/O RA4; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).

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AN3	Analog Input AN3. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN3; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
GND	Ground
AN12	Analog Input AN12. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN12; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN10	Analog Input AN10. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN10; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN8	Analog Input AN8. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN8; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN9	Analog Input AN9. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN9; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN11	Analog Input AN11. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN11; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN13	Analog Input AN13. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN13; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
RB6	Digital I/O RB6; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
RB7	Digital I/O RB7; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN0	Analog Input AN0. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN0; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN1	Analog Input AN1. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN1; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
AN2	Analog Input AN2. Input voltage range is 0 to +5V (see Note 1). Digital I/O AN2; configurable as a digital input, a digital output (5V) or an open-drain output (5V max pullup) (see Note 2).
GND	Ground
S2	Latching Relay 2 Set Contact (see Note 3)
C2	Latching Relay 2 Common Contact (see Note 3)
R2	Latching Relay 2 Reset Contact (see Note 3)

Notes:

1. The Analog Input Range is 0-5V. The maximum sample rate is 20Ksps. Refer to Section 7 for more details.

2. Digital outputs can sink or source 25mA; 90mA for all combined. Open-drain outputs are implemented by making the I/O pin an input. The maximum pullup voltage is 5.3 volts.

3. Relay contacts can support resistive loads of up to 4A @ 30 VDC, 0.6A @ 110 VDC and 1 A @ 125 VAC. **If this value is exceeded, the DLP-IO20 can be damaged**. The relay is set and reset under software control. For a functional schematic of the relay connections, refer to Figure 8.

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4. The DLP-IO20 uses a single-package multi-device driver (ULN2003APW). If only one of the driver channels is being used, it can provide a peak current of 300mA at a 100% duty cycle; but if all three channels are being used, they can only provide a peak current of 100mA each at a 100% duty cycle. **The 5V power source provided by the host USB interface has limited power. For this reason the amount of current drawn by the relay drivers MUST be limited to 300mA or there may not be enough current available to power the board, and the PC's USB port could be damaged**.

7.0 RELAY FUNCTIONAL SCHEMATIC

The DLP-IO20 contains two latching relays. These are controlled by host software. The relay contacts R1, S1, C1, R2, S2 and C2 are described in Table 1. A functional view of how one of the relays works is shown here:

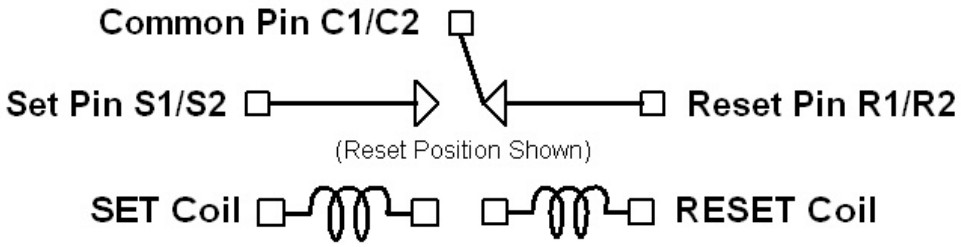


Figure 1: Relay Functional Schematic

Note: On power-up of the DLP-IO20, the relay states will be unknown. Each can power up in either the set or reset state. If a known initial state is required, the user will need to issue either a set or reset command upon power-up.

8.0 USING THE DLP-IO20

Simply connect the DLP-IO20 to the PC to initiate the loading of USB drivers. Once the USB drivers are loaded, the DLP-IO20 is ready for use. All commands are issued as multi-byte command packets consisting of at least two bytes.

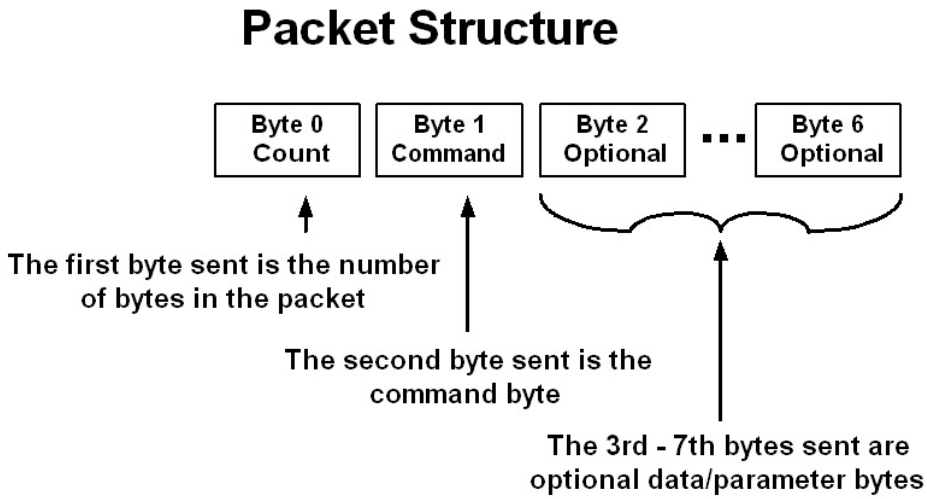


Figure 2: Multi-Byte Command Packets

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You can either utilize the TestApp program provided with the DLP-IO20 (as described in Section 8), or you can write your own program in your language of choice. Begin by opening the COM port, and send multi-byte commands as shown in Table 2 below. There is no need to set the baud rate because the DLP-IO20 uses a parallel interface between the USB IC and the microcontroller. (The Ping command can be used to locate the correct COM port used for communicating with the DLP-IO20, or you can look in Device Manager to see which port was assigned by Windows.)

TABLE 2

Command Packets

Command Packet	Description	Byte	Hex Value	Return/Comments
Ping	Issue Ping	0	0x02	2-Byte Packet
		1	0x27	Y (0x59) will be returned if the DLP-IO20 is found on the selected port
Flash LED	Flashes the D1 LED	0	0x02	2-Byte Packet
		1	0x28	Nothing Returned
LED Control	Turn the D1 LED On/Off	0	0x03	3-Byte Packet
		1	0x29	LED Control Command
		2	0x00 0x01	LED D1 port pin set Low (0) turns LED on LED D1 port pin set High (1) turns LED off Nothing Returned
Relay Control	Set/Reset Relays	0	0x04	4-Byte Packet
		1	0x30	Relay Control Command
		2	0x01 0x02	Select Relay 1 Select Relay 2
		3	0x00 0x01	Set Relay Reset Relay Nothing Returned

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Digital I/O Command	Control Direction and Output Value on Digital I/O	0	0x05	5-Byte Packet
		1	0x35	Digital I/O Command
		2	0x00	Select Channel AN0
			0x01	Select Channel AN1
			0x02	Select Channel AN2
			0x03	Select Channel AN3
			0x04	Select Channel AN4
			0x05	Select Channel AN5
			0x06	Select Channel AN6
			0x07	Select Channel AN7
			0x08	Select Channel AN8
			0x09	Select Channel AN9
			0x0A	Select Channel AN10
			0x0B	Select Channel AN11
			0x0C	Select Channel AN12
			0x0D	Select Channel AN13
			0x0E	Select Channel RA4
			0x0F	Select Channel P5
			0x10	Select Channel P6
			0x11	Select Channel P7
			0x12	Select Channel RB7
			0x13	Select Channel RB6
		3	0x00	Channel Configured as Digital Output
			0x01	Channel Configured as Digital Input
		4	0x00	Digital Output Set Low (0)
			0x01	Digital Output Set High (1) Note: Byte 4 is only used in output mode but **must be included** in all Digital IO Command Packets. When Byte 3 is set for input (0x01), a single byte is returned.
Enable/ Clear Event Counter Command	Enable and Clear Event Counter on Channels RB6 and RB7	0	0x04	4-Byte Packet
		1	0x36	Enable and Clear Event Counter Command
		2	0x06	Channel RB6
			0x07	Channel RB7
		3	0x00	Trigger Event Count on Falling Edge
			0x01	Trigger Event Count on Rising Edge
				Nothing Returned
Read Event Counter Command	Read Event Counter on Channels RB6 and RB7	0	0x03	3-Byte Packet
		1	0x37	Read Event Counter Command
		2	0x06	Channel D6
			0x07	Channel D7 32-bit count value returned as 4 bytes with the LS byte first.

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Detect Sensor Command	Determine if Temperature Sensor is Present and Retrieve the Serial Number (Designed to work with the **DS18B20+** sensor)	0	0x03	3-Byte Packet
		1	0x39	Detect Sensor Command (see Note 3)
		2	0x00 0x01 0x02 0x03 0x04 0x05 0x06 0x07 0x08 0x09 0x0A 0x0B 0x0C 0x0D 0x0E 0x12 0x13	Select Channel AN0 Select Channel AN1 Select Channel AN2 Select Channel AN3 Select Channel AN4 Select Channel AN5 Select Channel AN6 Select Channel AN7 Select Channel AN8 Select Channel AN9 Select Channel AN10 Select Channel AN11 Select Channel AN12 Select Channel AN13 Select Channel RA4 Select Channel RB7 Select Channel RB6 <u>8 Bytes are Returned by the Detect Command</u>: 0 : LS Byte (0) of Sensor Serial Number, or the following: 1 = Error: Short Circuit; Data Always Low 2 = Error: No DS18B20+ Sensor Detected 1 : Byte (1) of Sensor Serial Number; 0x00 on Error 2 : Byte (2) of Sensor Serial Number; 0x00 on Error 3 : Byte (3) of Sensor Serial Number; 0x00 on Error 4 : Byte (4) of Sensor Serial Number; 0x00 on Error 5 : Byte (5) of Sensor Serial Number; 0x00 on Error 6 : Byte (6) of Sensor Serial Number; 0x00 on Error 7 : MS Byte (7) of Sensor Serial Number; 0x00 on Error
Convert Sensor Command	Initiate Sensor Conversion	0	0x03	3-Byte Packet
		1	0x40	Convert Sensor Command (see Notes 1 & 2)
		2	0x01-0x13	Select Channel 0x00-0x13 (see Command 0x39 above) The host software must wait for conversion to complete before valid data can be read. Nothing Returned
Read Sensor Command		0	0x03	3-Byte Packet
		1	0x41	Read Sensor Command (see Note 3)
		2	0x01-0x13	Select Channel 0x00-0x13 (see Command 0x39 above) <u>2 bytes are returned</u>: 0 : LS Byte Temperature Value (see Note 3) 1: MS Byte of Temperature Value (see Note 3) 0x00 returned for both bytes indicates conversion not complete. A <u>successful</u> read initiates another conversion.

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Sensor Resolution Command	Configure the Sensor's Resolution	0	0x04	4-Byte Packet
		1	0x42	Set Resolution Command (see Note 3)
		2	0x01-0x13	Select Channel 0x00-0x13 (See Command 0x39 above)
		3	0x09 0x0A 0x0B 0x0C	9-Bit Resolution (0.5 ^{O}C); 94mS Max Convert Time 10-Bit Resolution (0.25 ^{O}C); 188mS Max Convert Time 11-Bit Resolution (0.125 ^{O}C); 375mS Max Convert Time 12-Bit Resolution (default) (0.0625 ^{O}C; 750mS Max Convert Time Nothing Returned
Single Channel A/D Conversion Command	Convert and Read the Analog Voltage on Selected Channel	0	0x03	3-Byte Packet
		1	0x50	Single-Channel A/D Convert/Read Command
		2	0x00 0x01 0x02 0x03 0x04 0x05 0x06 0x07 0x08 0x09 0x0A 0x0B 0x0C 0x0D	Select Channel AN0 Select Channel AN1 Select Channel AN2 Select Channel AN3 Select Channel AN4 Select Channel AN5 Select Channel AN6 Select Channel AN7 Select Channel AN8 Select Channel AN9 Select Channel AN10 Select Channel AN11 Select Channel AN12 Select Channel AN13 <u>2 Bytes are Returned by the A/D Command</u>: 0 : Least Significant Byte of Voltage Value 1 : Most Significant Byte of Voltage Value
Single-Channel A/D Multiple Conversion Command	Perform Multiple A/D Conversions on the Selected Channel, and Return the Data after Each Conversion	0	0x05	5-Byte Packet
		1	0x51	Single-Channel A/D Multiple Conversion Command
		2	0x01-0x0D	Select Channel 0x00-0x0D (see Command 0x50)
		3	0x00 0x01 0x02 0x03 0x04	Rate = 1K Samples per Second Rate = 2K Samples per Second Rate = 4K Samples per Second Rate = 10K Samples per Second Rate = 20K Samples per Second
		4	0x00 0x01 0x02 0x03 0x04 0x05 0x06	Number of Samples = 128 Number of Samples = 256 Number of Samples = 512 Number of Samples = 1024 Number of Samples = 2048 Number of Samples = 4096 Number of Samples = 8192

Returns data in real time as each A/D conversion completes; 2 bytes are returned for each conversion.

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Continuous Read Command	Stream Voltage Data Collected from Selected Channel Until Commanded to Stop	0	0x04	4-Byte Packet
		1	0x52	Single-Channel A/D Multiple Conversion Command
		2	0x01-0x0D	Select Channel 0x00-0x0D (see Command 0x50)
		3	0x000x01 0x02 0x03 0x04	Rate = 1K Samples per Second Rate = 2K Samples per Second Rate = 4K Samples per Second Rate = 10K Samples per Second Data will be streamed to the host until any byte is sent, at which point this command will be terminated.
Set External A/D Reference		0	0x02	2-Byte Packet
		1	0x53	Select the A/D reference voltage connected to the AN3 pin. (The valid range is 2.7-5.0V.) This voltage sets the maximum voltage that can be measured by the A/D.
Set Internal A/D Reference		0	0x02	2-Byte Packet
		1	0x54	Use the USB host 5V power source as the reference voltage (default).

Notes:

1. Requires DS18B20+ digital temperature sensor (purchased separately). See Section 9.0 of this document for connection details.

2. Before issuing a Convert Sensor Command, make sure that a digital temperature sensor is present on the selected digital I/O channel with a 1.5K-ohm pull-up resistor.

3. The temperature value returned is in ^{O}C and is assigned a 16-bit value. When the MS bit is high, this indicates a negative temperature. The user will need to handle the sign and convert the negative number before translating the binary representation into a decimal temperature value. One example of how to do this is shown in the DLP-IO20 demo code provided. Other examples are available from www.maxim-ic.com in Application Note AN162.pdf.

9.0 CONNECTING THE DIGITAL TEMPERATURE SENSOR

Up to 17 DS18B20+ digital temperature sensors can be connected to the DLP-IO20. For best performance, use Category 5/6 type computer cable to connect the sensors to the DLP-IO20. Two twisted-pair wires in the Cat 5/Cat 6 cable are required for the connection. The first pair are for Power (5V) and Ground, and the second pair are designated as Data and Ground. In addition, a 1.5K-ohm pull-up resistor is required for the data line. Figure 3 shows an example of this connection using Channel AN7:

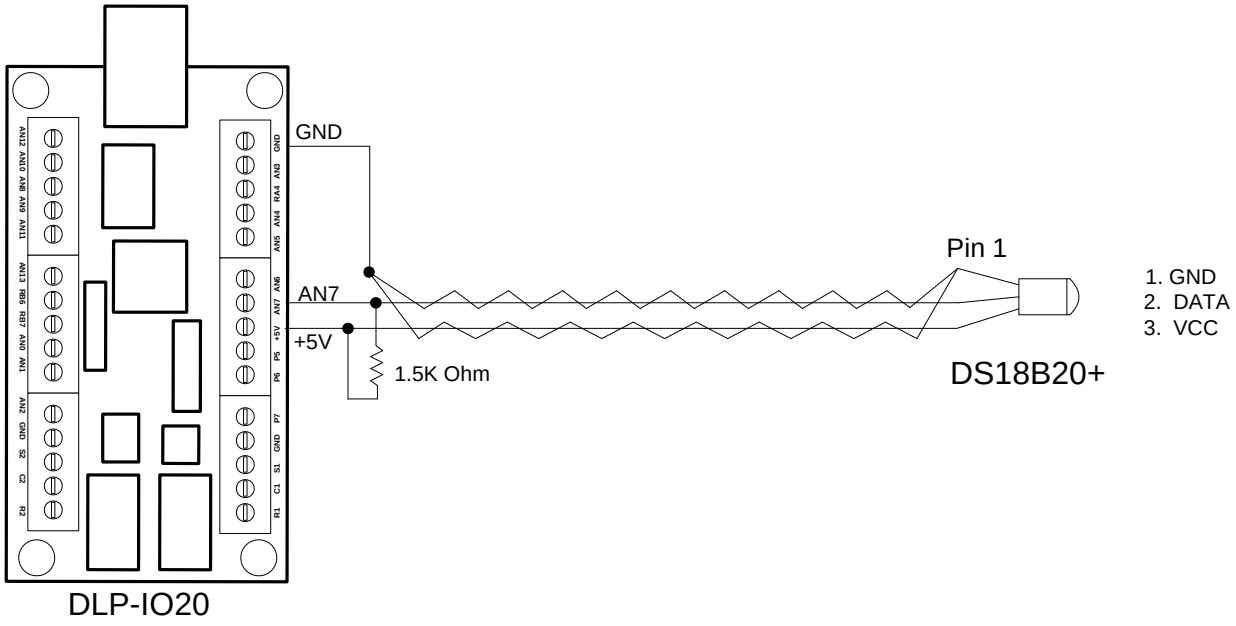


Figure 3: Digital Temperature Sensor Connection Example

To detect a sensor, send the DLP-IO20 the Detect Sensor Command (0x39) packet for the appropriate channel. Eight bytes will be returned from this command packet. If the channel is stuck Low, a "1" will be returned in the first byte. If no sensor is present, then a "2" will be returned in the first byte. In these two cases, the remaining seven bytes will be all zeroes. If a sensor is present and functional, its 8-byte serial number will be returned.

Next, send a Convert Sensor Command (0x40) to initiate the temperature-conversion process. At this point, a Read Sensor Command (0x41) packet can be issued to obtain the temperature value. The conversion can take up to 750mS to complete depending upon the resolution setting.

All commands are detailed in Table 2 under Section 8 of this datasheet.

10.0 DEMO APPLICATION PROGRAM

A test application program called IO20Demo is provided with the purchase of the DLP-IO20 that runs on Windows XP/Vista and can be used to interface with and control the DLP-IO20. (Note that the Visual C++ source is also available with the purchase of the DLP-IO20.) This application is designed to demonstrate all available features:

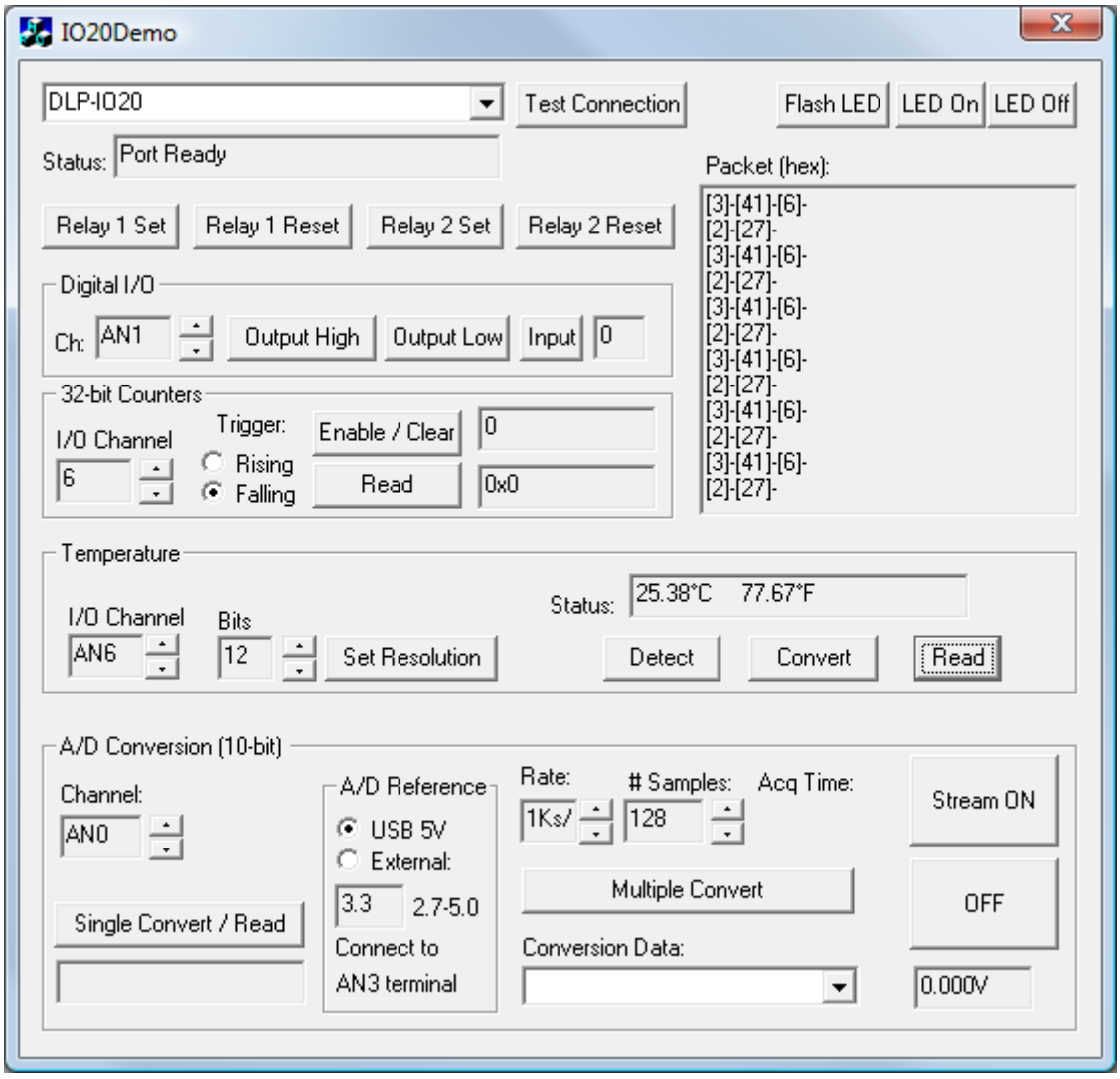
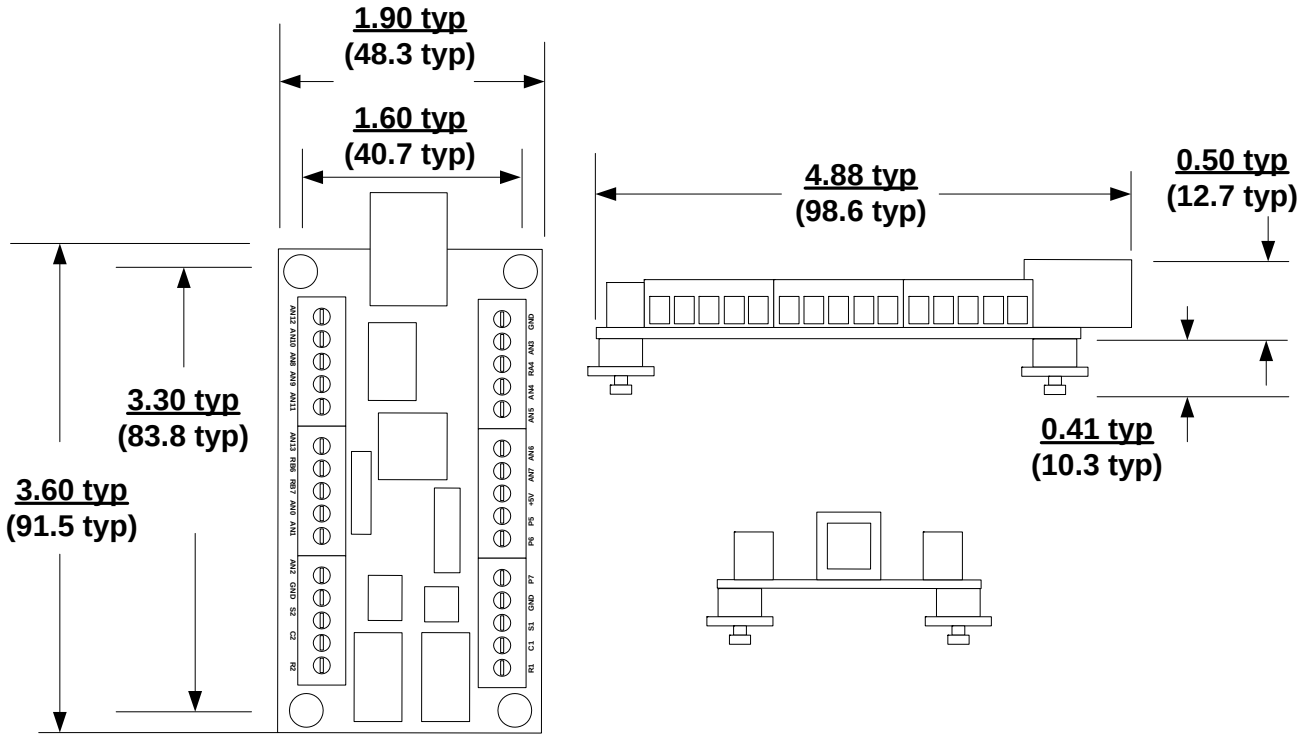


Figure 4: Test Application GUI

The version of the application provided for download with the DLP-IO20 targets Windows XP and Vista, but the Visual C++ 6.0 source code is available (upon purchase of the DLP-IO20) so that the application can be retargeted for different operating systems.

11.0 MECHANICAL DIMENSIONS IN INCHES (MM)



DLP-IO20

12.0 DISCLAIMER

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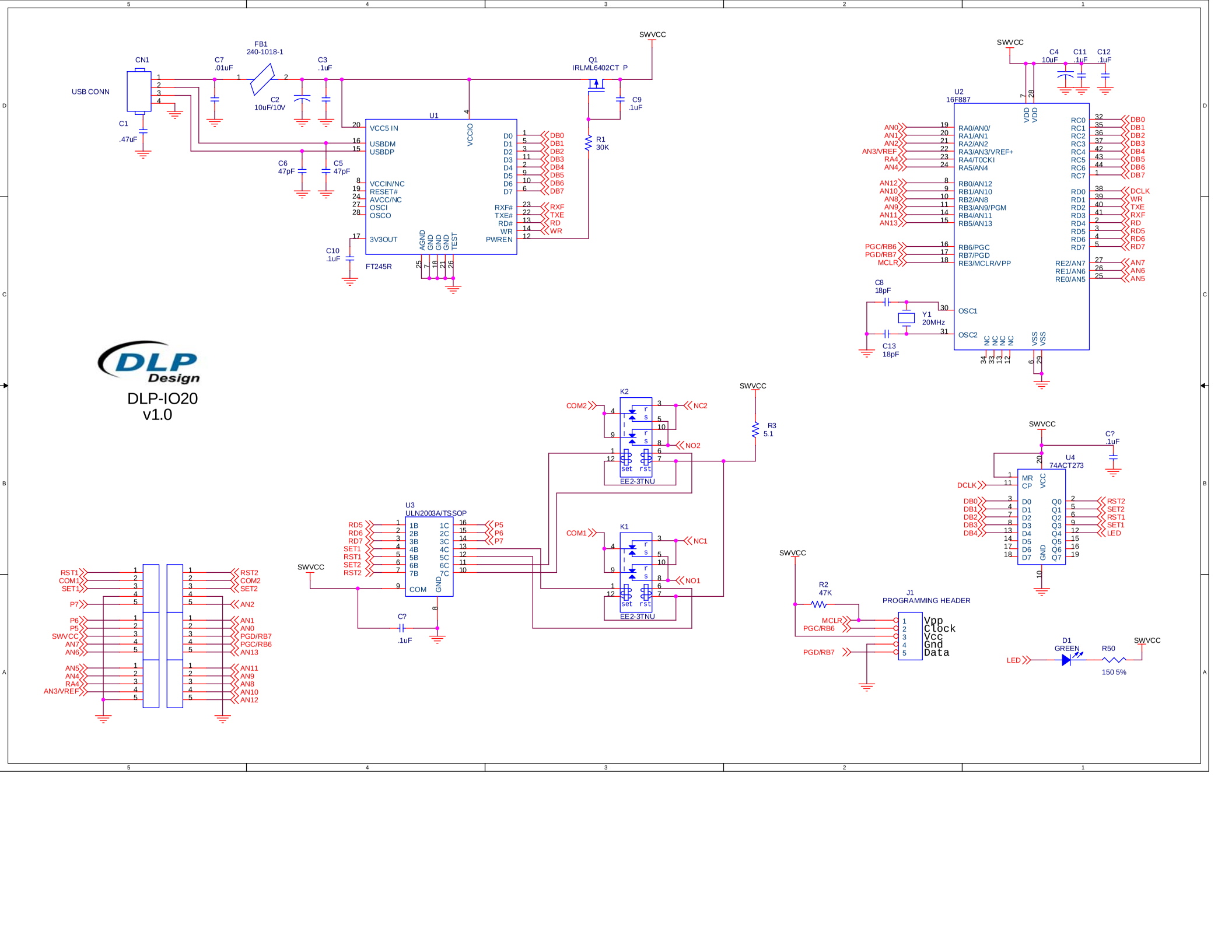
This document provides preliminary information that may be subject to change without notice.

13.0 CONTACT INFORMATION

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C3
.1uF
C6
47pF
C5
47pF
U1
FT245R
VCC5 IN
USBDM
USBDP
VCCIO
VCCIN/NC
RESET#
AVCC/NC
OSCI
OSCO
3V3OUT
AGND
GND
GND
GND
TEST
D0
D1
D2
D3
D4
D5
D6
D7
RXF#
TXE#
RD#
WR
PWREN
C10
.1uF
Q1
IRLML6402CT P
C9
.1uF
R1
30K
SWVCC
U2
16F887
VDD
VDD
RA0/AN0/
RA1/AN1
RA2/AN2
RA3/AN3/VREF+
RA4/T0CKI
RA5/AN4
RB0/AN12
RB1/AN10
RB2/AN8
RB3/AN9/PGM
RB4/AN11
RB5/AN13
RB6/PGC
RB7/PGD
RE3/MCLR/VPP
OSC1
OSC2
NC
NC
NC
NC
VSS
VSS
RC0
RC1
RC2
RC3
RC4
RC5
RC6
RC7
RD0
RD1
RD2
RD3
RD4
RD5
RD6
RD7
RE2/AN7
RE1/AN6
RE0/AN5
C4
10uF
C11
.1uF
C12
.1uF
C8
18pF
Y1
20MHz
C13
18pF
K2
EE2-3TNU
K1
EE2-3TNU
COM2
NC2
NO2
COM1
NC1
NO1
R3
5.1
U3
ULN2003A/TSSOP
1B
2B
3B
4B
5B
6B
7B
1C
2C
3C
4C
5C
6C
7C
COM
GND
C?
.1uF
U4
74ACT273
MR
CP
VCC
GND
C?
.1uF
R2
47K
J1
PROGRAMMING HEADER
Vpp
Clock
Vcc
Gnd
Data
D1
GREEN
R50
150 5%
LED
RST1
COM1
SET1
P7
P6
P5
SWVCC
AN7
AN6
AN5
AN4
RA4
AN3/VREF
RST2
COM2
SET2
AN2
AN1
AN0
PGD/RB7
PGC/RB6
AN13
AN11
AN9
AN8
AN10
AN12
RD5
RD6
RD7
SET1
RST1
SET2
RST2
P5
P6
P7
DCLK
DB0
DB1
DB2
DB3
DB4
RST2
SET2
RST1
SET1
LED
MCLR
PGC/RB6
PGD/RB7

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