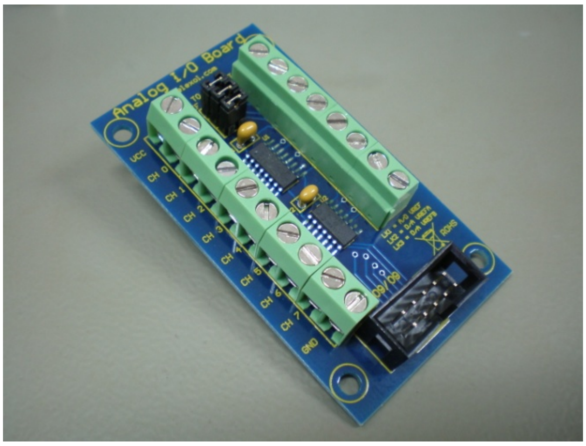
ANALOG I/O BOARD

FEATURES

- 1 x 8 Channel 10 bit Analog to Digital Converter (MCP3008)
- 1 x 12 bit Digital to Analog Converter with 2 Buffered Outputs
- Screw Terminal Blocks for Analog Inputs and Outputs
- Easy connection to the I/O port via a 10-way box header that suits a standard IDC connector.
- 72mm Standard width for DIN Rail Modules



GENERAL DESCRIPTION

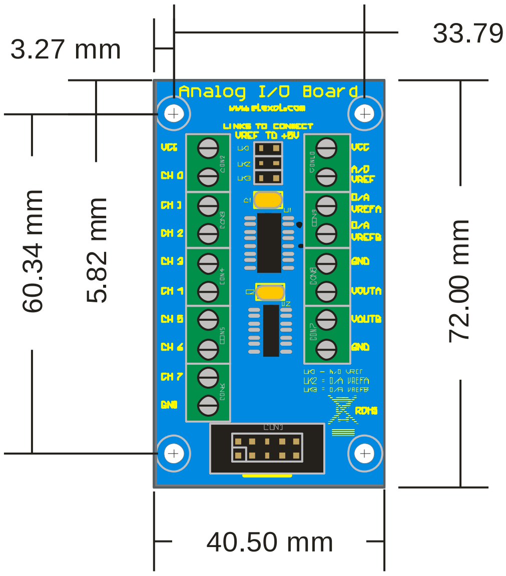
The Analog I/O Board is an accessory board that allows the implementation of an analog interface to Elexol's existing I/O 24 Range. The Elexol I/O 24 Range consists of Ether I/O 24 R, Ether I/O 24 DIP R, USB I/O 24 R and the USB I/O 24 DIP R.

The board consists of an 8 channel 10 bit Analog to Digital Converter (MCP3008) and a 12 bit Digital to Analog Converter with 2 buffered outputs (MCP4922). Communication to the A/D and D/A Converters is via the SPI interface of the I/O 24 module which is implemented in the firmware. For further information on implementing the SPI interface please refer to the user manual for the I/O 24 module.

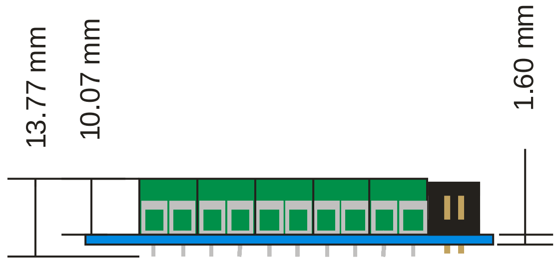
The 8 channels of the A/D, 2 channels outputs of the D/A, and all the VREF voltages are connected to screw terminals for easy access. These screw terminals will accept cables 0.5 – 2mm[1]. The connection between the I/O 24 module and the Analog I/O board is via a 30 cm IDC connection cable. This cable is provided with the board.

The board has been designed to a 72mm standard width so that it can easily be mounted in DIN rail mounting modules.

LAYOUT AND MECHANICALS



TOP VIEW



SIDE VIEW

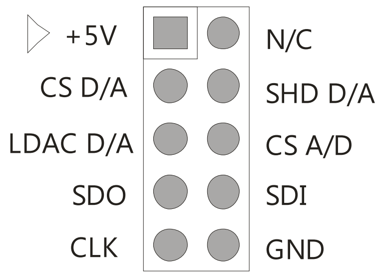
Dimensions: 1.59 X 2.8 X 0.59 inches (40.5 X 72 X 15mm)

PINOUTS AND BOARD CONNECTIONS

10 PIN BOX HEADER

Shown in the diagram below is the I/O port Connector for Analog Board.

SPI Connection to I/O 24 Port



Note: Pin1 Marked on I/O Accessory with ▷

Listed in Table 1 below are the connections for the 10 Pin Box Header

TABLE 1

PIN #	SIGNAL	TYPE	DESCRIPTION
1	+5V USB	PWR	+3.3V to +5V drawn from I/O module powers (Supplies power to the Analog I/O Board)
2	N/C	I	Not Connected (N/C)
3	CS D/A	I	CS is the chip select input for D/A, which requires an active-low signal to enable serial clock and data functions.
4	SHD D/A	I	SHDN is the hardware shutdown input for D/A, that requires an active-low input signal to configure the D/A’s in their low-power Standby mode.
5	LDAC D/A	I	LDAC (the latch DAC syncronization input) transfers the input latch registers to the DAC registers (output latches) when low. Can also be tied low if transfer on the rising edge of CS is desired.
6	CS A/D	I	The CS/SHDN input pin for the A/D is used to initiate communication with the device when pulled low. When pulled high, it will end a conversion and put the device in low power standby. The CS/SHDN pin must be pulled high between conversions.
7	SDO	O	Serial Data Out
8	SDI	I	Serial Data In
9	CLK	I	Serial Clock Input
10	GND	PWR	Ground signal from I/O module

SCREW TERMINAL CONNECTIONS

SIGNAL	TYPE	DESCRIPTION
+5V	PWR	+3.3V to +5V drawn from I/O module powers (Supplies power to the Analog I/O Board)
CH 7	I	Analog Input for Channel 7
CH 6	I	Analog Input for Channel 6
CH 5	I	Analog Input for Channel 5
CH 4	I	Analog Input for Channel 4
CH 3	I	Analog Input for Channel 3
CH 2	I	Analog Input for Channel 2
CH 1	I	Analog Input for Channel 1
CH 0	I	Analog Input for Channel 0
GND	PWR	Ground signal from I/O module
VOB	O	DAC Channel B Output Voltage
GND	PWR	Ground signal from I/O module
VOA	O	DAC Channel A Output Voltage
D/A VREFA	I	DAC Channel A Reference Voltage Input (AVSS to VDD)
D/A VREFB	I	DAC Channel B Reference Voltage Input (AVSS to VDD)
A/D VREF	I	ADC Reference Voltage Input (AVSS to VDD)
GND	PWR	Ground signal from I/O module

JUMPER CONNECTIONS (VREF DEFAULT RANGE JUMPERS)

There are 3 jumpers located on the Analog I/O Board designated LK1 to LK3. These jumpers are placed so that the Analog Input/output range (VREF) of the Channel can be set to read or output the full voltage range of the device.

The table below outlines the jumper configurations

JUMPER	DESCRIPTION
LK1	A/D VREF connection to 5V
LK2	D/A VREFB connection to 5V
LK3	D/A VREFA connection to 5V

These jumpers can be removed so that different VREF voltages can be used. When using a different VREF voltage please check that the maximum ratings are not exceeded.

NOTE: For the A/D and D/A when VREF is reduced the LSB size is reduced accordingly.

COMMUNICATIONS

SETTING UP THE PORT ON THE I/O 24 FOR SPI COMMUNICATIONS TO THE ANALOG BOARD

Communication to the Analog board is via SPI from the port of I/O 24. However the port direction and pins will need to be setup before communication can begin with the board. Below are the configurations that need to be setup on the I/O 24 for the analog board.

I/0 24 COMMAND	DESCRIPTION
!A 0x04	Initialise PORT Direction on I/O 24
A 0x79	Set CS for A/D and D/A to idle state
A 0x71	Lower CS for A/D and D/A to idle state
A 0x78	Lower CS for D/A and A/D to idle state
A 0x38	Lower CS for D/A and set LDAC to high
A 0x68	Lower LDAC

CONTROL BYTES AND COMMAND REGISTER

There are a number of control bytes / command registers that are used in order to communicate with the analog board. These control bytes /command registers along with their configuration bits are outlined below.

COMMON CONTROL BYTE CONFIGURATIONS FOR MCP3008 A/D FOR COMMUNICATIONS

CHANNEL SELECTION	INPUT PIN CONFIGURATION ON MCP3008	CONTROL BYTE (hex)	CONTROL BIT SELECTIONS							
			SGL/ DIFF	D2	D1	D0	X	X	X	X
CH0	Single-ended	0x80	1	0	0	0	0	0	0	0
CH1	Single-ended	0x90	1	0	0	1	0	0	0	0
CH2	Single-ended	0xA0	1	0	1	0	0	0	0	0
CH3	Single-ended	0XB0	1	0	1	1	0	0	0	0
CH4	Single-ended	0XC0	1	1	0	0	0	0	0	0
CH5	Single-ended	0XD0	1	1	0	1	0	0	0	0
CH6	Single-ended	0XE0	1	1	1	0	0	0	0	0
CH7	Single-ended	0XF0	1	1	1	1	0	0	0	0
CH0 = IN+ CH1 = IN-	Differential	0x00	0	0	0	0	0	0	0	0
CH0 = IN- CH1 = IN+	Differential	0x10	0	0	0	1	0	0	0	0
CH2 = IN+ CH3 = IN-	Differential	0x20	0	0	1	0	0	0	0	0
CH2 = IN- CH3 = IN+	Differential	0x30	0	0	1	1	0	0	0	0
CH4 = IN+ CH5 = IN-	Differential	0x40	0	1	0	0	0	0	0	0
CH4 = IN- CH5 = IN+	Differential	0x50	0	1	0	1	0	0	0	0
CH6 = IN+ CH7 = IN-	Differential	0x60	0	1	1	0	0	0	0	0
CH6 = IN- CH7 = IN+	Differential	0x70	0	1	1	1	0	0	0	0

The control bytes listed in the table above are used in the SPI communication to the analog device.

WRITE COMMAND REGISTER FOR THE MCP4922 D/A FOR COMMUNICATIONS

All writes to the MCP4922 are comprised of 16 bit words in this case write command MSB and LSB. The four upper bits in the Command Register are the configuration bits for the MCP4922 whilst the other 12 are data bits. Each of the Command register configuration bits are outlined below.

Write Command Register MSB

WRITE COMMAND REGISTER MSB								
Bit	15	14	13	12	11	10	9	8
Configuration Bit	A/B	BUF	GA	SHDN	D11	D10	D9	D8

Write Command Register LSB

WRITE COMMAND REGISTER LSB								
Bit	7	6	5	4	3	2	1	0
Configuration Bit	A/B	BUF	GA	SHDN	D11	D10	D9	D8

Configuration bit 15 A/B: DACA or DACB Select bit

1 = Write to DACB
0 = Write to DACA

Configuration bit 14 BUF: VREF Input Buffer Control bit

1 = Buffered
0 = Unbuffered

Configuration bit 13 GA: Output Gain Select bit

1 = 1x (VOUT = VREF * D/4096)
0 = 2x (VOUT = 2 * VREF * D/4096)

Configuration bit 12 SHDN: Output Power Down Control bit

1 = Output Power Down Control bit
0 = Output buffer disabled, Output is high impedance

Configuration bits 11-0 D11:D0: DAC Data bits

12 bit number "D" which sets the output value. Contains a value between 0 and 4095.

Examples on how to use this write command register to communicate with the MCP4922 are shown in the coding examples section.

BASIC OVERVIEW OF SPI COMMUNICATIONS WITH THE ANALOG BOARD

Listed below is a basic overview of the procedure that needs to be followed in order to communicate with the board.

1. Setup Direction Register on I/O 24 for Analog Board (if using the ETHER IO24 TCP, set the unit for SPI MODE 3)
2. Setup Port Values on I/O 24 for idle state on Analog Board
3. Lower the CS pin for chip communication
4. Start SPI communication by sending start byte
5. Send Control Byte or write command registers
6. Send Null Bytes if response is required. This is done to keep the SPI clock going or no responses will be clocked in
7. Raise the CS pin back to idle state.
8. Repeat from Step 3 for other commands.

The coding examples below go into more detail of what commands are issued to the board.

CODING EXAMPLES

Outlined below are some standard commands that can be sent to the Analog I/O board for both the USB I/O 24 and the Ether I/O 24. The example code has been written in Visual C# Express.

These examples are available for download from our website www.elexol.com

USB I/O 24 Commands
(This example is implemented on PORT A of the USB I/O 24.)

Control Byte Register for A/D channels

```
// Control Byte A/D         // SGL/DIFF  D2  D1  D0  X   X   X   X
// Control Byte CH0 = 0x80  //  1        0   0   0  X    X   X   X
// Control Byte CH1 = 0x90
// Control Byte CH2 = 0xA0
// Control Byte CH3 = 0xB0  //  1        0   1   1   x   x   x   x
// Control Byte CH4 = 0xC0
// Control Byte CH5 = 0xD0
// Control Byte CH6 = 0xE0
// Control Byte CH7 = 0xF0
```

Perform a Read on the Analog channel (CH0)

```
//Initialize Port directions
WriteDirection('A', 0x04); //set Port A to initialise A/D Board !A 0x04
//Initialise Port Values for A/D Board
// Set up SPI pins, CS
WriteValue('A', 0x79); //Enable the CS_n for A/D and D/A to idle state
(0111 1000)

//Perform Read on CH 0 A/D

WriteValue('A', 0x71); //Lower CS for U1
WriteValue('S', 0x01); //Send the Start Byte for U1 (0x01)
WriteValue('S', 0x80); //Send the Configure Byte to Read CH 0 on A/D
WriteValue('S', 0x00); //Send Null byte to read A/D value LSB
WriteValue('A', 0x79); //Idle CS for U1 and U2

temp = ReadValue_SPI(6); // Read the null bytes returned by SPI
portA = temp[3];
portA = portA & (byte)0x07; // ADC[11]-ADC[8]
portA = portA * 256 + temp[5]; // ADC[7]-ADC[0]
```

```
VoltageADC = (double)portA * 0.00488; // Conversion to Voltage from ADC //
with VRef set to 5V
TestTextBox.AppendText("The voltage read from PD 1 is : " + VoltageADC + "
V" + "\r\n");

unsafe private byte[] ReadValue_SPI(UInt32 rxCount)
{
   UInt32 dwRet = 0;
   FT_STATUS ftStatus = FT_STATUS.FT_OTHER_ERROR;
   byte[] cBuf = new byte[rxCount];
   dwRet = 0;
   long timeout;
   timeout = 0;
   do
   {
      ftStatus = FT_GetQueueStatus(m_hPort, ref dwRet);
      timeout++;
   } while ((dwRet < rxCount) && (timeout < 100000));

   if (timeout == 100000)
   {
      MessageBox.Show("Timeout while reading " +
      Convert.ToString(ftStatus));
      return (cBuf);
   }

   fixed (byte* pBuf = cBuf)
   {
      ftStatus = FT_Read(m_hPort, pBuf, rxCount, ref dwRet);
   }

   if (ftStatus != FT_STATUS.FT_OK)
   {
     MessageBox.Show("Failed To Read " + Convert.ToString(ftStatus));
   }
   return (cBuf);
}

unsafe private void WriteValue(char port, byte value)
{
   UInt32 dwRet = 0;
   FT_STATUS ftStatus = FT_STATUS.FT_OTHER_ERROR;
   byte[] cBuf = new byte[5];

   cBuf[0] = (byte)port;
   cBuf[1] = value;
   fixed (byte* pBuf = cBuf)
```

```
    {
        ftStatus = FT_Write(m_hPort, pBuf, 2, ref dwRet);
    }
}
unsafe private void WriteDirection(char port, byte value)
{
    UInt32 dwRet = 0;
    FT_STATUS ftStatus = FT_STATUS.FT_OTHER_ERROR;
    byte[] cBuf = new byte[5];

    cBuf[0] = (byte)'!';
    cBuf[1] = (byte)port;
    cBuf[2] = value;
    fixed (byte* pBuf = cBuf)
    {
        ftStatus = FT_Write(m_hPort, pBuf, 3, ref dwRet);
    }
}
```

Write voltage level on D/A channel (VOUTA and VOUTB)

```
// Idle state  = 0x78
// Lower CS for D/A = 0x70
// Write Command Register MSB   // A/B  BUF  GA  SHDN  D11  D10  D9  D8
// Write Command Register LSB   // D7   D6   D5  D4    D3   D2   D1  D0

//Initialize Port directions
WriteDirection('A', 0x04); //set Port A to initialise A/D Board
// Set up SPI pins, CS
WriteValue('A', 0x78); //Enable the CS_n for A/D and D/A to idle state

//This will output 2.5V on both D/A channels VOUTA and VOUTB

//Write 2.5V VOUTB
WriteValue('A', 0x38); //Lower CS for D/A and set LDAC to high
WriteValue('S', 0xF7); //Send the MSB of Write Command Register for D/A
WriteValue('S', 0xFF); //Send the LSB of Write Command Register for D/A
temp = ReadValue_SPI(4); // Read the null bytes returned by SPI
WriteValue('A', 0x78); //Idle CS D/A and A/D
WriteValue('A', 0x68); //Lower LDAC pin
WriteValue('A', 0x78); //Idle CS D/A and A/D raise LDAC to high

//Write 2.5V VOUTA
WriteValue('A', 0x38); //Lower CS for D/A and set LDAC to high
WriteValue('S', 0x77); //Send the MSB of Write Command Register for D/A
WriteValue('S', 0xFF); //Send the LSB of Write Command Register for D/A
temp = ReadValue_SPI(4); // Read the null bytes returned by SPI
WriteValue('A', 0x78); //Idle CS D/A and A/D
WriteValue('A', 0x68); //Lower LDAC pin
WriteValue('A', 0x78); //Idle CS D/A and A/D raise LDAC to high
```

Ether I/O 24 Commands

Perform a Read on the Analog channel (CH0) on Ether with IP address 10.10.10.10

```
System.Net.IPEndPoint RemoteIpEndPoint = new
System.Net.IPEndPoint(System.Net.IPAddress.Any, 0);

byte[] receiveBytes;
string returnData;
double VoltageADC;

//Initialize Port directions
data[0] = Convert.ToByte('!');//"!"
data[1] = Convert.ToByte('A');; //A
data[2] = 0x04;
//udpClient.Send(data, 3, EtherIP);
udpClient.Send(data, 3, "10.10.10.10", 2424);

// Set up SPI pins, CS
data[0] = Convert.ToByte('A');//"A"
data[1] = 0x78; //Enable the CS_n for A/D and D/A to idle state
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);


//Lower CS pin for A/D

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x71; //
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);

//Perform Read on A/D CH 0 will receive UDP packet back from SPI
//containing data from conversion. This will need to be dealt with in
//data received thread

data[0] = Convert.ToByte('S'); //"S"
data[1] = Convert.ToByte('A'); //"A"
data[2] = 0x03; //number of bytes to be sent out via SPI command
data[3] = 0x01; //first byte  //start byte
data[4] = 0x80; //second byte //command byte
data[5] = 0x00; //third byte //null byte
//udpClient.Send(data, 6, EtherIP);
udpClient.Send(data, 6, "10.10.10.10", 2424);
//Raise CS to idle state

data[0] = Convert.ToByte('A');//"A"
```

```
data[1] = 0x79; //"0x98"
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);

receiveBytes = udpClient.Receive(ref RemoteIpEndPoint);

returnData = System.Text.Encoding.ASCII.GetString(receiveBytes);

ReturnUDPData(receiveBytes, RemoteIpEndPoint);

public void ReturnUDPData(byte[] UDPData, IPEndPoint RemoteIP)

{

string MacString;
string VersionNumber;
string UDPDataString;
double VoltageADC;

if ((UDPData.Length == 6))

//SPI packets that we are recieving back are this long

{

  //need to check for S first, then A, number of bytes, ignore two bytes
and then data byte to read

  if (UDPData[0] == 0x53)

//we are dealing with an SPI packet coming back

  {

     value = 0;
     value = UDPData[4];
     value = value & (byte)0x07; // ADC[11]-ADC[8]
     value = (value * 256) + UDPData[5]; // ADC[7]-ADC[0]
     VoltageADC = (double)value * 0.00488;
// Conversion to Voltage from ADC // with VRef set to 5V
     TextBox.AppendText("The voltage read from PD 1 is : " + VoltageADC +
" V" + "\r\n");
   }


}
```

Write voltage level on D/A channel (VOUTA and VOUTB)

```
//Lower CS pin for D/A

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x38; //"0x98"
//udpClient.Send(data, 6, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);

// VOUTB set to 2.5V
data[0] = Convert.ToByte('S'); //"S"
data[1] = Convert.ToByte('A'); //"A"
data[2] = 0x02; //number of bytes to be sent out via SPI command
data[3] = 0xF7; //first byte  //Write command register MSB
data[4] = 0xFF; //second byte //Write command register LSB
//udpClient.Send(data, 6, EtherIP);
udpClient.Send(data, 5, "10.10.10.10", 2424);

//Raise CS to idle state

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x78; //"0x98"
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);

//Lower LDAC to output values

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x68; //"0x98"
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);


//Raise CS to idle state

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x78; //"0x98"
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);

//Lower CS pin for D/A

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x38; //"0x98"
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);
```

```
// VOUTA set to 2.5V

data[0] = Convert.ToByte('S'); //"S"
data[1] = Convert.ToByte('A'); //"A"
data[2] = 0x02; //number of bytes to be sent out via SPI command
data[3] = 0x77; //first byte  //Write command register MSB
data[4] = 0xFF; //second byte //Write command register LSB
//udpClient.Send(data, 5, EtherIP);
udpClient.Send(data, 5, "10.10.10.10", 2424);

//Raise CS to idle state

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x78; //"0x98"
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);

//Lower LDAC to output values

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x68; //"0x98"
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);

//Raise CS to idle state

data[0] = Convert.ToByte('A');//"A"
data[1] = 0x78; //"0x98"
//udpClient.Send(data, 2, EtherIP);
udpClient.Send(data, 2, "10.10.10.10", 2424);
```

ABSOLUTE MAXIMUM RATINGS

MCP3008

VDD.. 7.0V

All inputs and outputs w.r.t. VSS .... -0.6V to VDD +0.6V

Storage temperature .... -65°C to +150°C

Ambient temp. with power applied .... -65°C to +125°C

ESD protection on all pins .... > 4 kV

MCP4922

VDD.. 6.5V

All inputs and outputs w.r.t VSS .... AVSS -0.3V to VDD+0.3V

Current at Input Pins .... ±2 mA

Current at Supply Pins .... ±50 mA

Current at Output Pins .... ±25 mA

Storage temperature .... -65°C to +150°C

Ambient temp. with power applied .... -55°C to +125°C

ESD protection on all pins .... ≥ 4 kV (HBM), ≥ 400V (MM)

Maximum Junction Temperature (TJ) .... +150°C

FURTHER READING

Information about the Analogue to Digital and Digital to Analogue Converters can be found on the Microchip product datasheets for the devices. These can be downloaded from the Microchip website at www.microchip.com

DOCUMENT REVISION HISTORY

- Analog I/O Board Datasheet Revision 1 – Initial document created
- Added information regarding Ether IO24 TCP has to be in Mode 3