MSXB 048 Accessory Board Manual

Filtered Analog Input Expansion Board

Version 1.10

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Contents

MSXB 048: Filtered Analog Input Expansion Board

The Microstar Laboratories Filtered Analog Input Expansion Board, part number MSXB 048, provides anti-alias filtering and analog input expansion for 16 channels. MSXB 048 filter board has a four-pole low-pass Butterworth filter on each of the 16 channels. Input signals are connected to the MSXB 048 filter board by means of a DB-37 connector on the front panel. MSXB 048 filter board can sample an on-board +5V reference and the on-board analog signal ground. This allows software offset, gain calibration, and verification of proper operation without changing the input cabling.

The number of input expansion and filtering channels can be expanded to as many as 256 by using up to 16 MSXB 048 filter boards.

Microstar Laboratories has several models of MSXB 048 filter boards available. MSXB 048 filter board is compatible with the Standard Data Acquisition Processor backplane system and optionally can be built in a stand-alone or single-board external enclosure configuration. MSXB 048 filter boards mount directly in a standard Microstar Laboratories industrial enclosure fitted with a 68-line analog backplane.

Basic Models

Table 1 shows all current MSXB 048 filter board models. Other models may be available. Contact your Microstar Laboratories representative to determine all available models.

Table 1. MSXB 048 Basic Models

Product Name	Cutoff Frequency/DAP Connection
MSXB048-03-100-E2K	100 Hz, backplane
MSXB048-03-100-A2Z	100 Hz, shielded right angle stand-alone
MSXB048-03-250-E2K	250 Hz, backplane
MSXB048-03-250-A2Z	250 Hz, shielded right angle stand-alone
MSXB048-03-500-E2K	500 Hz, backplane
MSXB048-03-500-A2Z	500 Hz, shielded right angle stand-alone
MSXB048-03-1K-E2K	1 KHz, backplane
MSXB048-03-1K-A2Z	1 KHz, shielded right angle stand-alone
MSXB048-03-2.5K-E2K	2.5 KHz, backplane
MSXB048-03-2.5K-A2Z	2.5 KHz, shielded right angle stand-alone
MSXB048-03-5K-E2K	5 KHz, backplane
MSXB048-03-5K-A2Z	5 KHz, shielded right angle stand-alone
MSXB048-03-10K-E2K	10 KHz, backplane
MSXB048-03-10K-A2Z	10 KHz, shielded right angle stand-alone
MSXB048-03-25K-E2K	25 KHz, backplane
MSXB048-03-25K-A2Z	25 KHz, shielded right angle stand-alone
MSXB048-03-50K-E2K	50 KHz, backplane
MSXB048-03-50K-A2Z	50 KHz, shielded right angle stand-alone

The backplane model with DAP connection E2 connects to the DAP by installing into an analog backplane mounted in an industrial enclosure.

The stand-alone model with DAP Connection A2 connects to the DAP using an MSCBL040-01 or MSCBL041-01 cable.

Installation

The backplane models of Filtered Analog Input Expansion board connect directly to the analog backplane via connector J1. The MSXB 048 filter board installs into any available slot in the analog backplane.

When installing the MSXB 048 filter board, push the board firmly into the slot and make sure the board is securely connected to the backplane.

The stand-alone models and single-board enclosure models connect to the Data Acquisition Processor by means of the MSCBL040-01 or MSCBL041-01 cables. These 68-line cables connect the analog connector of a Data Acquisition Processor to connector J1 of the MSXB 048.

Warning: Never connect or disconnect the Filtered Analog Input Expansion Board from the analog backplane or the Data Acquisition Processor while power is applied to any of them.

Hardware Configuration

The following diagram shows the layout of Filtered Analog Input Expansion board:

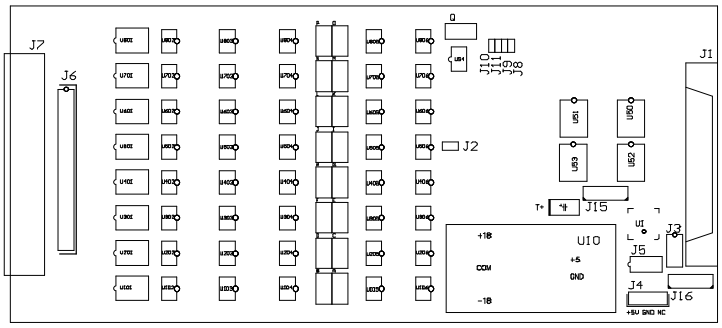

Figure 1. MSXB 048

The input signal terminals on the MSXB 048 filter board are called S0, S1, ..., S15. The input ground terminals are called G0, G1, ..., G15.

The MSXB 048 filter board has input multiplexers that select between the input signal, the on-board analog signal ground, and an on-board high precision +5V reference. Since the MSXB 048 filter board has on-board low pass filters, it is important to allow enough settling time after switching the input to allow the filters to settle to the new DC level. By selecting the speed at which the input multiplexers switch between Analog Sense (ground) and the +5V reference, filter attenuation can be measured at various signal frequencies.

Connecting Input Signals

Input signals are connected to the Filtered Analog Input Expansion board through a DB-37 connector. Figure 2 shows the pinout of connector DB-37 or connector J7 (looking into the board), each pin is labeled with the signal name:

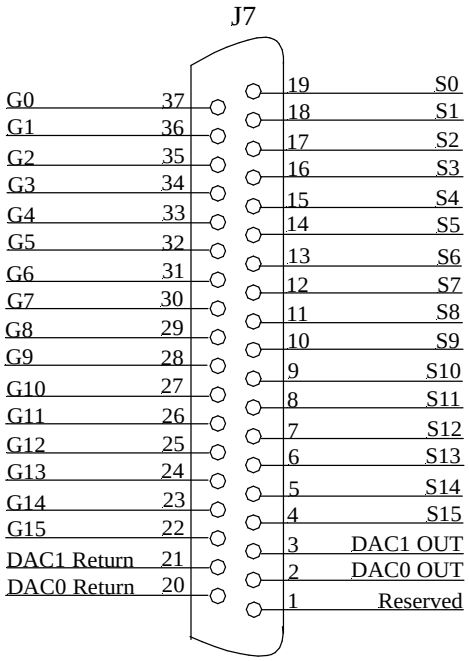

Figure 2. Connector DB-37

Analog input signals should be within the range from –25 volts to +25 volts, relative to the ground of the MSXB 048 filter board. Input signals may be applied to the MSXB 048 board when the power is off.

The MSXB 048 filter board is not designed for use in measuring differential signals, but the user can take the difference between two single ended signals using the differential amplifier on a DAP board. Table 2 shows the correspondence between differential and single-ended inputs.

Table 2. Differential Input Connections

Single-Ended Input	Differential Input
S0	D0-
S1	D0+
S2	D1-
S3	D1+
S4	D2-
S5	D2+
S6	D3-
S7	D3+
S8	D4-
S9	D4+
S10	D5-
S11	D5+
S12	D6-
S13	D6+
S14	D7-
S15	D7+

More Than One MSXB 048 Board

Up to 16 Filtered Analog Input Expansion boards can connect to a single DAP, providing 256 analog inputs. Each analog input expansion board, including MSXB 048 filter board, must be configured to recognize a unique input address range. Each MSXB 048 filter board uses two 16-channel address ranges – one "low order" range within the lower 256 channels and one "high order" range within the upper 256 channels. Use the low order address range for normal sampling. Use the high order range to sample on-board calibration signals. The jumper setting on connector J5 selects the board address ranges:

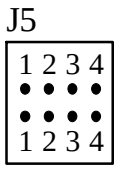

Figure 3. Input Pin Range Selection Header

Pin 1 of connector J5 is closest to the middle of the board. The input range is selected according to Table 3.

Table 3. Input Range Configuration

Signal Channel Range	Reference Channel Range	Board Number	Shunts
S0 - S15	S256 - S271	0	1, 2, 3, 4
S16 - S31	S272 - S287	1	1, 2, 3
S32 - S47	S288 - S303	2	1, 2, , 4
S48 - S63	S304 - S319	3	1, 2,
S64 - S79	S320 - S335	4	1, , 3, 4
S80 - S95	S336 - S351	5	1, , 3
S96 - S111	S352 - S367	6	1, , 4
S112 - S127	S368 - S383	7	1
S128 - S143	S384 - S399	8	2, 3, 4
S144 - S159	S400 - S415	9	2, 3
S160 - S175	S416 - S431	10	2, , 4
S176 - S191	S432 - S447	11	2
S192 - S207	S448 - S463	12	3, 4
S208 - S223	S464 - S479	13	3
S224 - S239	S480 - S495	14	4
S240 - S255	S496 - S511	15	none

Each jumper setting on connector J5 selects an address range of 16 input channels. When using multiple MSXB 048 filter boards, every input expansion board in the system must have a unique address range.

A MSXB 048 filter board derives +5V power from the 68-line backplane, with a typical power consumption of 5 Watts.

Clocking and Triggering Connections

Clocking and triggering signals can be connected to the Filtered Analog Input Expansion Board. See the Data Acquisition Processor manual for more information about hardware clocking and triggering.

External clock and trigger signals connected to the MSXB 048 filter board must be in the standard TTL range of 0 to 5 volts.

Connectors J15 and J16 on MSXB 048 provide access to the external clock and trigger signals from the Data Acquisition Processor. J15 and J16 are Molex part number 53014-0610. The mating connector consists of a shell and discrete crimp pins; the shell is Molex part number 51004-0600 and the crimp pins are Molex part number 50011-8100. The schematic diagrams for connectors J15 and J16 are shown below:

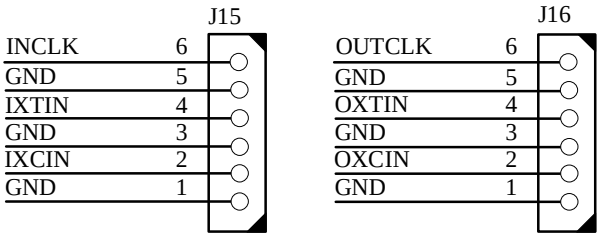

Figure 4. External Clock and Trigger Signals

The clocking and triggering labels on the Filtered Analog Input Expansion Board are defined as follows:

- IXCIN = External Input Clock – Input
- IXTIN = External Input Trigger – Input
- INCLK = Internal Input Clock – Output
- OXCIN = External Output Clock – Input
- OXTIN = External Output Trigger – Input
- OUTCLK = Internal Output Clock – Output

Software Configuration

The following is a typical input procedure definition. The input procedure DataRead acquires the signals on S0, S1, S2, …, and S15 sequentially. The TIME command sets the sampling time to 1000 microseconds. Since the input configuration samples sixteen pins, each pin is sampled every 16,000 microseconds. The MERGE command sends the input data from input channels to the binary communications pipe $BINOUT:

```
RESET
IDEF DataRead 16
  SET IP0  S0
  SET IP1  S1
  SET IP2  S2
  SET IP3  S3
  SET IP4  S4
  SET IP5  S5
  SET IP6  S6
  SET IP7  S7
  SET IP8  S8
  SET IP9  S9
  SET IP10 S10
  SET IP11 S11
  SET IP12 S12
  SET IP13 S13
  SET IP14 S14
  SET IP15 S15
  TIME 1000
  END
PDEF PrintProcess
  MERGE (IP(0 .. 15), $BINOUT)
  END
START DataRead, PrintProcess
```

Calibration

For many applications, the un-calibrated accuracy of the MSXB 048 works without software calibration. There is no need to use the calibration circuits in AC applications where DC accuracy does not matter.

For those applications where DC accuracy does matter, using the calibration circuits once per year is sufficient.

The Filtered Analog Input Expansion board has an on-board Analog Sense calibration signal and an on-board 5V reference. The MSXB 048 uses two board-level address ranges – a low address range within the lower 256 channels and a high address range within the upper 256 channels. Each address range consists of 16 single ended channels such as `S0` through `S15`. The user uses the low address range to sample signals and use the high address range to sample Analog Sense and +5V reference.

Table 4 shows the un-calibrated offset and gain errors of current models.

Table 4. Offset and Gain Errors

Models	**Offset Errors (mV)**		**Gain Errors (%)**	
	Worst Case	**Typical**	**Worst Case**	**Typical**
MSXB048-03-100-E2K	10.025	0.548	0.019	0.012
MSXB048-03-1K-E2K	10.6	0.885	0.015	0.011
MSXB048-03-10K-E2K	10.6	0.885	0.015	0.011

Calibration Scripts

There are two DAPL scripts, XB48CAL1.dap and XB48CAL2.dap, for the MSXB 048 calibration. These scripts can be found on the DAPtools Basic CD. Both scripts contain several input and processing procedures. XB48CAL1.dap shows how to send offset and gain data to the PC. XB48CAL2.dap shows how to load offset and gain data into DAPL variables and how to apply these data to normal readings.

Calibration Details

To calibrate the MSXB 048 filter board, the user has to determine the offset and gain errors on each channel of the board. The user can measure the offset error by sampling Analog Sense (ground) signals and measure the gain error by sampling +5V reference signals on all channels.

In order to correct the offset and gain errors, send the input signal data via the formula below and apply the offset and gain data obtained by sampling Analog Sense and +5V reference signals:

output = (input – ground) * 32768 / (reference – ground)

Parameters in the formula are defined as follows:

- output = Output data value
- input = Input data value
- ground = Analog Sense ground (offset error)
- reference = +5V reference (gain data)
- Use 32768 if using +/-5V input range in the DAP
- Use 16384 if using +/-10V input range in the DAP

The offset and gain errors do not change much over time. Therefore, Microstar Laboratories recommends to measure offset and gain errors at least once per year, then use those offset and gain data for subsequent signal measurements.

Independent of gain calibration, the +5V reference can be applied to determine if the board is working properly without changing the external connections to the board.

A state machine sets two states of operation for the MSXB 048 filter board, one for normal sampling and another for reading calibration signals. In the calibration state, an application reads all calibration data from the high address range. Use the low address range to reset the state machine. Use the high address range to advance the state machine. There is a multiplexer to select between the three inputs Signal, Analog Sense, and 5V reference. The user can change these inputs by making a series of access to the board at its high and low address ranges.

One or more samples from a high address enable a change of state in the state machine; a single low sample following the high sample(s) advances the state machine. When the state changes, the change occurs

at the single low sample between high samples. Two or more low samples reset the state machine to the normal sampling state where it remains until there is another high-low sample sequence.

In order to change the state of MSXB 048 to a calibration state, the following CalRef or CalGnd input procedures should be run first, then run CalRead input procedure to read the calibration data from the high address range, so the state does not change. The processing procedure CalFlush allows to read data from the CalRef input procedure and to place the data in a variable vbuff so that SAMPLEHOLD will wait for sampling to complete. The SAMPLEHOLD command pauses DAPL until the CalRef input procedure completes sampling before starting the CalRead input procedure. The processing procedure CalProcess defines a task that reads 100 data values from each input channel pipes IP0, …, IP15, averages the values, and places the averages into pipes P0, …, P15 respectively. MERGE puts all averages from pipes P0, …, P15 into the binary communications pipe $BINOUT.

The following input procedure shows how to access CalRef state (+5V reference) of the state machine:

```
IDEF CalRef 12
  SET IP0  S256  // Hold calibration state
  SET IP1  S256
  SET IP2  S0
  SET IP3  S0    // Bring cal signals to Signal state
  SET IP4  S256  // Enable cal state machine
  SET IP5  S0    // Transition cal signals to CalGnd state
  SET IP6  S256  // Enable cal state machine
  SET IP7  S0    // Transition cal signals to CalRef state
  SET IP8  S256  // Hold calibration CalRef state
  SET IP9  S256
  SET IP10 S256
  SET IP11 S256
  COUNT 12
  TIME 5000
  END
```

The following input procedure shows how to access CalGnd state (Analog Sense ground) of the state machine:

```
IDEF CalGnd 12
```

```
  SET IP0  S256  // Hold calibration state
  SET IP1  S256
  SET IP2  S0
  SET IP3  S0    // Bring cal signals to Signal state
  SET IP4  S256  // Enable cal state machine
  SET IP5  S0    // Transition cal signals to CalGnd state
  SET IP6  S256  // Hold calibration CalGnd state
  SET IP7  S256
  SET IP8  S256
  SET IP9  S256
  SET IP10 S256
  SET IP11 S256
  COUNT 12
  TIME 5000
  END
```

The following input procedure shows how to read the calibration data from the high address range:

```
IDEF CalRead 16
  SET IP0  S256
  SET IP1  S257
  SET IP2  S258
  SET IP3  S259
  SET IP4  S260
  SET IP5  S261
  SET IP6  S262
  SET IP7  S263
  SET IP8  S264
  SET IP9  S265
  SET IP10 S266
  SET IP11 S267
  SET IP12 S268
  SET IP13 S269
  SET IP14 S270
  SET IP15 S271
  COUNT 40000
  TIME 100
  END
```

The following processing procedure defines the task of CalFlush:

```
PDEF CalFlush
  PVALUE (IP(0 .. 11), vbuff)
```

```
END
```

The following processing procedure defines the tasks of CalProcess:

```
PDEF CalProcess
 AVERAGE (IP0, 100, P0)
 AVERAGE (IP1, 100, P1)
 AVERAGE (IP2, 100, P2)
 AVERAGE (IP3, 100, P3)
 AVERAGE (IP4, 100, P4)
 AVERAGE (IP5, 100, P5)
 AVERAGE (IP6, 100, P6)
 AVERAGE (IP7, 100, P7)
 AVERAGE (IP8, 100, P8)
 AVERAGE (IP9, 100, P9)
 AVERAGE (IP10, 100, P10)
 AVERAGE (IP11, 100, P11)
 AVERAGE (IP12, 100, P12)
 AVERAGE (IP13, 100, P13)
 AVERAGE (IP14, 100, P14)
 AVERAGE (IP15, 100, P15)
 MERGE (P0, P1, P2, P3, P4, P5, P6, P7, P8, P9,\
      P10, P11, P12, P13, P14, P15, $BINOUT )
 END
```

The following code shows how to use the SAMPLEHOLD command:

```
START CalRef, CalFlush
SAMPLEHOLD
STOP
START CalRead, CalProcess
```