Gas Panel Interface - Atmospheric

Instruction Manual

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1. DESCRIPTION

1.1. Overview

Model GPI-803 is a gas panel interface designed primarily for semiconductor processes performed in horizontal diffusion furnaces under atmospheric conditions. This includes dopant deposition, dopant drive-in, oxidation and anneal.

1.2. Features

- *+/- 15 VDC Power Supply adequate for (6) MFC's*
- *+24 VDC Power Supply for solenoids and sensors*
- *MFC Override relays to provide positive shutoff*
- *Monitor circuit for Type 'K' Torch thermocouple*
- *Selectable ratio circuit for slaving Hydrogen set-point to actual Oxygen flow*
- *Hardware interlocks on Hydrogen flow for Low O2 and Torch*
- *Control of upstream or downstream solenoid valves using the same control signals that control the MFC's or by using separate control signals*

1.3. Suggested Tymkon Configuration

Following is a recommended function template for installations in which the GPI-803 is used with a vertical Tymkon process sequencer. Tymkon software allows front panel functions to be remapped to different hardware ports, but adherence to the suggested layout to whatever extent possible minimizes hardware remapping and eases installation. When Hydrogen is not required in the process, avoid using Digital Output 3, if possible, as that function is hardware interlocked to Digital Output 4 (O2 Sol), Digital Input 4 (Lo O2) and Digital Input 5 (Torch).

Outputs				Inputs	
0	Load	**8**	TLC > Tube	**0**	BIC
1	Unload	**9**	N2 Safe (NO)	**1**	BOC
2	N2 Sol	**A**	N2 MFC	**2**	TMP Fault
3	H2 Sol	**B**	H2 MFC	**3**	Hi H2
4	O2 Sol	**C**	O2 MFC	**4**	Lo O2
5	TLC Sol	**D**	TLC MFC	**5**	Torch
6	Lo O2 Sol	**E**	Lo O2 MFC	**6**	GPI Fault
7		**F**		**7**	Ratio

2. INSTALLATION

2.1. DDC[1] Interface Connector, J1

The GPI-803 provides a 50-pin communications connector plug for interface to a process controller. The pinout of the connector exactly matches that of the most common Tymkon I/O boards, but may be adapted to process sequencers from other manufacturers.

Extension cables for this type of connector are available both in flat cable and round cable types and have gained wide acceptance in the communications and instrumentation industries.

A typical ribbon-cable receptacle-end connector is 3M P/N 3565-1000 and a mating plug-end connector is 3M P/N 3564-1002. These connectors may be used with standard flat ribbon (e.g. 3M P/N 3365-50) or with the round, shielded ribbon cable.

The pinout of the Interface Connector follows on the next page. Not all of the signals listed on the connector pinout are implemented in the GPI-803. The connector provides a generic interface that is shared by both atmospheric and LPCVD[2] gas panel interfaces.

The pins labeled "Digital Output" and those labeled "Analog Output" are signals from the process sequencer to the gas panel interface. These labeled "Digital Input" and those labeled "Analog Input" are signals from the gas panel interface to the process sequencer.

Note that the (16) "Digital Output" pins expect to see either mechanical contact closures or solid-state relay closures to "- SUPPLY" from the DDC. This signal is available on pin 38 of the Interface Connector. Furthermore, the (8) "Digital Input" pins provide contact closures to "- SUPPLY" to the DDC when the sensors are safe.

Note also that the signals present on the "Analog Output" and "Analog Input" pins are generally 0 to 5 Volts DC.

[1]DDC: Direct Digital Control system - Computer-controlled system that sequences gas valves, furnace temperature, boat loaders etc. in response to time-based recipes and external sensors.
[2]LPCVD: Low Pressure Chemical Vapor Deposition.

DDC Interface Connector, J1

Pin	Function	IDC
1	ANALOG OUTPUT F	1
2	ANALOG OUTPUT E	3
3	ANALOG OUTPUT D	5
4	ANALOG OUTPUT C	7
5	ANALOG OUTPUT B	9
6	ANALOG OUTPUT A	11
7	ANALOG OUTPUT 9	13
8	ANALOG OUTPUT 8	15
9	ANALOG COMMON	17
10	DIGITAL GROUND	19
11	ALARM SILENCE INPUT	21
12	RUN INPUT	23
13	DIGITAL INPUT 7	25
14	DIGITAL INPUT 5	27
15	DIGITAL INPUT 3	29
16	DIGITAL INPUT 1	31
17	OUTPUT F (NO)	33
18	OUTPUT D (NO)	35
19	OUTPUT B (NO)	37
20	OUTPUT 9 (NO)	39
21	OUTPUT 7 (NO)	41
22	OUTPUT 5 (NO)	43
23	OUTPUT 3 (NO)	45
24	OUTPUT 1 (NO)	47
25	+ SUPPLY (+5 to +40 VOLTS)	49

Pin	Function	IDC
26	ANALOG INPUT F	2
27	ANALOG INPUT E	4
28	ANALOG INPUT D	6
29	ANALOG INPUT C	8
30	ANALOG INPUT B	10
31	ANALOG INPUT A	12
32	ANALOG INPUT 9	14
33	ANALOG INPUT 8	16
34	ALARM (-) OUTPUT	18
35	ALARM (+) OUTPUT	20
36	ABORT INPUT	22
37	RESET INPUT	24
38	- SUPPLY (-5 to -40 VOLTS)	26
39	DIGITAL INPUT 6	28
40	DIGITAL INPUT 4	30
41	DIGITAL INPUT 2	32
42	DIGITAL INPUT 0	34
43	OUTPUT E (NO)	36
44	OUTPUT C (NO)	38
45	OUTPUT A (NO)	40
46	OUTPUT 8 (NO)	42
47	OUTPUT 6 (NO)	44
48	OUTPUT 4 (NO)	46
49	OUTPUT 2 (NO)	48
50	OUTPUT 0 (NO)	50

2.2. MFC Connectors, J2 through J7

20-conductor ribbon cables are used to connect the GPI to the Mass Flow Controllers. Following is the pinout of MFC 1 through MFC 6 (J2 through J7 respectively) on the Model 803 Gas Panel Interface. (The numbers in the "IDC" columns are the ribbon cable conductor numbers.)

Card Edge	IDC		Card Edge	IDC	
1	1	Case GND	A	2	Setpoint
2	3	Power Common	B	4	Signal Common
3	5	Output (0-5v)	C	6	Signal Common
4	7	+15 VDC	D	8	Valve Test
5	9	N/C	E	10	N/C
6	11	N/C	F	12	-15 VDC
7	13	Keyway	G	14	Keyway
8	15	N/C	H	16	N/C
9	17	N/C	I	18	N/C
10	19	Common	J	20	Valve Off

Unless requested by the customer, the GPI-803 provides an ***MFC Override*** relay for each gas channel. These six relays are controlled by Digital Outputs 'A' through 'F'. When an override relay is not energized, a set of normally closed contacts connects the appropriate *MFC Valve Off* pin to the *MFC Common* pin thereby forcing the MFC closed regardless of the analog setpoint. When the relay becomes energized, the override signal is released and the MFC is allowed to soft-start to the setpoint.

2.3. Solenoid Valves, J8

J8 is a 15-pin female 'D' connector located at the right side of the front panel. This connector contains the signals necessary to drive up to eight pilot valves or gas solenoids. If the valves are polarized, the positive side of the coil must be connected to one of the +24 Volts pins, while the negative side must be connected to one of the valve output signals.

> Note: Shorting any of the outputs on the Valve Connector may cause permanent damage to the GPI or to the process sequencer or DDC which drives the outputs.

A nylon-jacketed round cable, Belden 9542, may be used to connect the various solenoid valves to connector J8 on the GPI. The cable is terminated at the GPI end with a 15-pin male 'D' connector. The connector end should be secured to the GPI with two 4/40 machine screws usually provided on the connector hood. The pin-out is as follows:

J8 Pin	Color	Function	Recommended Use
1	BLACK	Output 2	N2 sol.
2	RED	Output 3	H2 sol.
3	ORANGE	Output 4	O2 sol.
4	GREEN	Output 5	HCl/TLC etc
5	BLUE	Output 6	
6	WHITE	Output 7	
7	RED / WHITE	Output 8	
8	GREEN / WHITE	Output 9	N2 Safe (N.O.)
9	BLACK / WHITE	+24 VDC	
10	RED / BLACK	+24 VDC	
11	ORANGE / BLACK	+24 VDC	
12	GREEN / BLACK	+24 VDC	
13	BLUE / BLACK	+24 VDC	
14	WHITE / BLACK	+24 VDC	
15	BLUE / WHITE	+24 VDC	

Note: If the process uses Hydrogen and Oxygen, proper interlock operation requires that the Hydrogen valve be assigned to Output 3 and that the Oxygen valve be assigned to Output 4. Otherwise, the wire colors and function assignments are suggestions provided for reference only.

2.4. Sensors, J9

A 9-pin female 'D' connector is provided for a Low O2 flow switch and/or other sensors. Any sensor that provides a relay contact or an NPN transistor output may be used.

Sensors that provide a relay contact output should be wired "*closed when safe*" and must provide contact closure to 24-volt return (available on pins 6, 7, 8 & 9 of J9).

Sensors that provide an NPN transistor output should be capable of 24-volt operation. A 24 Volts DC power supply is available on connectors J8 and J10 if required. The emitter of the sensor's output transistor should be wired to 24-volt

return available on pins 6, 7, 8 & 9 of J9 and the collector of the sensor's output transistor should be wired to the appropriate Digital Input pin on J9.

Pin	Function	Pre-assigned as:
1	Torch OK	Torch bypass
2	Digital Input 7	
3	Digital Input 2	
4	Digital Input 3	
5	Digital Input 4	Low O2
6	24 Volt Return	
7	24 Volt Return	
8	24 Volt Return	
9	24 Volt Return	

The circuit board in the Model 803C contains (3) jumpers, JP4 thru JP6, which control the behavior of Digital Input 4 (Lo O_2), Digital Input 5 (Lo Temp) & Digital Input 6 (GPI Fault). See page 13.

2.5. Auxiliary, J10

A 9-pin female 'D' connector is provided for connection to a boat loader. Two relays isolate LOAD and UNLOAD commands from the DDC. The common contacts of the two Form A relays are connected to J10 pin 3. When Digital Output 0 is energized the Normally Open contact of the LOAD relay becomes shorted to pin 3 (Output Common). When Digital Output 1 is energized the Normally Open contact of the UNLOAD relay becomes shorted to pin 3 (Output Common). The Digital Inputs connected to pins 1 and 5 are sent directly back to the DDC. These signals are typically assigned to BIC (Boat In Complete) and BOC (Boat Out Complete) respectively.

Pin	Function	Name
1	Digital Input 0	BIC
2	Digital Output 0	Load
3	Output Common	
4	Digital Output 1	Unload
5	Digital Input 1	BOC
6	24 Volt Return	
7	+24 Volts	
8	+24 Volts	
9	24 Volt Return	

2.6. Remote, J11

A 15-pin female 'D' connector is provided for access to various calibration and control signals. The signals available on this connector are used for:

- Remote process sequencer control
- Analog and Digital I/O
- Torch monitoring and adjustment
- Ratio setpoint adjustment

Pin	Function	Name
1	RUN	
2	RESET	
3	AL SILENCE	
4	ABORT	
5	DIGITAL OUTPUT 8	
6	DIGITAL OUTPUT 9	
7	ANALOG OUTPUT 8	
8	VREF (+5)	
9	24V RETURN	
10	RATIO SET	
11	LO TEMP SET	
12	TEMPERATURE	
13	ANALOG INPUT 8	
14	ANALOG COMMON	
15	+24 VDC	

The circuit board for the GPI, 9990301B, provides circuitry for interlocking Hydrogen gas flow on Output 3 to Torch temperature and Oxygen flow on burnt Hydrogen systems. Connector J11 contains the signals required to set the LO TORCH setpoint. Both the torch setpoint on Pin 11 and the temperature display on

Pin 12 are referenced to analog common on pin 14. Each of the temperature signals are scaled such that 1 volt DC represents 100 degrees Celsius.

2.7. Torch

A connector is provided for a Type K torch thermocouple. Using an AD595 IC inside the GPI-803, the thermocouple signal is amplified and compensated. The resulting signal is scaled such that each one-volt DC increment represents 100 degrees Celsius (for example, 6.5 volts = 650 degrees). This amplified signal is then compared to a user adjustable set point. The resulting digital signal is used in the Hydrogen interlock circuit. See page 9 for additional information.

2.8. Power Input

The current version of the GPI-803, Revision C, operates on 110 Volts AC. A standard IEC style power receptacle is provided for connection to an AC power source. See page 16 for additional information.

Note: Do not connect the unit to AC power until the valves and sensors are connected.

3. CONFIGURATION AND OPERATION

3.1. Output Jumpers

The MFC Override relays on the Model 803C are always controlled by Digital Outputs A through F. The corresponding solenoid valves, however, may be controlled by either Digital Outputs A through F or by Digital Outputs 2 through 7.

Six sets of jumpers allow each solenoid valve to be linked to an MFC Override or to be independently controlled by a separate Digital Output.

For each of the six sets of jumpers, when pins 1 and 2 are jumpered together, a Digital Output separate from the MFC Override controls the associated valve. When pins 3 and 4 are jumpered together, the same Digital Output that controls the MFC Override controls the associated valve.

3.2. Torch Jumper, JP1

The Model 803C includes a torch interlock that monitors the torch temperature on systems that use burn Hydrogen to form water vapor.

3.2.1. Circuit Description

A resistor on the circuit board in the GPI-803 limits the lowest setting of the LO TEMP potentiometer to about 550 degrees Celsius for safety reasons. The part number of this resistor varies on different versions of the circuit board as shown in a table below. This resistor usually has a value of 4640 ohms. If you choose to use a type 'R' or 'S' thermocouple in place of type 'K' for which the circuit is designed, this resistor must be replaced with a resistor having a value of 536 ohms (a standard value for 1%, RN55 metal film resistors). Be aware that after this modification, if a type 'K' T/C is used, it will be possible to set the LO TEMP limit to an unsafe value.

Note: For normal operation with a Type "K" Torch Thermocouple, do not install a jumper on JP1.

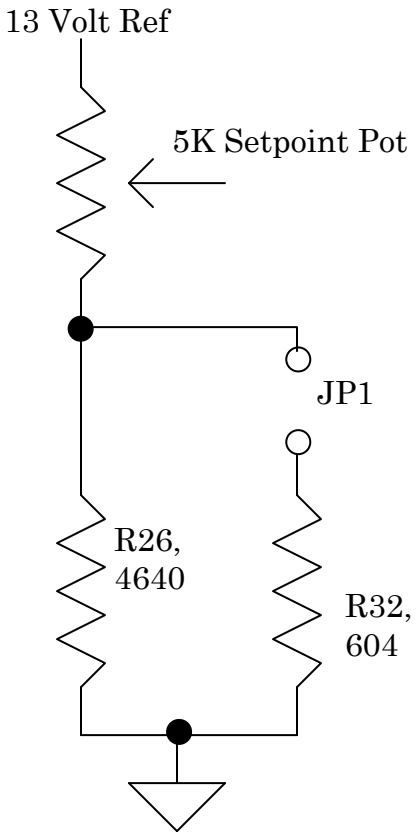
Note that version "C" of the PC board has a second resister already installed on the circuit board. This 604 ohm resister can be enabled by installed a jumper shunt across JP1. The parallel combination of R26 and R32, with the shunt installed, is 534 ohms.

With a 13 volt reference and a 534 ohm resistor in series with a 5000 ohm pot, the lowest possible setpoint voltage would be 1.25 volts corresponding to about 550 degrees with a Type 'R' thermocouple or 575 degrees with a Type 'S' thermocouple.

With JP1 removed and a 4640 resistor installed at R26, the lowest possible setting is 6.25 volts.

Model	Circuit Board	Part Number	Value
GPI-803-01	9990194A	R29	4700 ohms
GPI-803B	9990194B	R26	4700 ohms
GPI-803C	9990301A	R26	4700 ohms
GPI-803C	9990301B	R26	4640 ohms
		R32	604 ohms

3.2.2. Torch Setpoint Diagram



3.2.3. Adjusting the Torch Setpoint for a Type 'K' Thermocouple

The signals required to adjust the LO TORCH setpoint are available on connector J11.

J11 Pin	Function	
11	Torch Setpoint	DC Voltage referenced to Analog Ground. Represents the current Torch setpoint (1.0 VDC per 100 degrees Celsius).
12	Torch Temp	DC Voltage referenced to Analog Ground. Represents the current Torch temperature. (1.0 VDC per 100 degrees Celsius)
14	Analog Ground	

3.2.4. Using a Type 'R' or Type 'S' Thermocouple

At a particular temperature, Type 'K' thermocouples output about 4 or 5 times the voltage of a Type 'R' thermocouple. The IC used in the GPI-803 is an Analog Devices AD595 that provides cold-junction compensation and amplification of Type 'K' T/C's. The AD595 is also available in a Type 'J' version (AD594), but not as a Type 'R' or Type 'S'. When used with the appropriate thermocouple type, the AD594 and the AD594 both output 1.0 volts DC per 100 degrees Celsius.

When using a Type 'R' or Type 'S' T/C, determining the LO TEMP setpoint limit is not quite as straightforward. Use the following procedure:

- Determine the setpoint temperature limit in degrees Celsius.
- Use the NIST Type 'R' or Type 'S' thermocouple tables to determine the output voltage of a Type 'R' (or Type 'S') T/C at the setpoint temperature.
- Use the NIST Type 'K' thermocouple tables to determine the temperature at which a Type 'K' thermocouple would produce that same output voltage.
- Using the 100 Degrees Celsius / 1 Volt conversion factor, determine the voltage at that temperature.

Tables on the following pages have been pre-calculated for some common setpoints for Type 'R' and Type 'K' thermocouples.

Following are some typical Type 'R' setpoints determined using the technique described above:

Setpoint Temperature	Type 'R' Voltage	Type 'K' Temperature	Setpoint Voltage
450	3.933 mV	96 °	0.96 VDC
475	4.200 mV	103 °	1.03 VDC
500	4.471 mV	108 °	1.08 VDC
525	4.744 mV	116 °	1.16 VDC
550	5.021 mV	123 °	1.23 VDC
575	5.300 mV	129 °	1.29 VDC
600	5.582 mV	136 °	1.36 VDC
700	6.741 mV	165 °	1.65 VDC
800	7.949 mV	194 °	1.94 VDC
1200	13.224 mV	324 °	3.24 VDC
1250	13.922 mV	341 °	3.41 VDC
1300	14.624 mV	358 °	3.58 VDC

Following are some typical Type 'S' setpoints determined using the technique described above:

Setpoint Temperature	Type 'S' Voltage	Type 'K' Temperature	Setpoint Voltage
450	3.742 mV	91 °	0.91 VDC
475	3.987 mV	97 °	0.97 VDC
500	4.233 mV	103 °	1.03 VDC
525	4.482 mV	109 °	1.09 VDC
550	4.732 mV	115 °	1.15 VDC
575	4.984 mV	121 °	1.21 VDC
600	5.239 mV	127 °	1.27 VDC
700	6.275 mV	153 °	1.53 VDC
800	7.345 mV	180 °	1.80 VDC
1200	11.951 mV	294 °	2.94 VDC
1250	12.554 mV	308 °	3.08 VDC
1300	13.159 mV	323 °	3.23 VDC

3.3. Input Jumpers, JP4, JP5 & JP6

While the GPI-803 always expects sensors to be wired "Energized when Safe" for fail-safe operation, the signals that are returned to the DDC in response to the sensors may be configured for the reverse behavior.

The circuit board in the Model 803C contains (3) jumpers, JP4 thru JP6, which control the behavior of selected digital input signals sent from the GPI-803 back to the process sequencer.

Note that when viewing the labels on the circuit board, "NO" refers to "Normally Open" or "Energized when Safe" and "NC" refers to "Normally Closed" or "Energized when Unsafe".

Jumper	Label	Default	
JP4	Lo O_2	"NO"	Opens when an optional O2 flow sensor connected to J9 Pin 5 detects low O2 flow.
JP5	Lo Temp	"NO"	Opens when Torch Temperature falls below Setpoint (unless the torch interlock has been bypassed by jumpering the signal on J9 Pin 1 to 24V Return.)
JP6	GPI Fault	"24V RET"	Opens when GPI-803 is un-powered or if 24 Volt power supply fails.

3.4. Voltage Adjustment, +24 Volts DC

A potentiometer is provided to adjust the regulated 24-volt power supply. The supply has a range of approximately 3 to 30 volts, but keep in mind that the valves, relays and sensors have restricted operating ranges. It is advisable to operate in the range of 20 to 28 volts, preferably 23 to 25 volts.

In most cases the 24-volt supply will not require adjustment during the life of the equipment, but it is advisable to confirm proper operation once every two years.

3.5. H2/O2 Ratio Circuit

3.5.1. Ratio Jumper, JP2

The Model 803C provides a jumper to control the behavior of a Hydrogen/Oxygen ratio circuit.

When a jumper is installed between pins 2 and 3 of JP2 (labeled 'NORMAL' on the circuit board), the Hydrogen setpoint is not slaved to the actual O2 flow. In this mode of operation, the process sequencer is responsible for maintaining a safe H2/O2 ratio.

Note: In most installations, Pin 2 and Pin 3 of JP2 should remain jumpered together.

When a jumper is installed between pins 1 and 2 of JP2 (labeled 'RATIO' on the circuit board), the Hydrogen setpoint is slaved to the actual O2 flow. In this mode of operation, the H2/O2 ratio is controlled by a potentiometer, VR3, on the circuit board.

3.5.2. Adjusting the H2/O2 Ratio

When the H2/O2 ratio jumper, JP2, is jumpered for 'RATIO' mode, the ratio of the Hydrogen MFC setpoint to the actual O2 flow is determined by a potentiometer accessible through a hole at the top of the enclosure. A reference circuit is provided such that this ratio may be pre-adjusted without the need to have gases flowing.

A 'RATIO SET' signal is available on pin 10 of J11. This signal represents the setpoint being sent to the H2 MFC (assuming that JP2 is jumpered for 'RATIO') and is referenced to 'ANALOG COMMON' on pin 14 of J11. Any Digital Volt Meter capable of accurately displaying a 0 to 5 volt DC signal may be used for adjusting or monitoring this signal.

In order to adjust the H2/O2 ratio setpoint, it is required to know the relative orifice sizes of the Hydrogen and Oxygen Mass Flow Controllers. Some examples follow:

- If the size of the Hydrogen MFC orifice equals the size of the Oxygen MFC orifice, the setpoint voltage sent to the Hydrogen MFC must not exceed 2x the voltage representing the actual Oxygen flow. That is, the ratio of (H2 Setpoint):(O2 Actual) in terms of voltages must not exceed 2:1. Assuming that the voltage ratio is 2:1, the gas flow ratio would be 2:1, the maximum safe limit.
- If the size of the Hydrogen MFC orifice is 2 times the size of the Oxygen MFC orifice, the setpoint voltage sent to the Hydrogen MFC must not exceed the voltage representing the actual Oxygen flow. That is, the ratio of (H2 Setpoint):(O2 Actual) in terms of voltages must not exceed 1:1.

Assuming that the voltage ratio is 1:1, the gas flow ratio would be 2:1, the maximum safe limit.

A formula for determining the ratio of the Hydrogen setpoint voltage to the actual Oxygen voltage using actual flow rates is as follows:

(Desired H2 flow in LPM) / (size of H2 MFC orifice in LPM)
(Desired O2 flow in LPM) / (size of O2 MFC orifice in LPM)

A formula for determining the ratio of the Hydrogen setpoint voltage to the actual Oxygen voltage using target flow ratios is as follows:

(Desired H2:O2 flow ratio) * (size of O2 MFC orifice in LPM)
(size of H2 MFC orifice in LPM)

Once this voltage ratio is determined, multiply this number times the Oxygen flow to obtain the required Hydrogen setpoint.

A pushbutton switch is provided on the Model 803 to allow the ratio to be adjusted while no gases are flowing. This is the preferred way to adjust the ratio. When the pushbutton is depressed and the Oxygen flow is off, a 5-volt reference signal is provided to the ratio-adjust potentiometer. Multiply the target voltage ratio determined above times 5 volts to determine the target setpoint voltage as would be read on pin 10 of J11 with respect to pin 14 of J11.

A practical example follows:

A Hydrogen flow of 4 LPM is desired in a system with an Oxygen flow of 3 LPM. The Hydrogen MFC orifice is 20 LPM and the Oxygen MFC orifice is 10 LPM.

Using the formula (4 LPM) / (20 LPM) stated above, the desired voltage ratio is determined to be 67% as follows:

(3 LPM) / (10 LPM)

With the ratio pushbutton switch depressed, 5.0 volts would be applied to the ratio potentiometer. The desired RATIO SETPOINT would be 67% x 5 volts or 3.33 volts.

4. SPECIFICATIONS

4.1. Physical

Dimensions:	10.05 in. high x 6 in. wide x 4 in. deep
Weight:	5 lbs. maximum
Finish:	Cardinal, high bake, water-based paint, medium texture.

4.2. AC Power Requirements

Frequency:	50 or 60 Hertz
Voltage @ 60 Hz:	100 to 125 VAC
Voltage @ 50 Hz:	110 to 125 VAC
Power:	100 watts maximum

4.3. MFC Power Supply

Part Number:	Cosel, MMB50A-6-N
Current:	1.7 Amps at +15 Volts
	1.7 Amps at –15 Volts

5. APPENDIX

Front Panel Artwork