MOORE INDUSTRIES

INSTRUCTION MANUAL

DDI

Direct Digital Interface

Form 106-751-00A

January 1982

GENERAL INFORMATION

1.1 SCOPE OF MANUAL

This manual contains operating and maintenance information for the Direct Digital Interface (DDI), manufactured by MOORE INDUSTRIES INC., Sepulveda, California. The manual consists of six sections as follows:

Section 1, General Information, introduces the equipment function and describes the equipment physical apprearance, the equipment specifications, and any options available for the unit.

Section 2, Calibration, provides the information necessary to calibrate the unit. This section contains a list of the tools and test equipment necessary for calibrating the equipment; and illustrates the test setup.

Section 3, Installation and Operation, supplies the information needed to install and operate the equipment. The section contains figures that specify the installation requirements for the units, and text that informs the user on recommended wiring practices for the equipment.

Section 4, Theory of Operation, provides a detailed explanation of the internal function of the unit. The circuit theory is based on a block diagram that shows the functional elements of the unit.

Section 5, Maintenance, provides complete disassembly procedures for all unit configurations. Troubleshooting information is provided, as well as component replacement techniques to aid the technician in the repair of the equipment.

Sectiion 6, Unit Documentation, Provides the user with the MOORE INDUSTRIES computerized parts listing and identification. The section also provides a recommended spare parts list, schematics and parts assembly drawings.

1.2 EQUIPMENT DESCRIPTION

The Direct Digital Interface Model DDI, is a computer/manual display station designed to interface a digital computer such as Moore Industries 1002, with a valve or other final control element in a DDC loop.

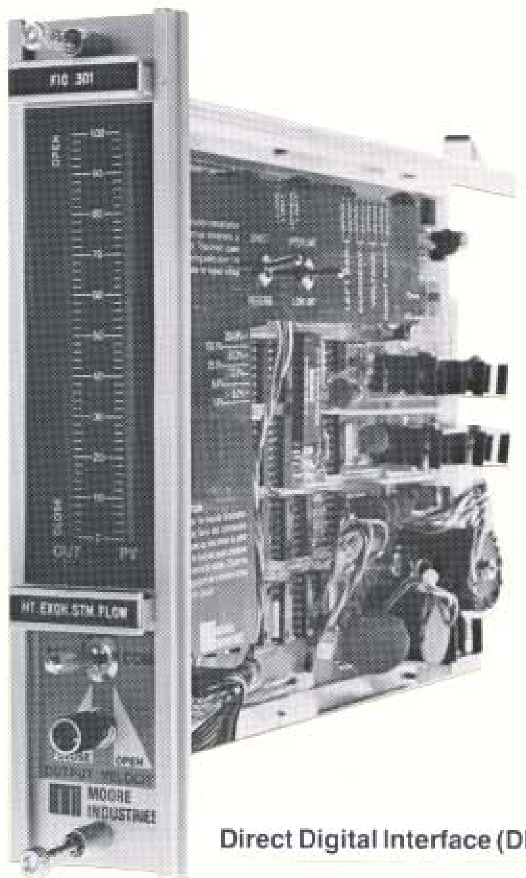
The unit accepts a variety of computer pulse trains in either a voltage or current mode, for conversion into an analog output that permits the computer to regulate the final element. The DDI uses a velocity algorithm to vary the output in incremental up or down changes, and provides switch selectable, bumpless transfer in either the manual or the computer mode.

Dual bar graphs indicate the selected parameters, and have a resolution of 0.5%. The left bar graph is switch selectable and displays, in red, the output value or the output signal limit. The right bar graph uses an orange color to allow visual distinction between indicators, and is switch selectable to display either the process variable or any auxiliary input.

Two alarm formats are provided, that cause either bar graph to flash at a 2 Hz rate when the display value exceeds 100%, or to flash at a 4 Hz rate when triggered by any of the external alarm inputs.

1.3 PHYSICAL DESCRIPTION

The DDI consists of a single printed circuit board, and a front panel control and display section, mounted to a frame assembly. The circuit board contains the electronic components required to perform the DDI functions, and uses a rear edge connector for power and input/output signals.



Direct Digital Interface (DDI)

1.4 SPECIFICATIONS

The specifications for the unit are listed in Table 1-1

Table 1-1 Unit Specifications

INPUT

ANALOG: For Process Variable and Auxiliary Display
Any combination of two.
Voltage: 1-5 VDC (>0.5 megohm)
Current: 4-20 mA (250 ohm)
10-50 mA (100 ohm)

ALARMS: Off = −24 to +1 VDC
On = +3 to +24 VDC

CONTROLS:
Mode Select—Protected Toggle switch for selection of computer or manual mode
Manual Output—Bipolar Velocity Control active in manual mode and pushed to operate variable from 0-20%/sec.
Predetermining Dip Switch—Selects analog output value that the unit will return to after a power off condition.
PV/Aux Switch—Selects either pv or auxiliary input for display on right bar graph.
Limit Switch—3 position switch, selects upper limit, normal or lower limit.
Direct/Reverse Switch—Reverses the indication of the output bar graph and the control action of the manual output adjustment potentiometer.
Status Output (TTL Compatible)
(NPN Transistor, isolated open-collector)
Saturated in computer mode and signal return common with alarm return
Saturation: 0.4 V max
Max Current: 5 mA
Max Voltage: 30 VDC

ENVIRONMENTAL:
Ambient Temperature:
Operating: 0-55°C
(32 to 131°F)
Storage: -30 to +80°C
Relative Humidity:
Operating: 10 to 90% RH
Non-Condensing
Storage: 5 to 95% RH
Weight: 34.5 oz (978 Grams)
Power: 24 ± 2 VDC at 0.5 amp nominal

INDICATOR:
Height: 4 inches
Resolution: 0.5%
Right bar: Orange for Process Variable (PV) or Auxiliary Input Display
Left bar: Red for Display Output or limits (display indications switch selectable)
Flashing: Displays flash at 2 Hz rate when range is over 100%, and flash at 4 Hz for alarm indication

OUTPUTS:
Analog: Select 1 voltage and 1 current
Voltage: 1-5 VDC (10K min)
Current: 4-20mA (1200 ohm max)
10-50mA (480 ohm max)
Ripple: Less than 10mV p/p
Load: ±.05% of span from 0 to max load
Drift: .01% of span per °C max
Limiting: Manual -25 to 150% fixed
Computer variable 0-100% of span
(Both limits displayable)

OPTIONS:
–D 25-pin subminiature D-style data interface connector, available with PMD housing.
–LIM Manual output limited to same values as when in computer control.
–RF RFI Protection available when used with PMD housings and DMR racks.

CERTIFICATION: CSA approval pending

CALIBRATION PROCEDURES

2.1 GENERAL INFORMATION

This section provides information about unit calibration. Units with standard input and output levels are calibrated at the factory. After the unit is unpacked, general operating level checks are recommended. Usually these checks, specified in this section under calibration procedures, require little or no adjustment.

2.2 CONTROLS DESCRIPTION AND LOCATION

Controls, switches and indicators, are listed in Table 2-1. Calibration controls used for maintenance are listed in Table 2-2.

The potentiometers used require 20 turns of the shaft to move the wiper from one end of the range to the other and are equipped with a slip clutch at either end of the travel to prevent damage if turned beyond the wiper stop. Usually a slight change in feel will be noticed when the clutch is slipping. However, either end can be reached by turning the shaft 20 turns in the desired direction. Controls are connected so that turning the shaft clockwise increases the quantity or makes it more positive, and turning the shaft counterclockwise has the opposite effect.

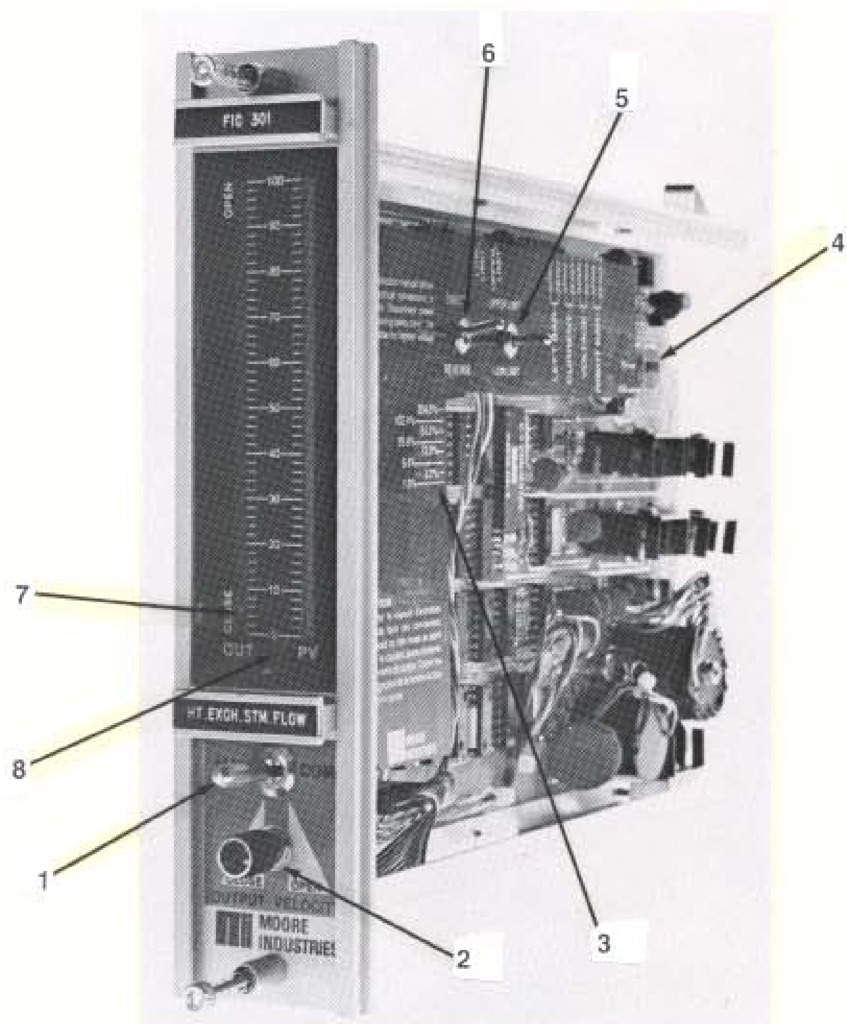


Figure 2-1 Front Panel Controls and Indicators

Table 2-1 Controls, Switches, and Indicators

Index	Nomenclature	Description
1.	Man/Comp Switch	Manual or computer mode switch, activates logic signals to the computer that indicate mode selected.
2.	Output Velocity	Switch / potentiometer only active when pressed in. Varies the manual set point.
3.	Predetermining dip switch	Selects analog output value to which the unit will return after a power fail condition.
4.	PV/Aux Switch	Selects either PV or AUX for display on right bar graph.
5.	Limit Switch	Multi-position switch, selects upper limit, normal or lower limit for display on left bar graph.
6.	Direct/Reverse Switch	Provides inversion of left bar graph and action of manual output control.
7.	Left Bar Graph	Gas discharge display that provides visual indication of either output value or output signal limit.
8.	Right Bar Graph	Gas discharge display that provides visual indication of either process variable or auxiliary input.

2.3 TEST EQUIPMENT AND TOOLS REQUIRED

Test equipment and tools required for calibration are described in Table 2-3; they are not supplied and must be provided by the user.

2.4 TEST EQUIPMENT SETUPS

Off-line calibration for all units requires the same test equipment setup regardless of option or physical configuration. The following paragraphs define the general test setup and identify the hookup requirements for the unit.

The test equipment setup required for calibration is shown on Figure 2-3.

2.5 CALIBRATION

Units are calibrated and checked for proper performance at the factory before they are shipped. However, unless calibration was requested to a specific set of input-output values, the unit performance should be checked by the user before the unit is placed in service. Calibration consists of simulating the operative signal input and adjusting the unit to obtain the specified output.

Adjustable input signal sources, input monitoring devices, and output monitoring are required for calibration. The monitoring devices (current or voltage) must have an accuracy of $\pm 0.05\%$ or better (see Table 2-2).

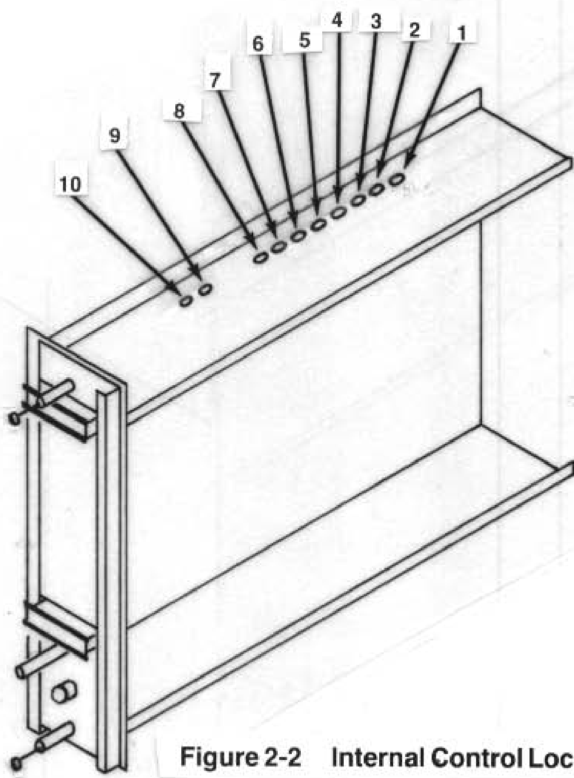


Figure 2-2 Internal Control Locations

Table 2-2 List of Internal Controls

Figure 2-2 Index	Description
1	Right bar zero adjust
2	Right bar span adjust
3	Voltage output zero adjust
4	Voltage output span adjust
5	Current output zero adjust
6	Current output span adjust
7	Left bar zero adjust
8	Left bar span adjust
9	Upper limit adjust
10	Lower limit adjust

2.5.1 Test Set-Up

Connect the unit under test (UUT) to the test equipment, using the connection diagram of figure 2-3.

> **NOTE**
>
> IC18 contains eight (8) rocker action switch assemblies. Each switch, and certain combinations, may be used to select percentage values for bar graph indication.

Adjust the "low limit" potentiometer fully CCW.

Adjust the "upper limit" potentiometer fully CW.

Adjust all remaining potentiometers to the center of the range, approximately 10 turns from either end.

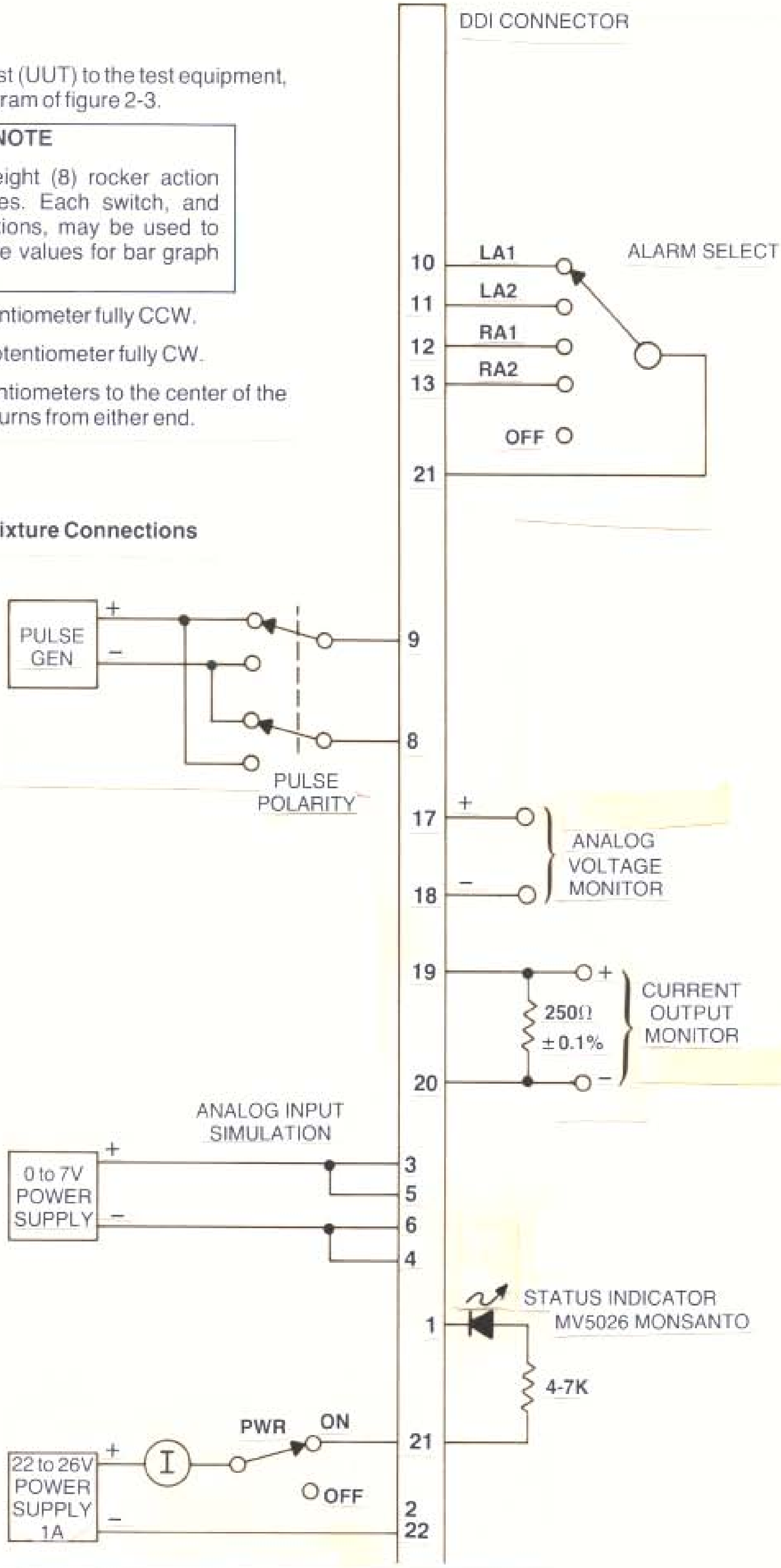


Figure 2-3 DDI Test Fixture Connections

Nomenclature	Characteristics	Function
Power supply	0 to 7 VDC @ 100mA	Analog input simulation
Power supply	22 to 24 VDC @ 1 AMP	Circuit Power Source
Digital volt meter	5½ digit, accuracy ±0.05%	Output signal monitoring
DC milliammeter	0 to 20mA, accuracy ±0.05%	Output signal monitoring
Pulse generator	Programmable, 0 to 1500 PPS variable pulse width 0 to 100 μsec at an amplitude of 5 volts	Digital input simulation

Table 2-3 Test Equipment Required

With power disconnected from the UUT, place the test equipment controls to the following positions.

PULSE GENERATOR

Pulse Polarity	Positive
Frequency	1000 PPS
Amplitude	+5 volts
Pulse width	50 μsec

ANALOG INPUT SIMULATOR
0.00 VDC

ALARM SELECT SWITCH
Off position

POWER SUPPLY
Voltage +24 VDC

UNIT UNDER TEST

Man/Comp switch	Comp
Output velocity	Mid-range
S3 PV/AUX switch	PV
S2 Cal switch	Normal
S1 Direct/reverse switch	Direct

2.5.2 Zero & Span Adjustment

a. On IC18, open all switches except switch 4, which is to be closed.

b. Apply power to the UUT and verify that the input current is 500 ± 50mA.

c. Adjust the "LEFT BAR ZERO" potentiometer for an indication of zero percent on the left bar graph (1 segment on).

d. Adjust the "VOLTAGE ZERO" potentiometer for a reading of 1.000 volt ±2mV on the analog voltage monitor.

e. Adjust the "CURRENT ZERO" potentiometer for a reading of 1.000 volt ±2mV on the current output monitor.

f. On IC18, open switch 4 and close switches 2,5,6,7 and 8.

g. Turn power to the UUT off and back on. (Enters IC18 setting)

h. Adjust the "LEFT BAR SPAN" potentiometer CW until the left bar graph flashes at a 2 Hz rate, and then slowly CCW until the bar just stops flashing.

i. Adjust the "VOLTAGE SPAN" potentiometer for a reading of 5.032 volts ±2mV on the analog voltage monitor.

j. Adjust the "CURRENT SPAN" potentiometer for a reading of 5.032 volts ±2mV on the current output monitor.

k. On IC18, open switches 2,5,6,7 and 8, and close switch 4.

l. Turn power to the UUT off and back on. (Enters IC18 setting)

m. Repeat steps c through l until no further adjustments are necessary.

n. Adjust the analog input simulator to 1.000 volt ±10mV.

o. Adjust the "RIGHT BAR ZERO" potentiometer for an indication of zero percent on the right bar graph. (1 segment on)

p. Adjust the analog input simulator to 5.000 volts ± 10mV.

q. Adjust the "RIGHT BAR SPAN" potentiometer for an indication of 100 percent on the right bar graph. (All segments on, not flashing)

r. Repeat steps n through q until no further adjustment is necessary.

2.5.3 Limit Adjustment

a. Set S2 on the UUT to the "LOW LIMIT" position.

b. Adjust the "LOW LIMIT" potentiometer until the left bar graph indicates the desired lower output limit.

c. Set S2 on the UUT to the "UPPER LIMIT" position.

d. Adjust the UPPER LIMIT potentiometer until the left bar graph indicates the desired upper output limit. NOTE: This value just be greater than the value set in step b, or less when S1 is set to the reverse position.

e. Set S2 on the UUT, to the "NORMAL" position.

2.5.4 Linearity Verification

a. Adjust the analog input simulator to 2.000 volts ±10mV and verify that the right bar graph indicates 25% ±1 segment.

b. Adjust the analog input simulator to 3.000 volts ±10mV and verify that the right bar graph indicates 50% ±1 segment.

c. Adjust the analog input simulator to 4.000 volts ±10mV and verify that the right bar graph indicates 75% ±1 segment.

2.5.5 Alarm Verification

a. Set the test fixture "ALARM SELECT" switch to the "LA1" position and verify that the left bar graph flashes at a 4 hertz rate.

b. Set the test fixture "ALARM SELECT" switch to the "LA2" position and verify that the left bar graph flashes at a 4 hertz rate.

c. Set the test fixture "ALARM SELECT" switch to the "RA1" position and verify that the right bar graph flashes at a 4 hertz rate.

d. Set the test fixture "ALARM SELECT" switch to the "RA2" position and verify that the right bar graph flashes at a 4 hertz rate.

2.5.6 Status Verification

a. Set the MAN/COMP switch on the UUT to the "MAN" position and verify that the test fixture status indicator is off.

b. Set the MAN/COMP switch on the UUT to the "COMP" position and verify that the test fixture status indicator is on.

2.5.7 Manual and Reverse Verification

a. Set the MAN/COMP Switch on the UUT to the "MAN" position and S1 to the "DIRECT" position.

b. Push in and adjust the "OUTPUT VELOCITY" potentiometer on the UUT and verify that the left bar graph ramps at a variable rate that is up when the potentiometer is adjusted CW and down when adjusted CCW.

c. Adjust the "Output Velocity" potentiometer as in step b for an indication of 75%.

d. Set S1 on the UUT to the "REVERSE" position and verify that the left bar graph indicates 25%.

e. Repeat step b.

INSTALLATION & OPERATION

3.1 GENERAL

The Direct Digital Interface is designed for either panel mounting, using the PMD enclosure, or rack mounting, using the DMR multiple rack frame enclosure. Mechanical dimensions for the PMD enclosure are shown in figure 3-1, and dimensions for the DMR are shown in figure 3-2.

3.2 ELECTRICAL CONNECTIONS

6-32 nickle plated brass screws are used for connections on the terminal block at the rear of the panel mount enclosure. Connections to the unit should be made with #6 spade lugs, using 24 AWG insulated conductor. To avoid induced transient noise, twisted conductors are recommended. Figure 3-3 shows the terminal block nomenclature assigned to the PMD enclosure.

3.2.1 Cable Assembly

Cable assemblies are provided for each DDI unit when the DMR rack mount configuration is used, and when the –D option is specified for the PMD panel mount configuration. Figure 3-4 shows the cable assembly, and table 3-1 identifies the pin number and the function assignment of the connector.

Table 3-1 Connector Function Assignment

	PIN #	DDI FUNCTION
	1	+AUX (AUXILIARY INPUT)
	2	AR (ANALOG RETURN)
	3	+PV (PROCESS VARIABLE)
	4	AR (ANALOG RETURN)
PULSE TRAIN	5	DN/CK (DOWN/CLOCK)
PULSE TRAIN	6	COM (COMMON)
PULSE TRAIN	7	UP/DN (UP/DOWN)
	8	LA1 (LEFT ALARM 1)
	9	LA2 (LEFT ALARM 2)
	10	RA1 (RIGHT ALARM 1)
	11	RA2 (RIGHT ALARM 2)
	12	+V (OUT 1-5V)
	13	AR (ANALOG RETURN)
	14	DR (DIGITAL RETURN)
	15	+STAT (STATUS OUTPUT)

Note: Pin #14 is isolated from analog returns and pulse train common.

Table 3-2 Pulse Train Specifications

Resolution	0.1% of span, 1000 pulses full scale (consult factory for other resolutions)
Repetition Rate	10 KHz max
Width	50 μ sec min
Rise/Fall Times	50 μ sec max
Off Time	50 μ sec min
Voltage Levels	Positive: +3 to +24 Vdc Negative: −3 to −24 Vdc Zero: −1 to +1 Vdc
Current Levels	Positive: +7 to +20 mA Negative: −7 to −20 mA Zero: −2 to +2 mA

Figure 3-1 PMD Enclosure Dimensions

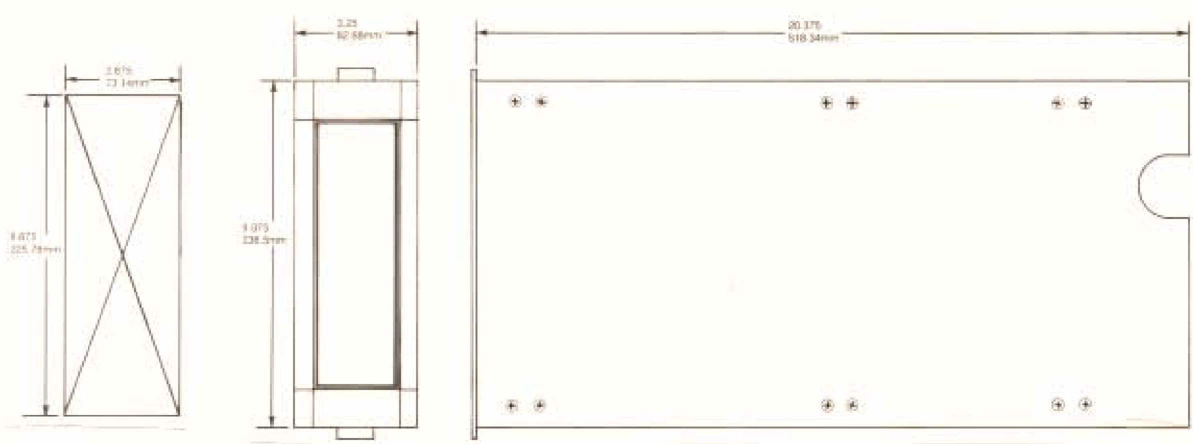
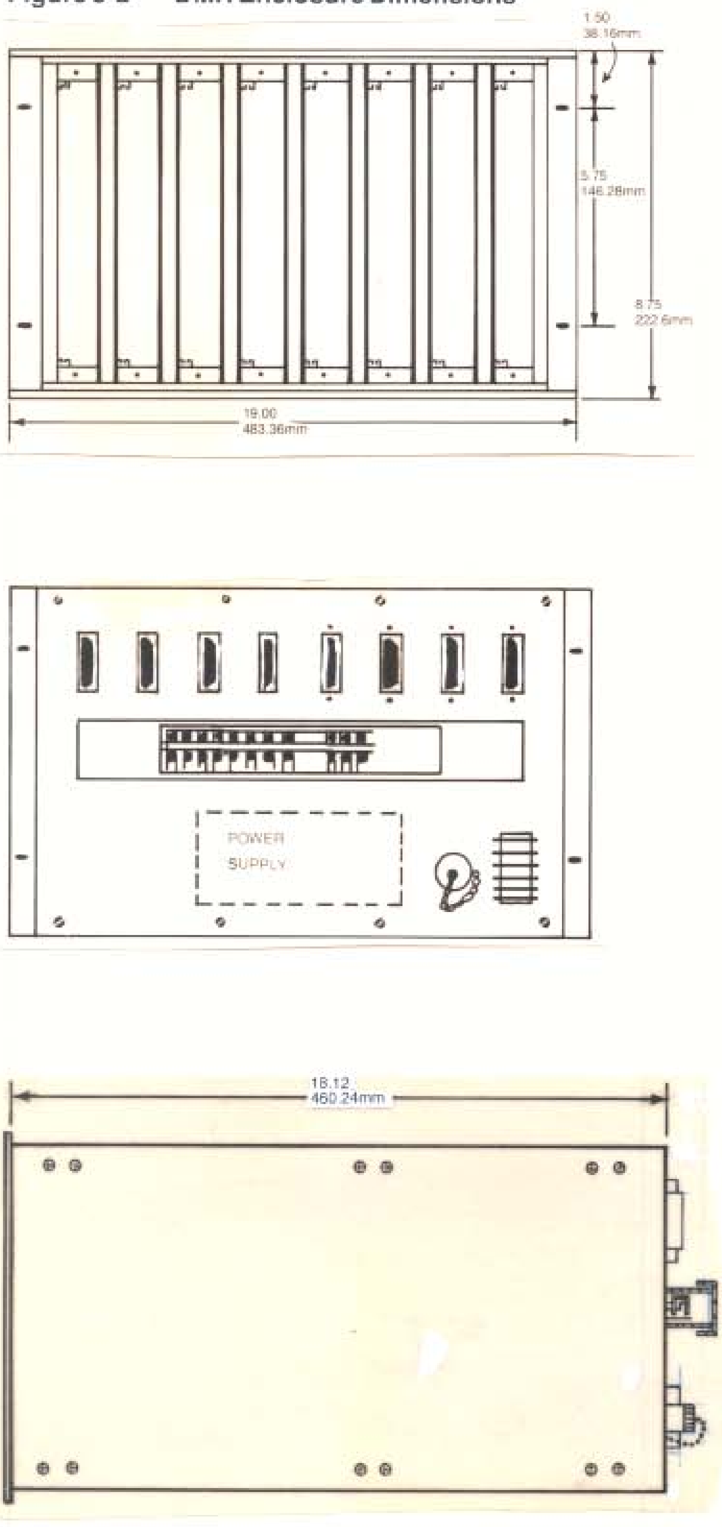


Figure 3-2 DMR Enclosure Dimensions



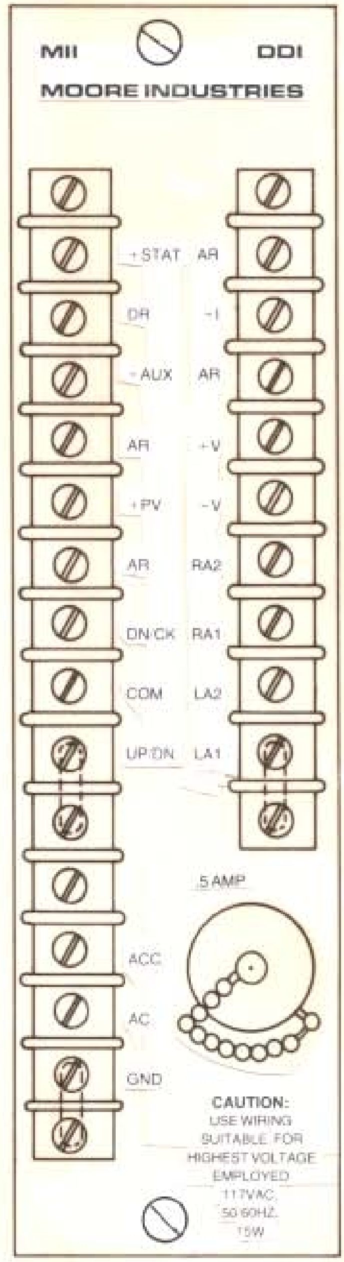


Figure 3-3 PMD Terminal Block

3.2.2 Digital Formats

Various digital input pulse formats may be used with the direct digital interface, both 2-wire and 3-wire configurations. Figure 3-5 identifies the digital formats which are prefixed with A,B,C, or D, followed by a V for voltage or an I for current. Table 3-2 provides the specifications for the input pulse train.

3.3 INSTALLATION

The panel mount enclosure is designed for installation in panels up to one-half inch thick, within an opening of 2.875 inches wide, and 8.875 inches high. The enclosure is held in position by top and bottom mounted screw assemblies that are adjusted from the rear to draw the enclosure flange up against the mounting panel.

3.4 DMR INSTALLATION

The rack mount enclosure may contain up to eight DDI assemblies, that slide into assigned positions using top and bottom mounted printed circuit card guides. The enclosure is designed for flush mounting within a rack frame that meets EIA standards, and is held in position by four 10-32 screws.

3.5 INTERCONNECT DIAGRAM

Figure 3-6 shows the interconnection of the direct digital interface and the remaining process loop. When using a 2-wire digital input pulse format, the unused connection should not be terminated. Alarm signal inputs have been configured such that an alarm OFF condition is represented by a dc voltage within the range of -24 to +1 volt, and an ON condition is represented by the range of +3 to +24 volts.

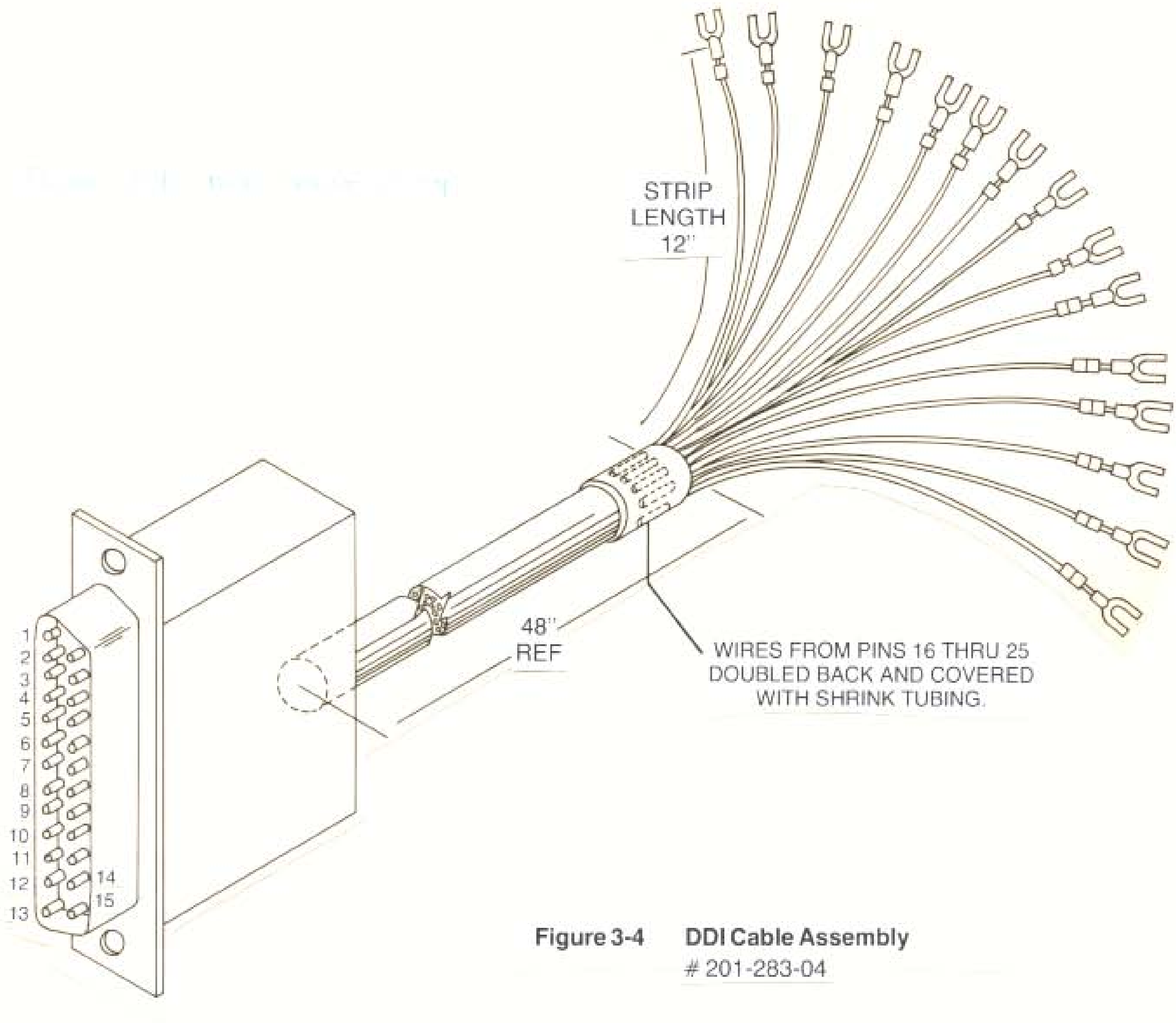


Figure 3-4 DDI Cable Assembly
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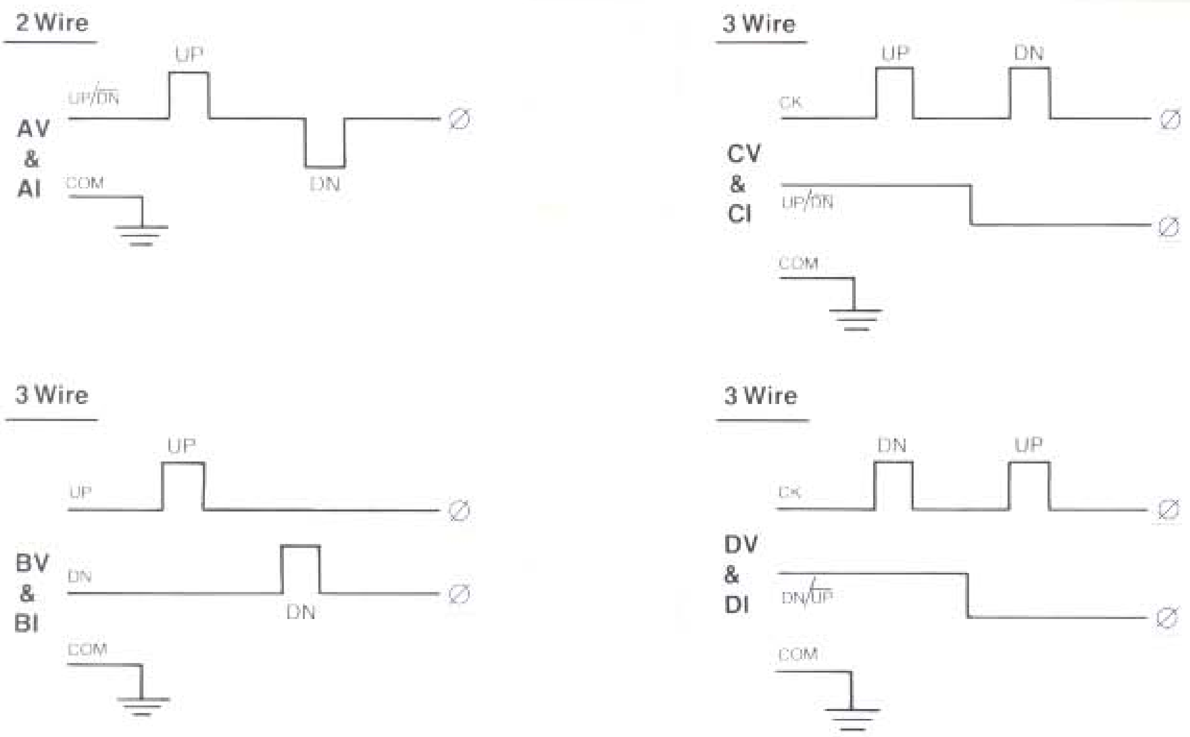

Figure 3-5 Digital Input Pulse Formats

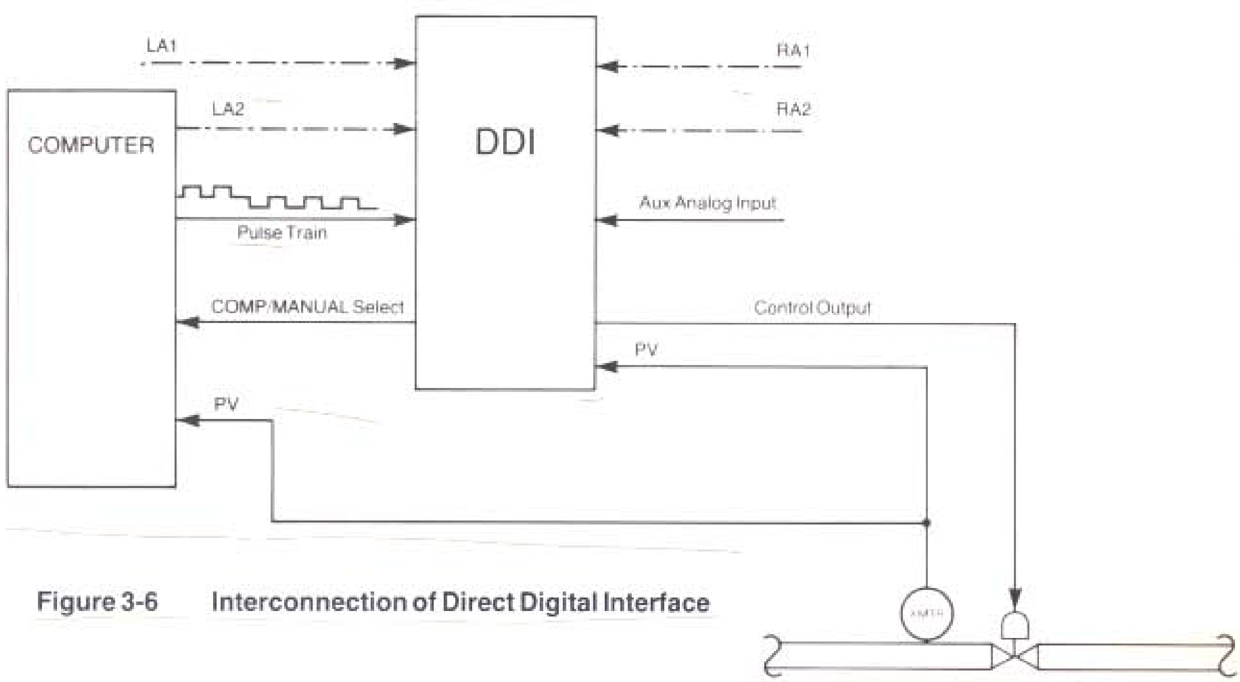

Figure 3-6 Interconnection of Direct Digital Interface

THEORY OF OPERATION

4.1 GENERAL

This section describes the theory of operation for the unit. The description of each circuit is presented in sufficient detail to allow troubleshooting to the integrated circuit level. Figure 4-1 is a block diagram of the DDI circuits and should be referred to when reading. Pin numbers identified in the theory of operation refer to either component pins or PC board connection pins.

4.2 FUNCTIONAL DESCRIPTION

The Direct Digital Interface provides switch selection for computer control or manual control of a variable signal to a final control element. In the computer mode, automated digital pulse information is displayed on a visual indicator, then converted to an analog signal that is applied to the device being controlled. In the manual mode, the signal is variable, using a front panel mounted potentiometer that changes the analog output value and indicates the parameter on a bar graph display.

4.3 POWER SUPPLY

DC voltage is applied to pins 21 and 22, then regulated by VR4. The voltage is applied across R113 to provide start up of the inverter circuit composed of Q7, Q8 and associated components. The chopped signal is applied to the primaries of both T1, a 12 watt transformer which provides voltages for the main circuits, and T2 which is a high voltage step-up transformer used to produce the +250 volts for the gas discharge display. Voltages at the secondaries of T2 are rectified and produce an unregulated +28 volts DC which is used at the output stages as well as regulated ±15vdc and a +5vdc used by the remaining circuits.

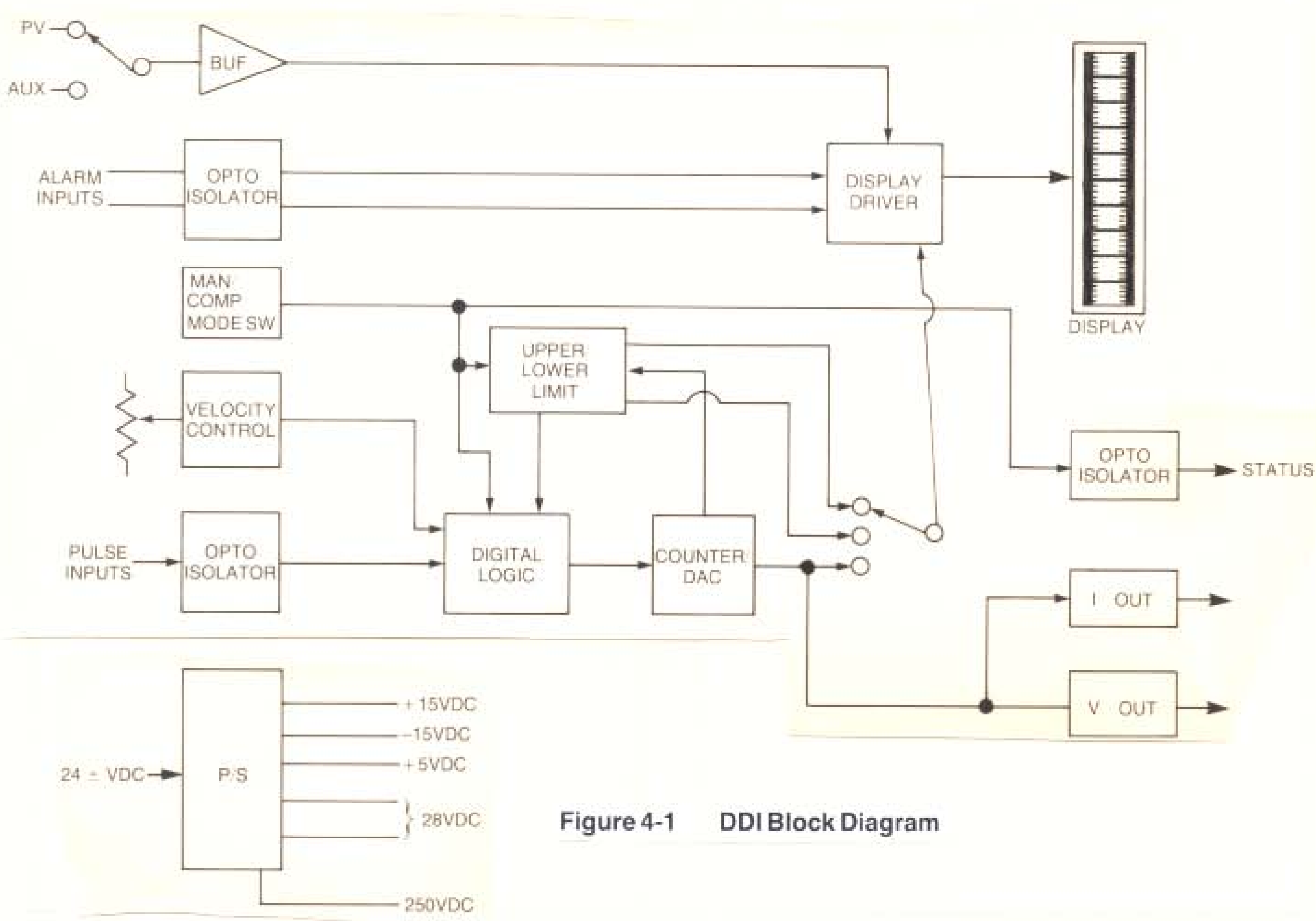

Figure 4-1 DDI Block Diagram

4.4 MODE SELECTION

A front panel mounted locking toggle switch, SW101, allows the selection of either of two modes: computer (remote) or manual (local) control. The mode select circuit is composed of SW101, IC37 and associated components that provide a status signal to indicate the selected mode. The status signal bit is derived from PIN 3 of IC37 and applied to the circuits of Q1 and Q2, then opto-isolated by IC5 to produce an output signal that is on when in the computer mode and off when in manual. The limit protection circuit and the request acknowledge circuit also use the mode status bit as inputs to logic selection components.

4.4.1 Manual Mode

In the manual mode, control of the analog output signal is provided by the velocity potentiometer which is mounted to the front panel. The velocity control potentiometer is ganged with SW102 to provide variation of oscillator frequencies generated by the circuit composed of IC34 and IC35. The control functions increase one oscillator frequency up to 200 hertz, and simultaneously decrease the frequency of the remaining oscillator. The oscillators are complementary bi-stable circuits, that produce both up and down pulses used to drive the increment and decrement flip-flops.

4.4.2 Computer Mode

In the remote, or computer, mode, pulse format control signals are applied at pin 7 which is used as a down or clock (DN/CLK) pulse input, pin 9 which is an up or down-not (UP/$\overline{\text{DN}}$) pulse input, and pin 8 which is common. The pulse train format and polarity are determined by the selected values of discrete components and the location of jumpers. The incoming computer signal is opto-isolated by IC23, then applied to the inverters of IC32 before being sent to the increment/decrement request flip-flops.

4.5 REQUEST FLIP-FLOPS

Up and down pulse information from the selected control mode is applied to the increment and decrement flip-flops, consisting of IC38 and IC40. One-half of the integrated circuit is used to produce an up pulse and the remaining half produces a down pulse. IC38 provides up and down pulses for the manual control mode, and IC40 produces up and down pulses for the computer mode. Pulse information from the computer, or manual control, is applied to the arbitration circuit of IC39 and IC43 to provide an input to the sequencer. The sequencer circuit consists of IC36 and IC42, and timing is provided by the signal generator, IC32 and IC37, to produce 200 KHz clock pulses.

4.6 COUNTER CIRCUITS

Information from the sequencer circuit is applied to one portion of IC36 to provide a direction latch which connects logic to both the request acknowledge circuit and the up/down counters. IC18 contains eight toggle switches used to predetermine start-up values in 1.6% increments and to provide input logic to the up/down counters formed by IC20, IC29, and IC30. The outputs from the counters are applied to IC21 and IC31 which invert the signals, translate the level, and drive IC22, the digital to analog converter (DAC). Inputs to the D to A converter range from a count of 256 which represents zero percent, up to 1256 which represents the one hundred percent value. Pins 16 and 24 of the DAC are tied together and provide a voltage output that is connected to a reference circuit. The positive and negative 6.3 volt references are generated by operational amplifiers IC3 and IC8, and provide reference voltages to the limit protection circuit. Upper and lower limit voltages are derived from the positive reference voltage and are applied across voltage dividers before going into the comparator circuits of IC8. Each comparator output is connected through IC9 and IC28 to produce a limiting signal and rollover inhibit. The rollover inhibit prevents the counter from decrementing when its value is at zero, and prevents incrementing when the counter is at its maximum value.

4.7 DISPLAY DRIVERS

The upper and lower limit voltages are selectable for calibration by switch S2, and applied to IC7 and IC4 which comprise a dual analog inverter stage. With S2 in the normal position and S1-A in the reverse position, the output of IC7 is supplied to the display driver. This causes the left bar graph display to decrease when the DAC output increases. When S1-A is set in the direct position, the output of IC4 is supplied to the display driver, causing the left bar graph display to increase when the DAC output increases.

4.7.1 Left Side Display

Display information for the left bar graph is derived from the D to A converter, and applied to the inverting input of IC2, for comparison with the output of a sawtooth generator circuit that is applied to the non-inverting input of IC2. The output of the comparator is applied to the D input of a flip-flop, IC14, the Q output of which is resistor-coupled to the base of the left display driver transistor, Q5.

4.7.2 Right Side Display

Signals that are to be indicated on the right side of the bar graph display are connected to the DDI input pins numbered 3 and 4 for auxiliary, and pins 5 and 6 for process variable. Slide switch S3 is mounted on the printed circuit board and provides selection of the desired input signal. The signal is connected to the non-inverting input of IC12 which buffers the variable before it is applied to the inverting input of comparator IC1. The sawtooth generator circuit is connected to the non-inverting input of IC1, the output of which is applied to pin 5 of IC14, the D input of a flip-flop. The Q output, pin 1 of IC14, is resistor-coupled to the base of Q6, the right display driver transistor.

4.7.3 Sawtooth Generator Circuit

Sawtooth waveforms are produced by the 8 bit ladder network of IC6, with timing controlled by a 12 KHz clock circuit. Output logic signals are derived from IC6 at Q1, Q4, Q7, and Q8 which provide inputs to two sections of IC24. The logic states are coupled through sections of IC24, IC25, and IC27 to control IC17 which provides syncronization for an alarm flashing circuit, and IC26 which provides sequencing of the phase drive signals to the bar graph displays.

The shape of the sawtooth waveform, as shown in Figure 4-2, indicates an increasing ramp, a sharp decrease, and an off time between pulses. The resulting logic generated by the sawtooth on and off times determines the state of outputs Q2, Q3, and Q4 of the sequencer, IC26. The output from Q2 is coupled to the SET input functions of the dual flip-flop, IC14, to turn the bar graph display off during the sawtooth off time. The Q3 output from IC26 provides a RESET function to the ladder network of IC6, and the Q4 output is used in the phase determination and sequence logic formed by the remaining sections of IC24, IC25, and IC26. The phase determining and sequence logic drives IC33 which consists of high voltage transistor drivers that are connected to the bar graph display.

4.7.4 Alarm Inputs

Two alarm conditions will cause the bar graph displays to flash and provide a visual indication of either an overrange condition, which flashes at a 2 hertz rate, or an external alarm input condition, which flashes at a 4 hertz rate. An overrange condition occurs if a count total greater than 201 clock pulses is detected from the output of the ladder network formed by IC6. The detected overrange condition changes the state of the affected dual flip-flop IC16, which then toggles at a 2 hertz rate until the range returns to a value less than or equal to 100%.

External alarm signals are connected to input pins 10, 11, 12, or 13, and are diode-coupled to the input of IC13 for isolation before being applied to each section of the dual flip-flop IC15. The 4 hertz flashing rate of IC15 is derived from the Q4 output of the alarm flash rate syncronizer, IC17.

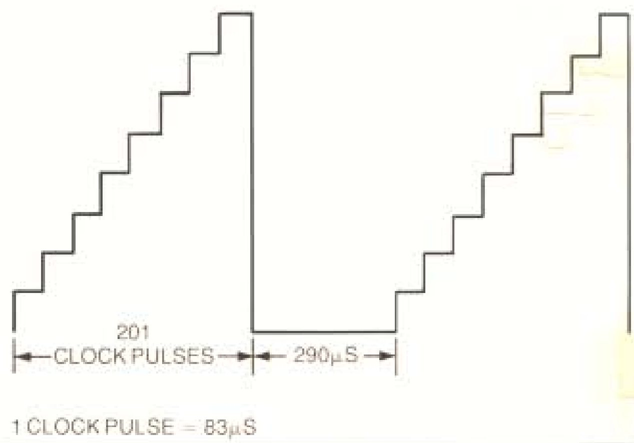

Figure 4-2 Sawtooth Waveform

4.8 OUTPUT CIRCUITS

Both voltage and current signals are available as output signals from the DDI, for use in the control of the final element. Signal levels from the D to A converter are applied through resistor divider networks and provide inputs to operational amplifiers IC10, in the current output stage, and IC11, in the voltage output stage. The current output stage uses the inverting input, pin 2 of IC10, to produce an output change at pin 6, which varies the bias of transistors Q3 and Q4. The change in conduction of the transistors, varies the current draw from the 28 volt section of the power supply and provides output current at pins 19 and 20. The voltage output stage uses the non-inverting input, pin 3 of IC11, to produce a variable DC at the output, pin 6, of the operational amplifier which is connected to the voltage output pins.

MAINTENANCE & TROUBLESHOOTING

5.1 INTRODUCTION AND GENERAL INFORMATION

This section contains information to aid in the maintenance of the unit. This includes disassembly instructions for general troubleshooting, and special techniques required to replace components.

5.2 DISASSEMBLY

When unit troubleshooting is required, it is first necessary to disassemble the unit. The physical configuration of the unit determines the steps to be followed in disassembly. These are described in the following paragraphs.

NOTE

Always identify wires by tagging before disconnecting existing connections.

CAUTION

DISCONNECT INPUT SIGNAL AND REMOVE POWER INPUT BEFORE DISASSEMBLING UNIT.

To disassemble a unit, remove it from the installed position. After the unit has been removed, disassemble the unit as follows to gain access to the circuit board.

a. Remove four screws securing the back cover to the unit.

b. Remove the hex nuts from the direct/reverse and the calibration switch, and remove the front cover.

c. Points on the circuit board may now be reached for troubleshooting. It is suggested that mounting screws be replaced, for easy location at reassembly.

5.3 TROUBLESHOOTING

The schematic diagrams include flagged numbers (or letters) at various points in the circuit. Table 5-1 gives the voltages and waveforms at these points. The assembly drawing shows the physical locations of the parts on the circuit board. Bear in mind that the circuit board is protected with a moisture-resistant coating. Therefore, it may be necessary to use a needle-point probe and exert a fair amount of pressure to break through the coating when it is desired to observe the signal or voltage at a specific point. When connecting a probe to a component on the circuit board, exercise care to make sure the probe does not short-circuit to an adjacent component.

In general, troubleshooting is carried out by tracing the signal with an oscilloscope and referring to the schematic diagrams to determine what component might be causing an observed abnormal indication. If the original symptom was a complete failure of the unit to operate, the most logical components to suspect are those associated with the power supply in the unit (including any voltage regulator). If the unit was producing an incorrect (but not zero) output, check the outputs from the voltage regulator and, if these are normal, apply a standard input signal and trace the resulting signal through the unit.

The front indicator is an excellent tool to use for troubleshooting. Using the control switches in conjunction with the display can provide valuable aids in fault isolation.

Test Point	Level
1	+250 ± 20 volts DC
2	+15vdc ± 5%
3	–15vdc ± 5%
4	+5vdc ± 5%
5	26 to 30vdc measured between D and E
6	0 to 6.3 volt square wave @ 12 kHz
7	0 to 5vdc (varies with DAC output)
8	0 to 15 volt square wave @ 0 to 200 hertz
9	0 to 15 volt square wave @ 80 to 200 kHz
10	–6.3vdc ± 5%
11	+6.3vdc ± 5%
12	0 to 15 volt logic (both points low at comparison)
A	See figure 4-2

Table 5-1 Test Point Signal Levels

5.4 PLUG-IN BOARD CONNECTOR CLEANING

Modules which have been in service for a long period of time may develop resistive coatings on the gold-plated contacts of the plug-in boards. This coating, if allowed to build up, can cause malfunctions by decreasing the noise margin of a circuit. There are two types of foreign material coatings which can develop on the gold-plated contacts of a plug-in module. The first type is INORGANIC. This type of contamination results when copper "bleeds" through the gold plating and oxidizes. The second form of contamination involves ORGANIC substances, which usually are a result of careless handling, and are mainly made up of fingerprints, salts, and oils deposited when the plug-in boards are handled by the gold-plated contacts. Contamination by organic substances can be reduced by careful handling.

Although rack connectors are usually of the self-cleaning type, it may become necessary to clean the module fingers to ensure reliable connection. When module contacts are in need of cleaning, the following procedures are recommended:

Removal of Inorganic Contaminants

a. Immerse contacts of plug-in board in an ultrasonic bath of deionized water and a mild detergent for at least 30 seconds.

b. Repeat step (a) with pure deionized water only.

> **CAUTION**
>
> REMOVE WATER IMMEDIATELY FROM CONTACTS. IF THIS IS NOT DONE QUICKLY, DAMAGE TO CONTACTS MAY RESULT.

c. Remove water by immersing contacts in an ethane or methanol bath to same depth used during the ultrasonic cleaning of step (a). Never wipe or use an abrasive cleaner on the contacts. If wiping is necessary, use K-Dry towels or equivalent.

Removal of Organic Contaminants

a. After inorganic contaminants and water have been removed, organic materials may be removed by immersion of contacts in trichloroethane for at least 30 seconds.

> **CAUTION**
>
> NEVER USE AN ERASER ON THE CONTACTS. THE USE OF ABRASIVE CLEANERS OR ERASERS ON PLUG-IN BOARD CONTACTS IS CONSIDERED A PHYSICAL ABUSE TO THE UNIT AND MAY VOID THE WARRANTY.

b. Let contacts air dry or wipe with a very fine, nonabrasive material such as K-Dry towels or equivalent.

5.5 COMPONENT REPLACEMENT GENERAL INFORMATION

Replace all defective components with identical parts. Refer to Section 6 for a list of recommended replacement parts. The last row of numbers in the parts list is the number of spares recommended to be kept on hand for that part, per unit, for up to ten units of the same type. For more than ten units, a spares complement of 10+ on the indicated parts should be used.

5.5.1 Component Replacement Techniques

Most parts used in the unit are quite small and are located in a confined area. Therefore, small hand tools are a necessity when servicing the unit. The following is a summary of the general techniques and precautions that should be observed to prevent damage to components in the unit:

> **CAUTION**
>
> CMOS INTEGRATED CIRCUITS ARE VERY SUSCEPTIBLE TO STATIC ELECTRICITY. WHEN REPLACING THESE COMPONENTS, DO NOT HANDLE LEADS BEFORE SOLDERING INTO BOARD. ENSURE THAT SOLDERING IRON IS GROUNDED. SOLDER POWER INPUT LEADS BEFORE SOLDERING GROUND CONNECTIONS. FAILURE TO TAKE THESE PRECAUTIONS WILL DAMAGE COMPONENTS.

a. Use a transformer-operated low-voltage soldering iron with a grounded tip and rated at not more than 50 watts. A temperature controlled tip is desirable.

b. Use extreme care when unsoldering the leads to any component. Do not keep the soldering iron on a point for more than a few seconds at a time. Use a suction-type solder-removing tool (solder sucker) as an aid in unsoldering transistors and integrated circuits. The protective coating on the unit may be removed with trichloroethane or equivalent. Be sure adequate ventilation is provided when using this or any other chemical.

c. Do not excessively bend or twist the leads of small components; they break easily.

d. Before removing a component, observe the lead dress. Be sure that the lead dress of the replacement is the same as that of the original.

e. Handle MOSFETs only by the case; if the fingers are allowed to contact the leads, the MOSFET may be ruined. Be sure to leave the metal sleeve around the leads until just before the device is installed on the printed circuit board.

f. Remove all flux from soldered joints with trichloro-ethane or equivalent.

g. Test the unit for proper operation and, if necessary, recalibrate by the procedure given in Section 2. When the performance of the unit is known to be satisfactory, apply clear *acrylic* to reseal the unit where required. Check that all leads are clear of the board edge before reinstalling the board into its case.

h. Before reinstalling the unit, mount the front and rear plastic covers. Be sure to use the same screws (or screws of the same size) as the ones removed. Longer screws will damage the unit.

UNIT DOCUMENTATION

6.1 GENERAL

This section consists of a computer print-out table that provides parts identification information for the unit. Wiring lists have been provided in this section as an aid to the maintenance personnel.

Parts information is grouped according to the number of assemblies. If the unit contains two PC boards, the table will be divided into two major sections: one section will contain information related to PC1 and the other section will list PC2 components information. Each major section in the table contains a complete parts list headed LIST OF MATERIALS specifying which PC board it is describing. This list of materials consists of the following headings:

ITEM: A reference numeral used for data processing and not used by maintenance personnel.

NAME: Gives the nomenclature of the part.

DESCRIPTION: Identifies the component by manufacturer's part number, usually followed by component's parameters or value.

REF: Lists the reference designation for the component, referred to in Section 4, on the schematic and assembly drawings.

PART NUMBER: This column specifies the Moore Industries assigned part number. This is the part identification required when ordering parts from Moore Industries.

SPARE: The numeral in this column specifies the recommended number of component spares per unit type that should be kept on hand by maintenance personnel.

6.2 GLOSSARY OF ABBREVIATIONS

C	Capacitor
CR	Diode - zener included
HW	Special hardware
J	Connecting buss wire
L	Inductor
LB	Label
PC	Printed circuit board
R	Resistor
T	Transformer
IC	Integrated circuit
Q	Transistor
LED	Light emitting diode
TB	Terminal block
VS	Voltage regulating varistor
VR	Voltage regulator

RETURN PROCEDURES

To return equipment to Moore Industries for repair, follow these four steps:

1. Call Moore Industries and request a Returned Material Authorization (RMA) number.

   Warranty Repair –
   If you are unsure if your unit is still under warranty, we can use the unit's serial number to verify the warranty status for you over the phone. Be sure to include the RMA number on all documentation.

   Non-Warranty Repair –
   If your unit is out of warranty, be prepared to give us a Purchase Order number when you call. In most cases, we will be able to quote you the repair costs at that time. The repair price you are quoted will be a "Not To Exceed" price, which means that the actual repair costs may be less than the quote. Be sure to include the RMA number on all documentation.

2. Provide us with the following documentation:
   a) A note listing the symptoms that indicate the unit needs repair
   b) Complete shipping information for return of the equipment after repair
   c) The name and phone number of the person to contact if questions arise at the factory

3. Use sufficient packing material and carefully pack the equipment in a sturdy shipping container.

4. Ship the equipment to the Moore Industries location nearest you.

The returned equipment will be inspected and tested at the factory. A Moore Industries representative will contact the person designated on your documentation if more information is needed. The repaired equipment, or its replacement, will be returned to you in accordance with the shipping instructions furnished in your documentation.

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