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User's Guide for the 2.7-kJ Wire Burst Controller: Analog Modules, Inc. Model 880-317 with Upgraded Charging Control Box

by W Casey Uhlig and Jeff Cameron

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W Casey Uhlig and Jeff Cameron
DEVCOM Army Research Laboratory

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14. ABSTRACT
The Analog Modules, Inc. Model 880-317 fixed pulse width controller supplies a single pulse varying from 0 to 3000 V with a pulsed width of approximately 400 µs. The module contains two 300-µF capacitors connected in parallel for a total of 600 µF, an internal inductance of 15 µH, and internal resistance of about 200 mΩ. The internal dump resistor for discharging the capacitors is 17 kΩ and requires approximately 1 min to be fully discharged. The purpose of this guide is to provide general instructions for the module's use with the modifications and an upgraded control box as implemented and required to meet the US Army Combat Capabilities Development Command Army Research Laboratory's safe use guidance.

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Sciences of Extreme Materials, Weapons Sciences, wire burst, pulse controller, pulse control module

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1. Introduction

The Analog Modules, Inc. Model 880-317 fixed pulse width controller supplies a single pulse varying from 0 to 3000 V with a pulsed width of approximately 400 µs. Figure 1 shows an example of an electrical pulse with the module set to 1500 V into a 42-mm-long copper (Cu) wire with a diameter of 125 µm. The output achieved a peak current of 3.44 kA. The module contains two 300-µF capacitors connected in parallel for a total of 600 µF, an internal inductance of 15 µH, and internal resistance of about 200 mΩ. The internal dump resistor for discharging the capacitors has a time constant of about 10 s. Thus, the internal dump resistor is on the order of 17 kΩ and requires approximately 1 min to be fully discharged. The purpose of this guide is to provide general instructions for the module's use with the modifications and control box as implemented and required to meet the US Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory's (ARL's) safe use guidance. Therefore, further internal specifications will not be listed here but are included in the manufacturer's operating manual (see Appendix).

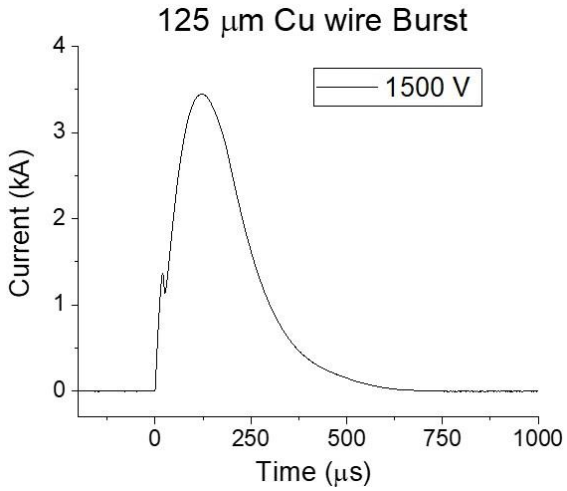


Fig. 1 Electrical pulse with a setting of 1500 V into a 125-µm Cu wire

2. Requirements

The pulser module requires 193–253 volts alternating current (VAC) single phase 15-A supply. Because the module does not have a power switch, it needs to be switched externally. We have also determined that the power can be supplied via a 240-VAC source or by using two legs of a 208-VAC three-phase source. The pulser is controlled and monitored via a 25-pin input connector to control the charge voltage, enabling charge, triggering, and so on. See Appendix for the pinouts. The

module VAC source and the 25-pin control connection is supplied by a control box custom built by ARL (Fig. 2).

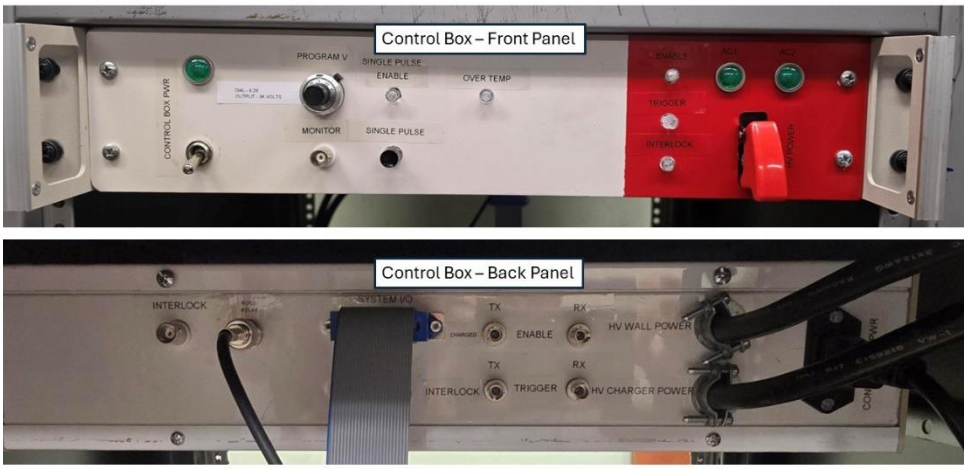


Fig. 2 Control box front and rear panels

The 120 VAC has two independent disconnects to the pulser. The first is a lockable three-phase manual disconnect from the facility's 120-VAC power source. The second is by way of two electrical relays located in the control box and facility internal electrical interlock system that are linked via a BNC cable. One is a single-pole, double-throw 24-volts direct current (VDC) relay located inside the control box that disconnects the 240 VAC being supplied to the pulser. The second electrical relay is in the facility internal electrical interlock system; this relay disconnects the control box relay in the event of a door opening when power is applied to the pulser. By interlocking the control box, the power to the pulser module is removed and cannot be powered on unless the interlock is engaged. An interlocked 120-VAC power source is shown in Fig. 3.

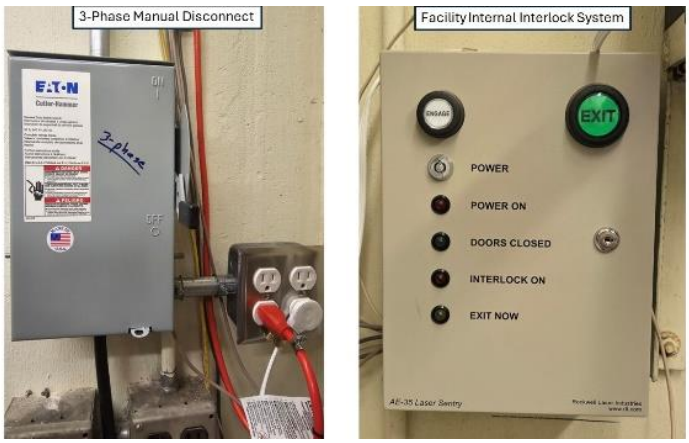


Fig. 3 Interlocked power source for control box circuit and relay to dump resistor

The pulser module was also modified by adding a direct connection to the internal capacitors to enable direct shorting and monitoring of the voltage on the capacitors. This connection is hard wired to a Ross relay, dump resistor, and 1/1000 high voltage (HV) probe (shown in Fig. 4). The Ross relay must also be powered by an interlocked power source. Thus, if the interlock is broken, the VAC power to the pulser will be turned off and the Ross relay will be closed. The time constant for the dump resistor circuit is 1.5 s and thus a charge of 3000 V will be reduced to less than 60 V in 6 s and will be fully discharged in less than 10 s.

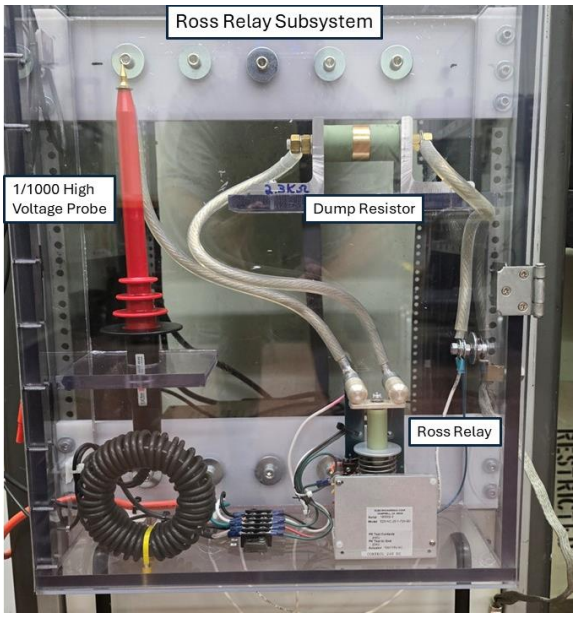


Fig. 4 Modification to the pulser module for direct shorting and monitoring of the internal capacitors through a Ross relay and external dump resistor

To avoid HVs in areas where personnel will be located during testing, charging and triggering must be controlled via fiber optic input. The charge enable must be high during charging and remain on during triggering. The pulser requires a trigger pulse length of 5 ms. Longer times can damage the system. However, any length trigger can be sent to the optical input; the control box circuit will output a single pulse and is set to 5 ms.

3. Procedure

1) Verify the operator has in their possession the keys to the remote control box (shown in Fig. 5) and three-phase manual disconnect switch (locked in the disengaged position).

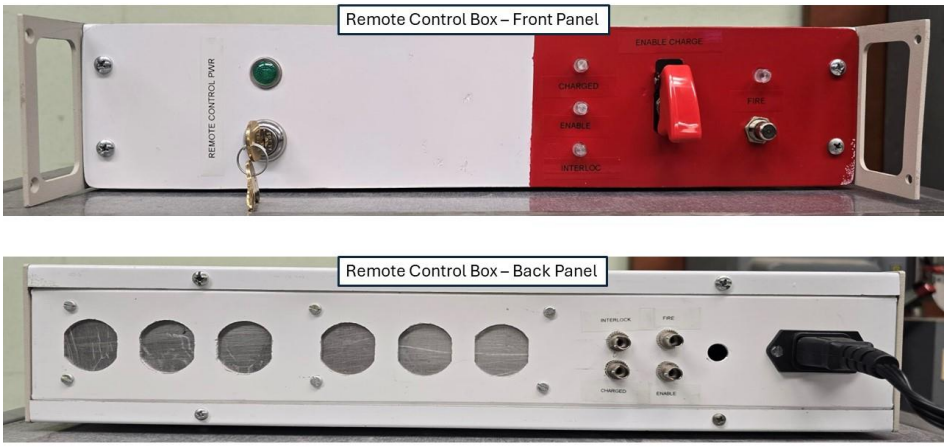


Fig. 5 Remote control box

2) With power disconnected to the pulser and control box, connect a voltmeter to the 0–10-V charge monitor on the back panel of the control box. Connect a second voltmeter to the output of the HV probe connected to the direct connect on the capacitors and verify 0.0 V.

3) Connect the burst wire or other load to pulser HV output, optical inputs, and any other diagnostic required. If desired, a local monitoring of the trigger can be connected on the control box front panel.

4) Set the voltage control dial on the front of the control box to the desired value from 0 to 10.

5) Ensure the interlocks are NOT engaged and connect all power sources and interlock cables.

6) Turn on control box power switch and the pulser module power switch by lifting the red safety cover and turn on the HV power. Engage the single pulse push button on the control box.

7) Ensure the area is clear of all personnel.

8) Unlock and move the three-phase manual disconnect switch to the “on” position.

9) While standing a minimum of 8 ft from the pulser, power on the facility internal interlock system, close the gate, engage the interlock, and verify “Interlock On” illuminates.

10) On the control box front panel, both HV power lights on the front panel of the control box should be lit. If the single pulse enable LED is not lit, press the enable trigger button on the front panel of the control box.

11) Press the exit button on the interlock system and move to the experiment control area, making sure that the interlock system reengages.

12) Ensure that you can monitor the voltmeters from Step 2 remotely.

13) Put on appropriate hearing protection.

14) Using the key, power on the remote control box and alert the area of impending experiment (via whistles, etc.), then enable charge by lifting the red safety cover and moving the switch to the up position. Monitor the voltmeters to ensure proper charging to the desired voltage and note the actual charge voltage.

15) Send trigger. The wire should burst, or if there is a different load, discharge of the capacitors should be indicated by a drop in the voltage monitored on the voltmeter. The system will immediately begin to charge again.

16) Disengage the charge enable signal, turn off remote control box, and remove the key. The decay of the voltage on the voltmeters should be observable at the internal dump resistor rate.

17) Disengage the interlock system by opening the gate, but do not enter the area. After 10 s and visible verification that the voltmeters read 0.0 V and the Ross relay is closed, the area may be entered according to any wait times required for the air to be clear (e.g., if the wire was burst in open air).

18) After entering the room, disengage and lock the three-phase manual disconnect switch. Turn off the facilities internal interlock system and the power switches on the front panel of the control box (pulser module power switch and control box power switch).

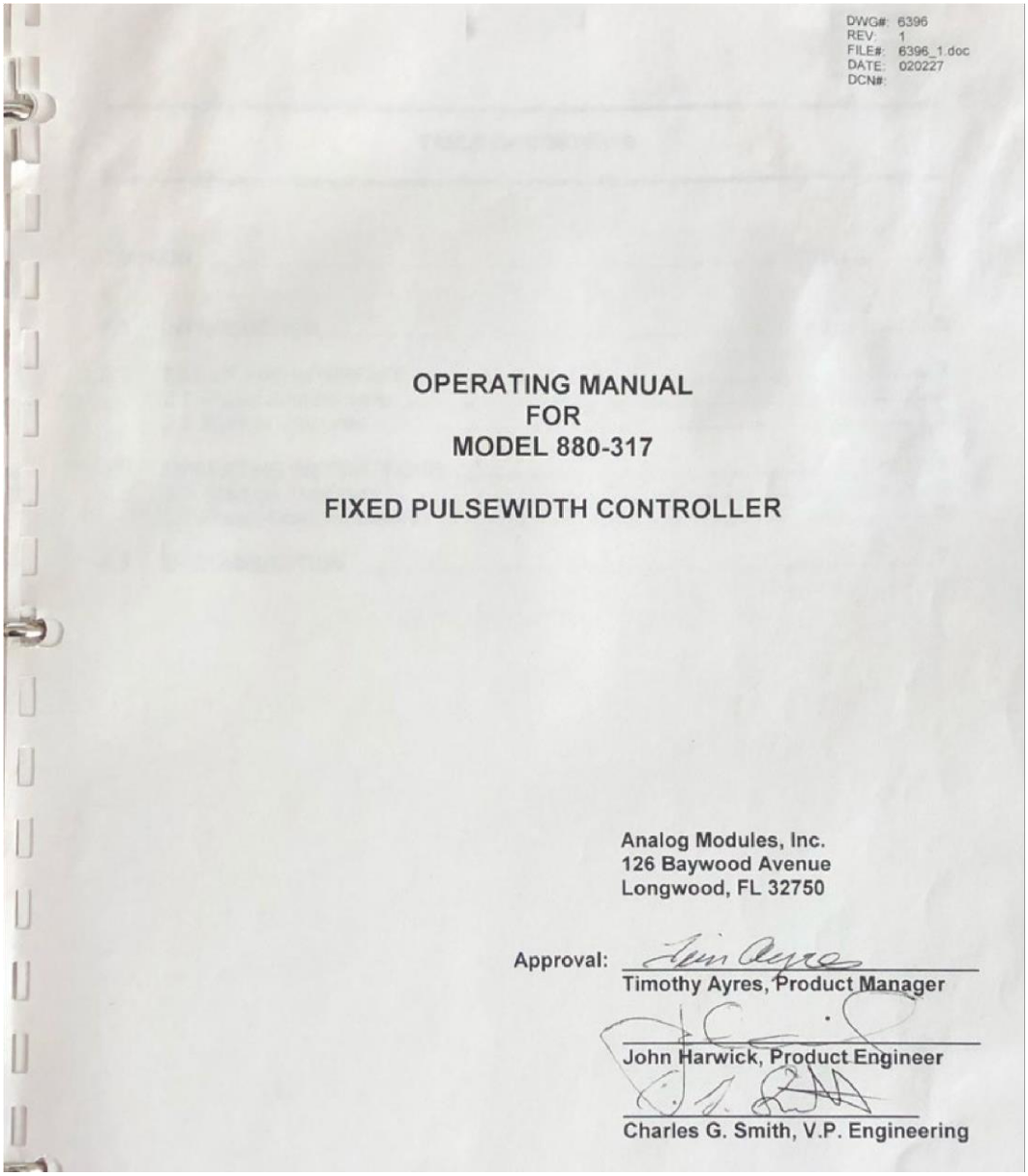
4. Conclusion

A control box and characterization of the Analog Modules, Inc. Model 880-317 fixed pulse width controller was completed. The pulser supplies a single pulse varying from 0 to 3000 V with a fixed pulse width of approximately 400 µs. The control box provides a means to charge and trigger the system remotely via fiber optics to meet ARL's safe use guidance.

Appendix. Operating Manual

This appendix appears in its original form, without editorial change.

Below is a copy of the original manufacturer's operator manual as well as a later version obtained directly from the company.



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DATE: 020227
DCN#:

OPERATING MANUAL
FOR
MODEL 880-317

FIXED PULSEWIDTH CONTROLLER

Analog Modules, Inc.
126 Baywood Avenue
Longwood, FL 32750

Approval:
Timothy Ayres, Product Manager

John Harwick, Product Engineer

Charles G. Smith, V.P. Engineering

DWG#: 6396
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FILE#: 6396_1.doc
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TABLE OF CONTENTS

SECTION 1

INTRODUCTION

1.0 INTRODUCTION

The *Model 880-317* Laser Controller is an OEM type power supply capable of driving small wire loads.

The system is a fixed pulsewidth, single mesh, PFN driver. The PFN energy is variable through adjustment of the capacitor charge voltage. The maximum capacitor voltage is 3000 VDC. The power supply is capable of delivering 1250W maximum ramp power to the PFN.

The PFN is designed to drive a 0.004 wire load that will disintegrate when the PFN discharges.

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CAUTION

READ THIS BEFORE PROCEEDING FURTHER

The voltages generated by this equipment are LETHAL. To avoid electrocution, good care and judgment must be used. The safety interlocks are provided for your protection and should never be disabled or defeated. Covers should not be removed without first disconnecting the AC power lines servicing this equipment. All storage capacitors should be discharged before any attempt is made to enter the unit, or move connectors or output cable. If any doubt exists, check capacitors with a HV probe or voltmeter. Ensure all metal boxes are connected to ground.

When shipping, the rack boxes should be appropriately supported or removed to avoid damage due to shock. Inspect all cables for looseness at connectors and visual damage. Do not support units by front panel only -- use multiple supports. Protect exposed power and output connections from human touch.

Once the power has been removed, or the high voltage has been disabled, allow at least one (1) minute for the voltage to bleed from the capacitor energy storage bank.

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Pin #	Signal		Description
1	Intlk Com.	Output	Connects to the common terminal of one pole of the cover switch. Pins 1 & 14 together provide an external indication of the cover switch status
14	Intlk N/O	Output	Connects to the N/O terminal of one pole of the cover switch. Pins 1 & 14 together provide an external indication of the cover switch status.
2	Program V	Input	A 0-10V scaled differential input to control the output voltage of the chargers. 10V equals the full scale output of the charger. The charger will output a voltage proportional to this program input only when the Enable line is active. Input impedance is 4kΩ. (Figure 2)
15	Program Rtn	Input	This pin goes to the inverting input of the differential amp controlling the program voltage.
3	Enable	Input	A 5V, 10mA input signal activates the Enable line. This is an optically isolated input. This signal gates the circuitry that controls the enable lines on all of the high voltage charger control lines and the dump circuit. Removing the enable signal activates the PFN dump circuit. (Figure 1)
16	Enable Rtn		This pin is connected to the Enable line opto isolator diode cathode.
4	Trigger	Input	A 5V, 10 ma input signal will trigger the high voltage pulse. This signal is optically isolated. The trigger pulsewidth determines the quench time for the charger. The minimum recommended trigger pulsewidth is 5mS. This trigger pulsewidth must be adjusted to prevent the charger from running during the PFN discharge. The trigger signal will be blocked from passing on to the high voltage control circuits when the enable line is not active. (Figure 1)
17	Trigger Rtn		This pin is connected to the trigger line opto isolator diode cathode.
5, 6	+24V	Input	This pin connects to a +24V source to power peripheral devices. The available current draw is 500mA maximum.
18, 19	+24V Rtn	Input	This is the return pin for the +24V source.
7	HV Sense	Output	A differential amp monitors the PFN voltage, and outputs a proportional signal on this pin 10V full scale. The source impedance is 100Ω. (Figure 4)
20	HV Sense Rtn		This is a signal ground for the HV sense signal that is common to +24 Rtn. It is strongly recommended that this signal be monitored differentially by the end user. Directly connecting this pin to the user control circuit ground may cause ground loops and other undesirable signal interference.
8	Chassis		This pin is common to chassis. It may be used for cable shielding.
9	Charged	Output	Opto isolator transistor output. 24V maximum, 10mA sink. Pin 9 is the collector, pin 22 is the emitter. The transistor turns on when the power supply has reached regulation. (Figure 3)
22	Charged Rtn		
10	Overtemp	Output	Opto isolator transistor output. 24V maximum, 10mA sink. Pin 10 is the collector, pin 23 is the emitter. The transistor turns on when the power supply has overheated. (Figure 3)
23	Overtemp Rtn		

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SECTION 2

SET-UP AND INTERFACE

2.0 SET-UP AND INTERFACE

Make all connections as indicated in the attached System Interconnection Diagram.

2.1 Power Requirements

198-253 VAC Single Phase 15A

Via line cord.

Please note that the AC power input to the unit is hard wired in the system. There are no AC switches of any kind inside the unit. Once power is applied to the line cord, the system is fully powered. The line cord must be connected to a switched AC source of adequate rating.

2.2 System Interfaces

Please refer to the attached interface drawing.

System I/O Connector:
25 Pin female D Connector:

SECTION 3

OPERATING INSTRUCTIONS

3.1 Start-Up Procedure

1. Establish control signals to the 25 pin I/O connector on the rear panel. Verify that the Program voltage, Enable, and Fire signals are all inactive.

2. Apply AC Mains voltage to the system.

When it is desired to arm the system for firing:

3. Apply 5V to the enable line.
   The capacitor dump circuit will also be turned off at this point, and the power supply modules enabled.

4. Apply the desired voltage to the program line.
   The power supply modules will charge the capacitor bank to the selected voltage. Both the HV Sense output, and the Charged indication signal can verify this. The system has a high voltage watch dog circuit to prevent prolonged short circuit operation of the capacitor charging modules. If the PFN does not reach full charge within a pre-programmed period of time, the capacitor charging modules will be disabled.

   To re-activate the charging modules, the Enable signal must be removed, and then re-applied. The chargers will not operate otherwise.

SEC

DOCUMI

4.0 DOCUMENTATION

Drawing Title

Interface Diagram

Interconnection Diagram

Misprinted missing info →

5. The wire load is now ready to be
signal of 5ms or greater on the trigg

The trigger pulse also acts as a
The pulsewidth of the trigger sig
cause the HV power supply t
discharge process.

3.2 Power-Down Procedure

a. Remove the trigger signal.
b. Remove the Program voltage.
c. Remove the HV Enable signal.
d. Switch off the AC Mains to the ur

While operating the system it is impo

The capacitor dumping circuit has been
in the capacitor bank. As with all resi
power limitations.

Cycling the enable line on and off may
the dump circuit.

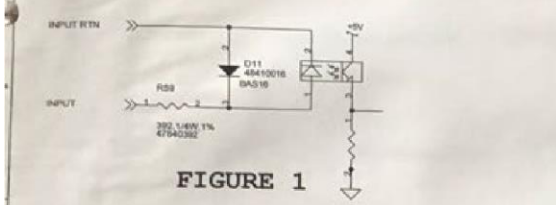

FIGURE 1

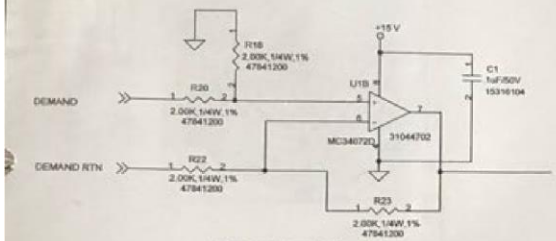

FIGURE 2

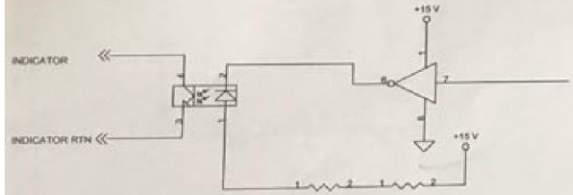

FIGURE 3

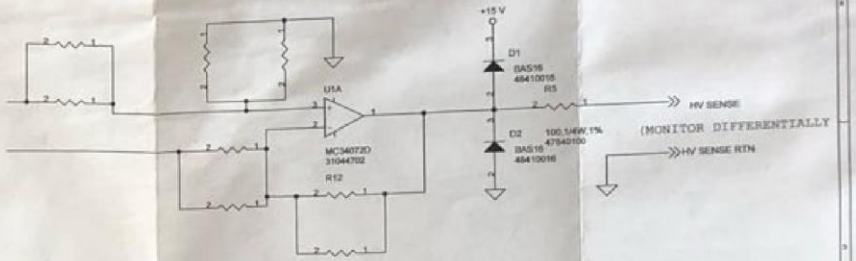

FIGURE 4

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						1	REV

ANALOG MODULES, INC.

DRAWN BY	DATE	CHECKED BY	DATE
J. HARWICK	990430		
LEAD APPROVAL	DATE	FINAL APPROVAL	DATE

TITLE: INTERFACE DIAGRAM
OEM INTERFACE PCB

SCALE	SIZE	CAGE CODE	SHEET	DRAWING NUMBER	REV
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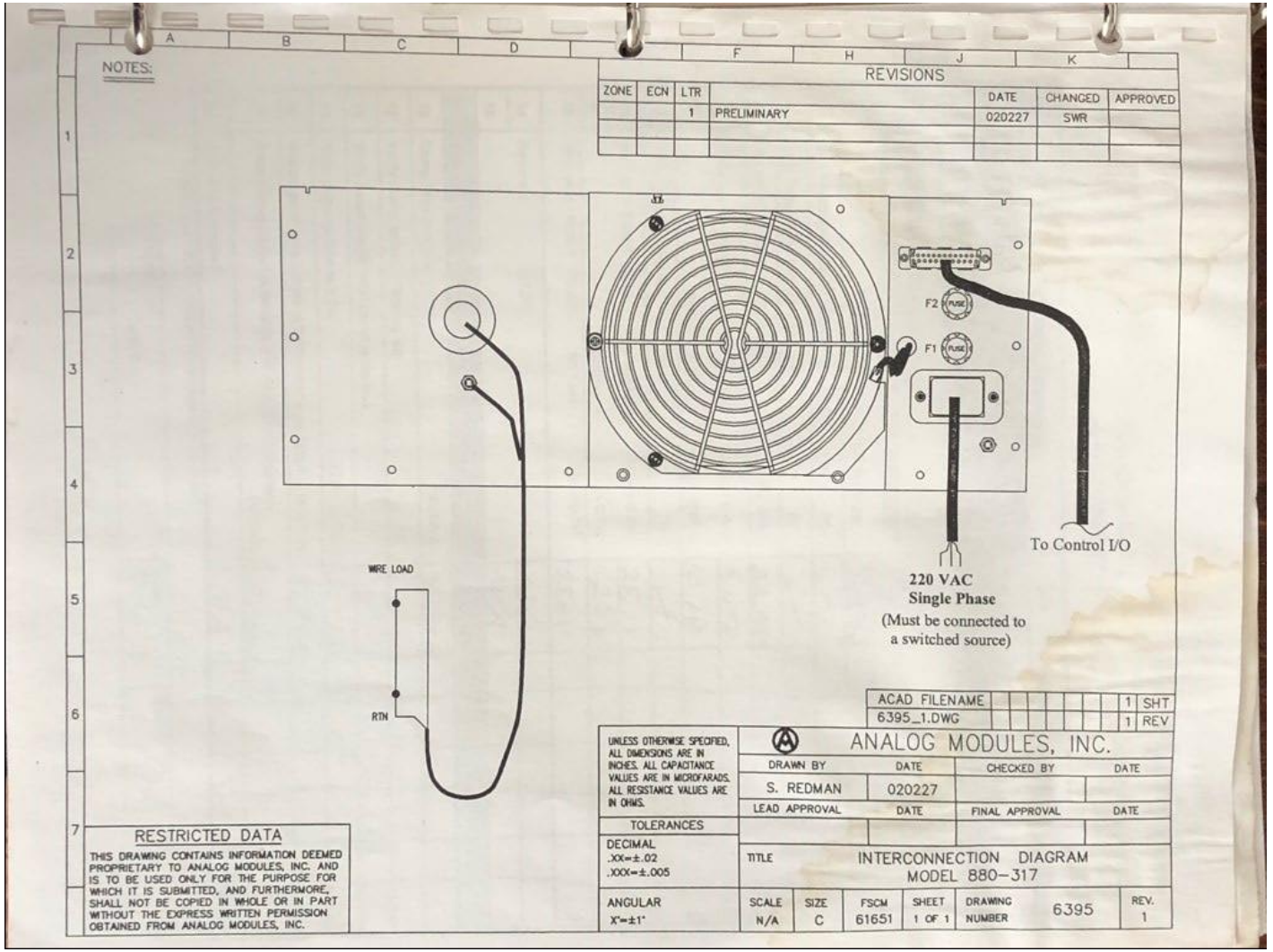
NOTES:
REVISIONS
ZONE | ECN | LTR | | DATE | CHANGED | APPROVED
1 | PRELIMINARY | 020227 | SWR
F2
F1
To Control I/O
220 VAC
Single Phase
(Must be connected to
a switched source)
WIRE LOAD
RTN
ACAD FILENAME
6395_1.DWG
1 SHT
1 REV
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES. ALL CAPACITANCE VALUES ARE IN MICROFARADS. ALL RESISTANCE VALUES ARE IN OHMS.
TOLERANCES
DECIMAL
.XX=±.02
.XXX=±.005
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ANALOG MODULES, INC.
DRAWN BY S. REDMAN DATE 020227
CHECKED BY DATE
LEAD APPROVAL DATE
FINAL APPROVAL DATE
TITLE INTERCONNECTION DIAGRAM
MODEL 880-317
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SIZE C
FSCM 61651
SHEET 1 OF 1
DRAWING NUMBER 6395
REV. 1
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Customer: US Army
Job #: 10459
Date: 2-27-02
Revision: 1
Revision Date: 2-27-02

Approval

Project Engineer	Stamp	Date
	AMI 25	2-27-02

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XX = N/A
XXX = N/A

TITLE

TEST DATA SHEET
MODEL 880-317

ANGULAR	SCALE	SIZE	FSCM	SHEET	DRAWING NUMBER	REV.
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REV. 1
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DCN#

Test Data Sheet
Model 880-317

	Test [pin#, rtn#] (Tolerance)			S/N	S/N	S/N	S/N
				78982	N/A	N/A	N/A
	25 PIN I/O						
1	Verify Cover Interlock Operation	[1,14]	(Y)	✓			
2	[redacted] HV Enable Blocked		(Y)	✓			
3	Program V [2,15]	5V = X V out	(1450<X<1547)	1511V			
4		10V = X V out	(2975<X<3025)	3008V			
5	Verify HV Enable Operation @ 4.5V input	[3,16]	(Y)	✓			
6	Verify Trigger Operation @ 4.5V input	[4,17]	(Y)	✓			
7	Record 24V Output	[5,6-18,19]	(23-27V)	26.6V			
8	HV Sense [7,20]	1500 V = X V out	(4.9-5.1V)	5.05V			
9		3000V = X V out	(9.8-10.2V)	10.1V			
10	Verify Chassis Continuity	[8]	(Y)	✓			
11	Charged - Note 1 [9,22]	Not Regulating	(>pin5-0.5V)	25.1V			
12		Regulating	(< 0.7V)	.25V			
13	Overtemp - Note 1 [10,23]	No Fault	(>pin5-0.5V)	25.0V			
14	Reserved	[11,24]		N/A			
15				N/A			
	System Operation		**(tolerance)**				
16	Dump Time to < 60V		(<60Sec.)	40sec			
17	Verify Fan direction - blowing out		(Y)	✓			
18	Verify power supply short circuit protection		(Y)	✓			
19	Record charge time to 3.0kV		(2.0 – 2.2 sec)	2.1sec			
20	Record peak lamp current at 3.0KV discharge, 600µF		(4.5-7KA)	8136A			
21	Record lamp current pulsewidth FWHM at 2.8KV discharge		(<600uS)	200uS			
22	Burn-In not required			N/A	✓	✓	✓

Note 1: Use 2.42K ohm pullup resistor to pin 5. (24V)

Technician:	Date:	Stamp:
[signature]	5-1-03	

2 of 2

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DATE 020227
DCN#

Test Data Sheet
Model 880-317

	Test [pin#, rtn#] (Tolerance)			S/N	S/N	S/N	S/N
				78241	N/A	N/A	N/A
	25 PIN I/O						
1	Verify Cover Interlock Operation	[1,14]	(Y)	✓			
2	HV Enable Blocked		(Y)	✓			
3	Program V [2,15] 5V = X V out		(1450<X<1547)	14.96			
4	10V = X V out		(2975<X<3025)	3006			
5	Verify HV Enable Operation @ 4.5V input	[3,16]	(Y)	✓			
6	Verify Trigger Operation @ 4.5V input	[4,17]	(Y)	✓			
7	Record 24V Output	[5,6-18,19]	(23-27V)	26.6V			
8	HV Sense [7,20] 1500 V = X V out		(4.9-5.1V)	5.08V			
9	3000V = X V out		(9.8-10.2V)	10.19V			
10	Verify Chassis Continuity	[8]	(Y)	✓			
11	Charged - Note 1 [9,22] Not Regulating		(>pin5-0.5V)	26.6V			
12	Regulating		(< 0.7V)	.17V			
13	Overtemp - Note 1 [10,23] No Fault		(>pin5-0.5V)	14.5V			
14	Reserved	[11,24]		N/A			
15				N/A			
	System Operation (tolerance)						
16	Dump Time to < 60V		(<60Sec.)	38sec			
17	Verify Fan direction - blowing out		(Y)	✓			
18	Verify power supply short circuit protection		(Y)	✓			
19	Record charge time to 3.0kV		(2.0 – 2.2 sec)	2.1sec			
20	Record peak lamp current at 3.0KV discharge, 600µF		(4.5-7KA)	6.345A			
21	Record lamp current pulsewidth FWHM at 2.8KV discharge		(<600uS)	500us			
22	Burn-In not required			—			

Note 1: Use 2.42K ohm pullup resistor to pin 5. (24V)

Technician:	Date:	Stamp:
CEm	2-27-02	

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---**Power Input:**

Voltage - 198-253 VAC,1φ via line cord.

Current - ≈6A @ 1000W output with 230VAC input.

Protective Earth Ground - 1/4" stud.

PFN:

Capacitance - 2ea 300 uf +/- 10%

Inductance - 15 uH +/- 10%

Lamp Output:

Voltage - 3000 VDC max.

PFN Current Rating - 55A RMS max. continuous, 8,000A peak.

Output Power - 1000W continuous

Size:

Chassis - 6.5" x 17" x 21"

Front Panel - 19" x 7"

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I/O Specifications:

25 pin D connector: (rear panel)

Pin	Signal Description		
1-	Intlk Com.	Output:	Connects to the common terminal of one pole of the cover switch. Pins 1 & 14 together provide an external indication of the cover switch status.
14	Intlk N/O		Connects to the normally open terminal of the cover switch.
2-	Program V	Input:	0-10V differential input to control the output voltage of the chargers. Active only when enable is active. Input impedance is 4kΩ.
15-	Program Rtn	Input:	This pin goes to the inverting input of the differential amp controlling the program voltage. Input impedance is 4kΩ.
3-	Enable	Input:	5V, 10mA input signal enables the power supply. Opto isolator input. This signal gates the circuitry that controls the enable lines on all of the charger control lines, all simmer enable lines, and the dump circuit. Removing enable signal activates Dump circuit.
16-	Enable Rtn		Opto isolator input diode cathode.

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4- Trigger	Input:	5V, 10mA input signal will trigger the flashlamp. Opto Isolator input. The trigger pulse width determines the quench time for the charger. The trigger signal will be blocked from passing on to the high voltage control circuits when the Enable is not active.
17- Trigger Rtn		Opto isolator input diode cathode.
5,6- +24V	Output:	+24V source to power peripheral devices. 500mA Maximum draw.
18,19- +24V Rtn	Output:	Return path for a +24V.
7- HV Sense	Output:	A differential amp monitors the PFN voltage, and outputs a signal on this pin 10V full scale. The source impedance is 100Ω.
20- HV Sense RTN		Signal ground common to +24 Rtn. It is strongly recommended that the HV sense signal be monitored differentially by the end user.
8- Chassis		This pin is common to chassis for use as shielding.
9- Charged	Output:	Opto isolator transistor output. 24V maximum, 10mA sink. Pin 9 is the collector, pin 22 is the emitter. The transistor turns on

			when the power supply has reached regulation.
22-	Charged Rtn		Opto isolator input diode cathode.
10-	Overtemp	Output:	Opto isolator transistor output. 24V maximum, 10mA sink. Pin 10 is the collector, pin 23 is the emitter. The transistor turns on when the power supply has overheated.
23	Overtemp Rtn		Opto isolator input diode cathode.
11-	Reserved		
24-	Reserved		
12-	Reserved		
25-	Reserved		
21-	Reserved		
13-	Reserved		

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Revision History:

Rev. 1 010613 -	New specification based on 880-260.
Rev. 2 020226 -	Changed RMS current from 25A to 55A, deleted simmer sense output from interface description.
Rev. 3	

List of Symbols, Abbreviations, and Acronyms

ARL	Army Research Laboratory
BNC	Bayonet Neill–Concelman
Cu	copper
DEVCOM	US Army Combat Capabilities Development Command
HV	high voltage
LED	light-emitting diode
VAC	volts alternating current
VDC	volts direct current

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