REACTION INSTRUMENTS

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TECHNICAL MANUAL
FOR
MODEL 409-2
VLF/HF MULTICOUPLER

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(703) 471-6060

SECTION I
GENERAL INFORMATION

1.1 DESCRIPTION

1.2 The Reaction Instruments Model 409-2 VLF/HF Multicoupler is a compact unit which allows coupling of up to eight VLF/HF receivers to a single antenna. A low noise input amplifier provides a nominal gain of 5 dB and achieves a wide dynamic range over a broad band covering the VLF and HF bands. A highly effective input protection circuit prevents circuit damage due to high level transients such as might result from lightning surges.

1.3 The Model 409-2 VLF/HF Multicoupler operates from either 115 or 230 Vac and is housed in a 1-3/4" high half-rack mount chassis. A rack adapter is available which permits mounting of two units side-by-side in a standard 19" EIA rack. A Tempest option is available.

1.4 ELECTRICAL SPECIFICATIONS (over 90% of band)

Frequency Range (3 dB bandwidth)	1 kHz to 60 MHz
Number of Inputs	one
Number of Outputs	4 to 8
Impedance (input and output)	50 ohms (75 ohms available)
Input Return Loss	>12 dBm
Output Return Loss	>20 dBm
Gain	5 dB nominal
Intercept Points (output)	
IP3	+28 dBm
IP2	+40 dBm
Isolation (output to output)	40 dB
Isolation (reverse)	50 dB
1 dB Gain Compression (referred to output)	16 dBm
Noise Figure	8 dB nominal at 30 MHz

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1.5 GENERAL SPECIFICATIONS

Style	1-3/4" high, 22" deep, 8-1/2" wide. EIA rack adapter available.
Connectors	BNC - rear panel mounted
Power	115/230 Vac ±10%, 48 to 62 Hz 15 watts nominal.
EMI	TEMPEST option available
Temperature (operating)	0 to 50 degrees C
Weight	6 lbs.

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SECTION IV
PRINCIPLES OF OPERATION

4.1 GENERAL PRINCIPLES OF OPERATION

4.2 Input signals in the 1 kHz to 60 MHz range enter the 409-2 Multicoupler at RF IN connector J1. The input signals go directly to the VLF-HF Multicoupler Amplifier Assembly A1 where a lightning protection circuit prevents damage from surges due to high ambient RF field conditions or from nearby lightning strikes. The signals then pass through a filter and matching network and on to the individual amplifier sections. Each amplifier section provides a signal gain of 5 dB. The output signal appears at RF OUT connectors J2 though J9 for distribution to the receivers.

4.3 The 409-2 accepts 115 or 230 Vac at the AC IN connector at the rear of the unit. Input power goes through line filter FL1 and is controlled at POWER switch S1 on the front panel. From here the filtered line voltage enters the Power Supply Assembly A2 and is converted to regulated +15 Vdc and -12 VDC output. These voltages are then sent to the Amplifier Assembly A1. Switch A2S1 on the top of the Power Supply is used to change the input voltage from 115 to 230 Vac.

4.4 DETAILED PRINCIPLES OF OPERATION

4.5 AMPLIFIER (Refer to Drawing 41988-01)

4.6 Connector J1 accepts input signals in the band 1 kHz to 60 MHz. These signals are first applied to a lightning protection circuit discussed in further detail in paragraph 4.13. In normal operation, the protection circuit is functionally equivalent to an artificial transmission line having low loss with the result that the input signals appear with negligible attenuation at the E2-E3 jumper.

4.7 Following terminal E3, a high-pass filter causes applied signals below in-band frequencies to be dissipated in dummy load R48. Signals in the VLF-HF band are coupled via a matching network to the gate of transistor Q1, a high-level VMOS field-effect transistor operating in a common-source, class A mode. The forward gate bias for the device, controlled by potentiometer R6, is adjusted to produce a quiescent drain current of 0.5 A.

4.8 The ac signal component of the drain current in Q1 is coupled by blocking capacitor C22 to a 50 ohm transmission line terminated at the far end by the parallel connection of resistors R43 and R44. These resistors also function to hold the dc voltage on the transmission line at -8 volts.

4.9 The transmission appears as a flat resistive load to the Q1 stage. The net voltage gain for in-band signals between the input at J1 and any point along the transmission line is nominally X4.

4.10 The eight isolated inputs of the multicoupler are produced by identical emitter-follower stages Q2 through Q9, which are uniformly spaced along the transmission line. Each emitter-follower has, in the frequency band of interest, a flat frequency response and a high input impedance, so that loading of the transmission line by the emitter-follower is negligible.

4.11 In a typical emitter-follower stage, Q2 for example, the low output impedance of the stage is brought up to 50 ohms by series resistor R12. Blocking capacitor C24 prevents emitter-follower supply voltage, applied via L11 and R10, from reaching the RF output connector at J2. When the RF output at J2 is match-terminated, the additional drop in signal voltage across R12, nearly 2:1, brings the overall voltage gain of the multicoupler to approximately 6 dB.

4.12 LIGHTNING PROTECTION

4.13 Protection against damage due to lightning-induced input surges or high-level RF inputs is provided by a lightning protection circuit installed within the Model 409-2 amplifier module in series with the RF input to the amplifier.

4.14 The circuit uses a gas-type surge voltage protector shunting the RF input. This is followed by a multi-section low pass filter and by reverse-biased diodes CR2 and CR3 which act as high speed diode clamps.

4.15 The low-pass filter, which includes inductors L1 through L5, has a flat passband extending to beyond 60 MHz, and functions primarily as a kind of impedance inverter separating the gas-type surge protector from the clamping diodes.

4.16 An incident voltage surge of large amplitude will initially propagate down the low-pass filter and become instantaneously clamped at +5V or -5V, depending on the polarity of the surge, by diode CR2 or CR3. The initial diode current may be many tens of amperes.

4.17 With an ignition delay of less than a microsecond, the gas tube at the input will then begin to conduct, the major part of the surge energy being either absorbed by the gas tube or reflected back out the input terminal. Due to the impedance isolation provided by the series connection of inductors L1 through L5, almost all of the incident surge current following an initial ignition delay flows through the gas tube.

4.18 The surge protection circuit will withstand the repeated discharge into its input of a 1000pF capacitor charged to 10 kVdc.

4.19 POWER SUPPLY (Refer to Drawing 32205)

4.20 Voltage regulator U1 supplies +15 Vdc to the VMOS amplifier stage. Regulator U2 supplies -12 Vdc to the emitter-follower stages. Filtered but unregulated B+ and B- for both regulators is produced by a capacitor-input full-wave bridge rectifier driven by power transformer T1. Shunt capacitors C1 through C4 on the ac side of the rectifier bridge help to reduce the conduction of interference out to the power line that is produced by switching of the rectifier diodes. Selector switch S1 configures the primary windings of T1 for operation on either 115 or 230 Vac.

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SECTION V
MAINTENANCE

5.1 PREVENTIVE MAINTENANCE

5.2 For maximum useful life of this equipment, Reaction Instruments recommends that no preventive maintenance be performed.

5.3 MINOR PARTS REPLACEMENT

5.4 Only the fuse and the POWER switch lamp may be replaced in the operating area.

WARNING

Dangerous voltages are present inside this unit. Remove all electrical power before opening this unit for service.

5.5 The fuse is replaced by removing the top cover of the unit and then removing the protective shield covering the power supply PCB. Replace with a 250 volt 0.5 amp slo-blow fuse.

5.6 The POWER switch lamp is replaced by pulling the switch lens from the switch body. Replace with a number 370 miniature lamp. Reinstall the lens by pressing it into place..

5.7 CORRECTIVE MAINTENANCE

5.8 Reaction Instruments recommends that corrective maintenance not be performed in the field and that the malfunctioning unit be returned to the factory for repair. Call (703) 471-6060 for return authorization. The following information is provided as a guide to be used when it is not possible to return the unit for repair.

5.9 Section IV, Principles of Operation, discusses the basic theory of the unit. This section should be reviewed before attempting any troubleshooting procedure.

5.10 When there is an apparent malfunction of the multicoupler, an important first step is to verify that the multicoupler itself is at fault. For this purpose, the coaxial cable leading to the multicoupler input jack should be disconnected and reconnected directly to one of the receivers normally connected to the multicoupler. Only if this results in normal operation for the receiver in question should a malfunction in the multicoupler be assumed.

5.11 The next step in the troubleshooting is to verify that the regulated and unregulated supply voltages are within normal limits. With a 115 Vac line input, the unregulated B+ across capacitor C5 in the power supply should be 21 +/-1 Vdc, and the B-, across capacitor C8, should be 21 +/-1 Vdc. In the event of loss of load, due perhaps to an open circuit failure of one of the regulators, these voltages will increase to about 27 Vdc. The normal regulator output voltages are 14.5 +/-0.5 Vdc for the positive regulator (U1), and -12 +/-0.5 Vdc for the negative regulator.

5.12 Additional simple dc checks will further localize circuit malfunctions in the multicoupler. The dc current drawn by Q1, measured by placing a dc ammeter in series with the B+ line, should be approximately 500 mA. Gate bias potentiometer R6 is used to adjust the operating current in Q1. The normal gate bias is in the range of 4 to 6 Vdc.

5.13 If R6 cannot be adjusted to produce the specified drain current, the probable cause is an open circuit failure in Q1. If the measured gate voltage is near zero at all settings of R6, the probable cause is a gate-source short circuit in Q1. In either case, Q1 should be replaced.

5.14 Similar dc checks can be used to troubleshoot the emitter-follower output stages. The normal operating current of each emitter-follower is 40mA, resulting in a 2.8 Vdc drop across each of the 68 ohm emitter pull-down resistors. Direct comparison of base and emitter voltages on the emitter-followers will quickly localize a failed component.

5.15 NOTE: The NPN transistors used have very high gain-bandwidth products, and even a short length of wire making a direct connection to the base or emitter of one of these stages may induce a parasitic UHF oscillation. To avoid this possibility, add a several thousand ohm resistor in series with the end of the volt meter test lead, and make the connection to the transistor terminal via the resistor.

5.16 POWER SUPPLY

5.17 The power supply is a regulated and supplies -12 Vdc and +15 Vdc. Additional filtering is provided in order to limit conducted EMI resulting from switching transients in the rectifiers.

5.18 If fuses continue to blow, this would indicate either shorted rectifier diodes or shorted capacitors C1, C2, C3, C4,C5, or C8, each of which can be checked with an ohmmeter.

5.19 With the power supply operating under load (i.e., multicoupler module connected), the B+ and B- ripple across C5 or C8 should be less than 0.6 Vp-p at twice the line frequency. If ripple is seen at the line frequency, check the rectifier diodes. If excessive ripple is seen at twice the line frequency, check the filter capacitors.

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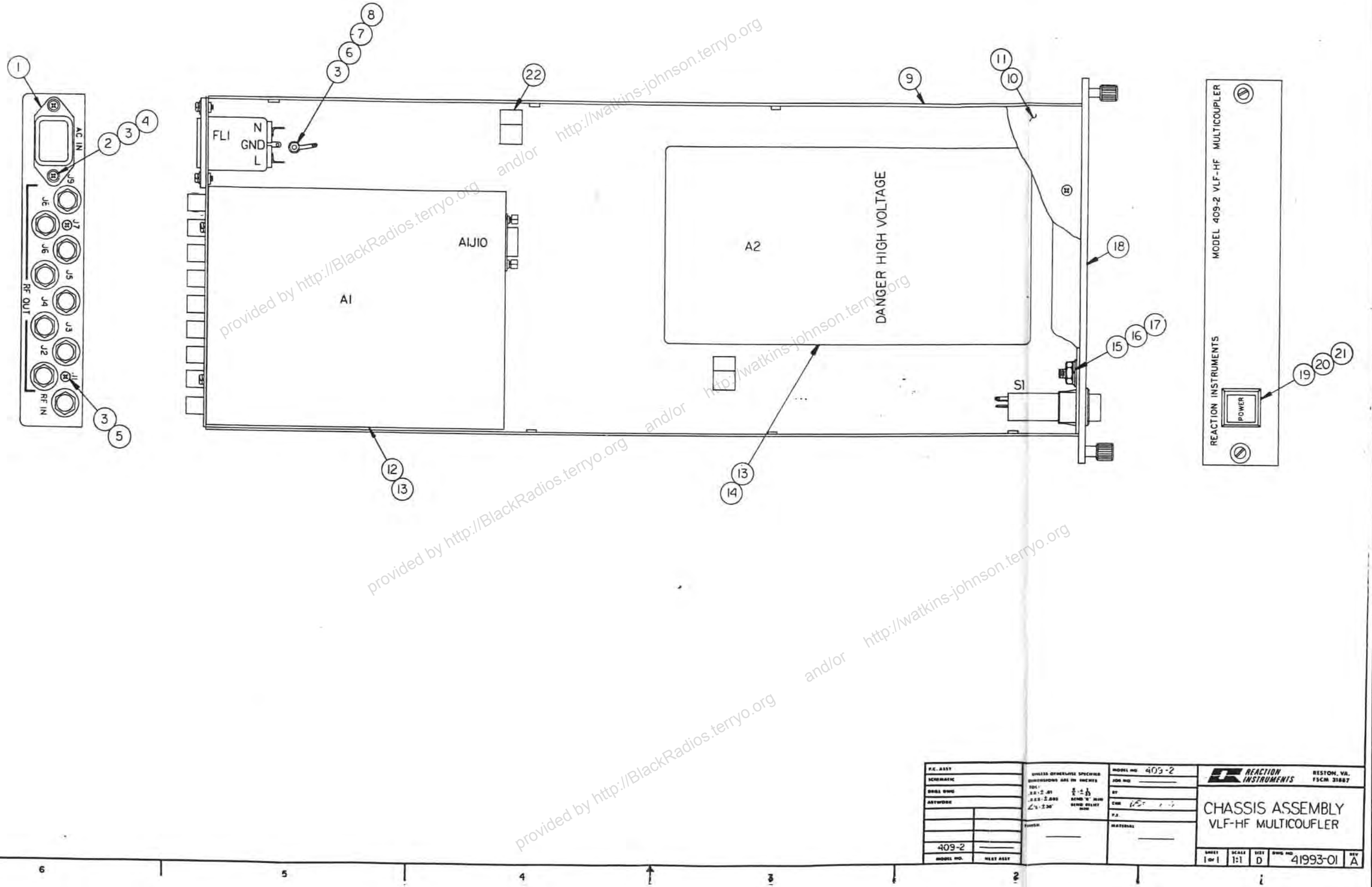
REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	PRODUCTION RELEASE	1-88	



P.C. ASSY	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	MODEL NO. 409-2	REACTION INSTRUMENTS	RESTON, VA. FSCM 31887	
SCHEMATIC	TOL: .XX ± .01, .XXX ± .005, ∠ ± 30°	JOB NO.	CHASSIS ASSEMBLY		
DRILL DWG	± 1/64, BEND 'R' MIN BEND INSIDE RAD	BY	VLF-HF MULTICOUFLER		
ARTWORK		CHK			
		P.I.			
		FINISH	MATERIAL		
409-2					
MODEL NO.	NEXT ASSY		SHEET 1 of 1	SCALE 1:1	SIZE D
			DWG NO. 41993-01		REV A

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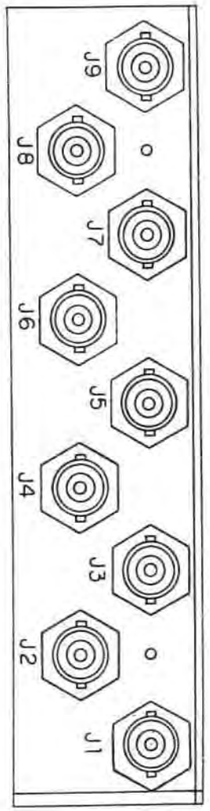
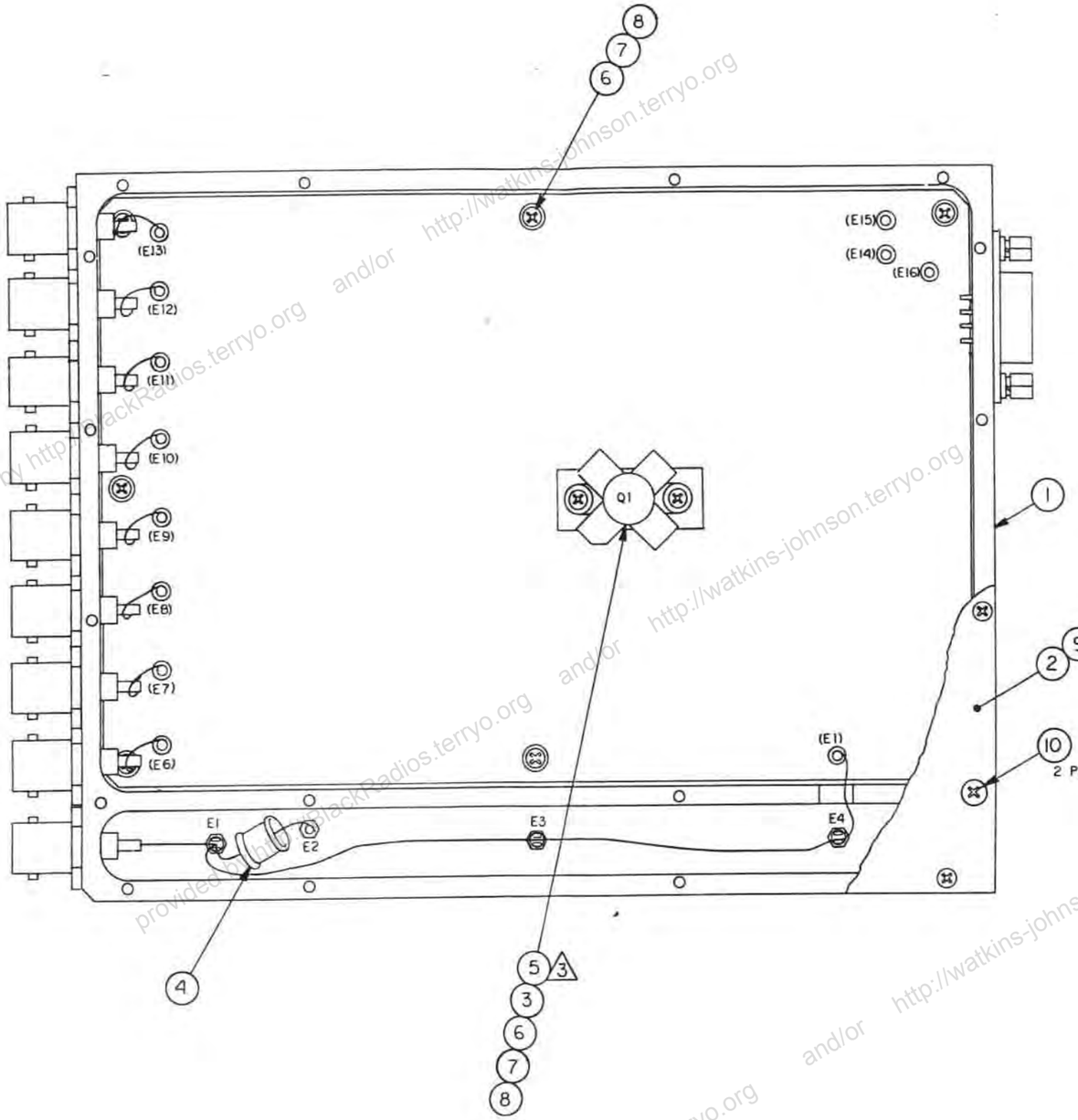
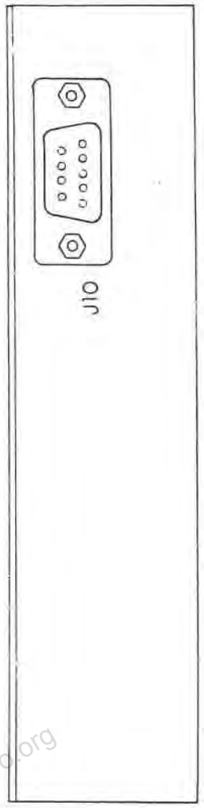
REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	PRODUCTION RELEASE	1/88	MST
	B	SEE ECN 829	7/88	[illegible]







NOTES:

1. REFERENCE DESIGNATIONS SHOWN IN PARENTHESIS ARE FOR REFERENCE ONLY AND ARE ASSEMBLED PRIOR TO THIS ASSEMBLY.
2. J1-J10 TO BE INSTALLED AFTER P.C. BOARD IS MOUNTED IN MODULE.
3. APPLY THERMAL COMPOUND UNDER Q1.
4. INSTALL Q1 WITH PROPER HARDWARE BEFORE SOLDERING TO P.C. BOARD.

P.C. ASSY		MODEL NO. 409-2	REACTION INSTRUMENTS RESTON, VA. FSCM 31887
SCHEMATIC		JOB NO. 8003	
DRILL DWG		BY [illegible] 1-88	MODULE ASSEMBLY VLF-HF MULTICOUPLER
ARTWORK		CHK	
		P.E.	
		FINISH	MATERIAL
409-2 MODEL NO.	41993-01 NEXT ASSY	SHEET 1 OF 1	SCALE 2:1 SIZE D DWG NO. 41992-01 REV B

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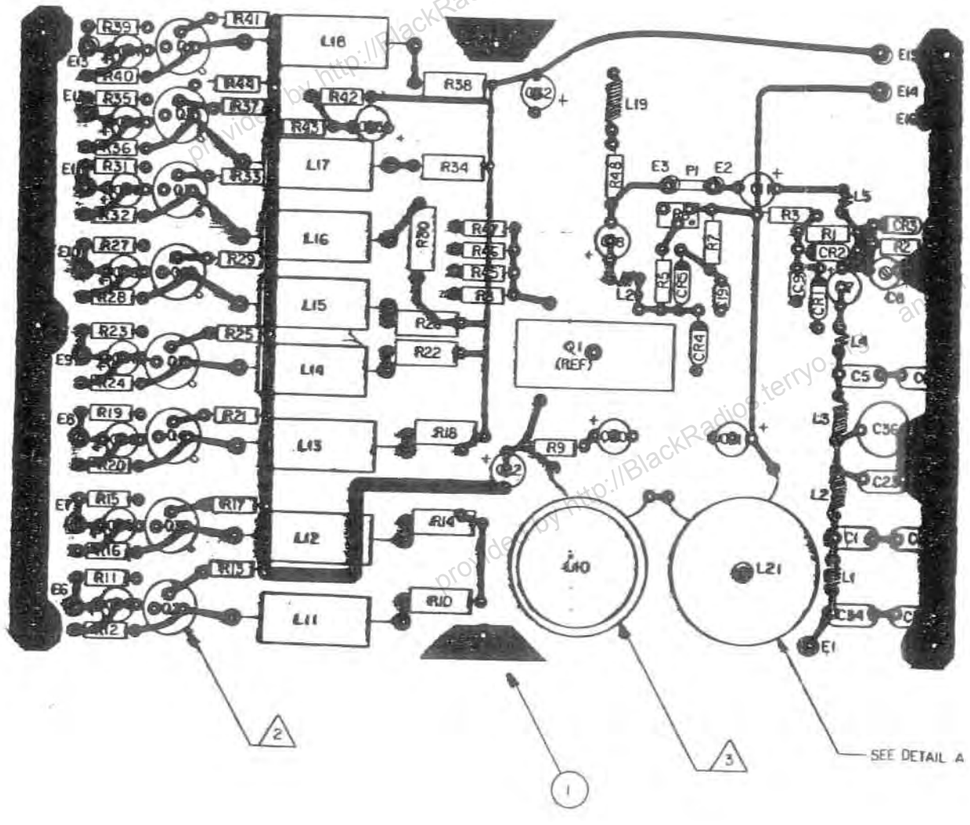
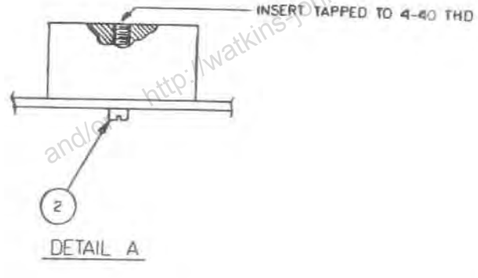
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	PRODUCTION RELEASE	1/88	JST
	B	SEE ECN 787	2/25/88	C.D.





DETAIL A

NOTES:

1. Q1 TO BE INSTALLED AT MODULE ASSY LEVEL.
2. SOLDER TABS OF Q2-Q9 TO GND PLANE.
3. EPOXY L10 TO PC BOARD.

P.C. ASSY (41991-01)	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOL: .XX ± .01, .XXX ± .005, ∠'s ± 2°	MODEL NO. 409-2	REACTION INSTRUMENTS HERNDON, VA. FSCM 21557
SCHEMATIC 41988-01		JOB NO. 8003	
DRILL DWG 41990-01		BY J. Whitney 1-88	PCB ASSEMBLY
ARTWORK 41989-01		CHK 1-7-88 1-8-88	VLF-HF MULTICOUPLER
		P.S.	
	FINISH	MATERIAL	

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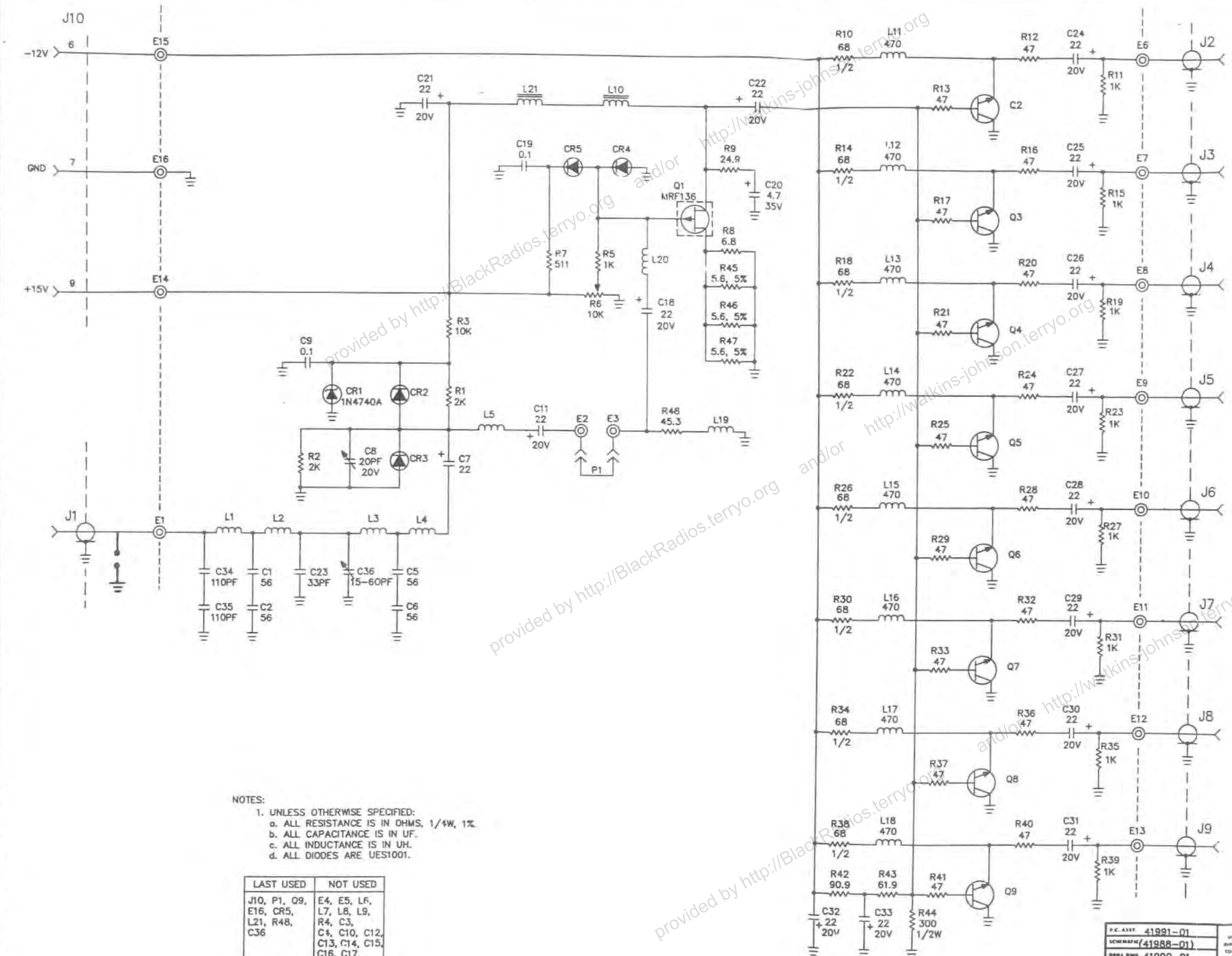

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   a. ALL RESISTANCE IS IN OHMS, 1/4W, 1%.
   b. ALL CAPACITANCE IS IN UF.
   c. ALL INDUCTANCE IS IN UH.
   d. ALL DIODES ARE UES1001.

LAST USED	NOT USED
J10, P1, Q9, E16, CR5, L21, R48, C36	E4, E5, L6, L7, L8, L9, R4, C3, C4, C10, C12, C13, C14, C15, C16, C17,

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	ENGINEERING RELEASE		

P.C. ASSY 41991-01
SCHEMATIC (41988-01)
DRILL DWG 41990-01
ARTWORK 41989-01

MODEL NO. 409-2
BY DBH 1/88

REACTION INSTRUMENTS
HERNDON, VA.
FSCM 31887

SCHEMATIC

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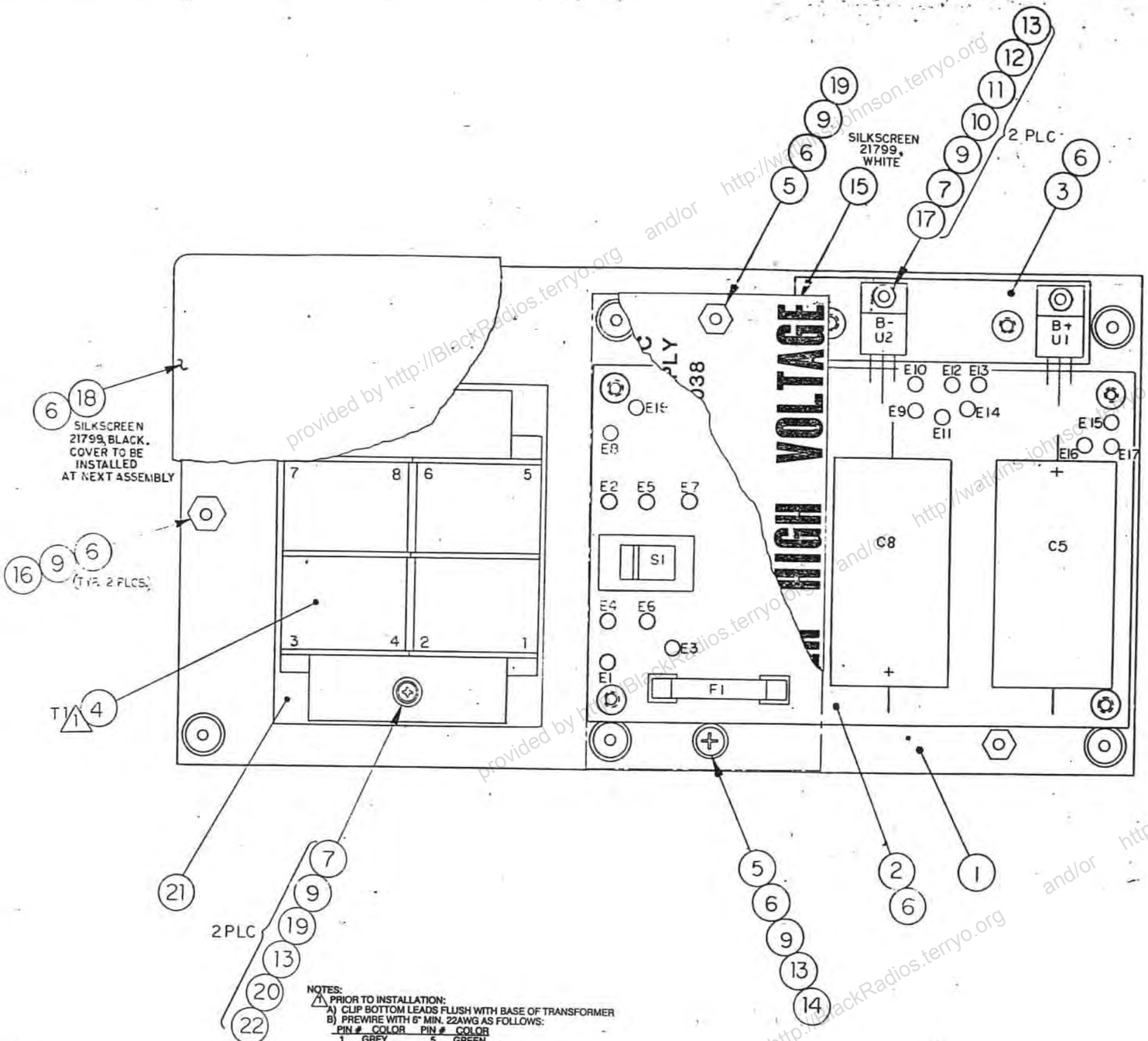
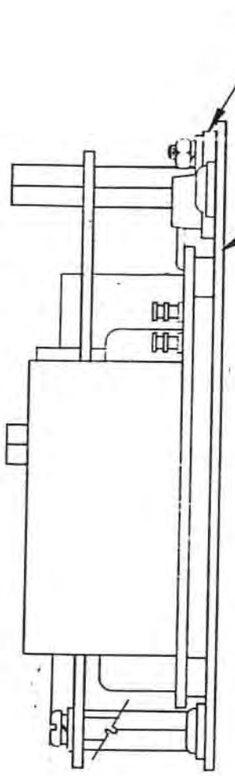
REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	B	SEE ECN 699	8-67	[illegible]



NOTES:
⚠1 PRIOR TO INSTALLATION:
A) CLIP BOTTOM LEADS FLUSH WITH BASE OF TRANSFORMER
B) PREWIRE WITH 6" MIN. 22AWG AS FOLLOWS:

PIN #	COLOR	PIN #	COLOR
1	GREY	5	GREEN
2	W/GREY	6	W/GREEN
3	BLUE	7	BROWN
4	W/BLUE	8	W/BROWN



FOR PARTS LIST, SEE PL41038

NUMBER 32205		410-2	RESTON INSTRUMENTS RESTON VA 1ECM 31887
ARTWORK 21799		DIST. PG 9-9-82	ASSEMBLY +15/12VDC POWER SUPPLY

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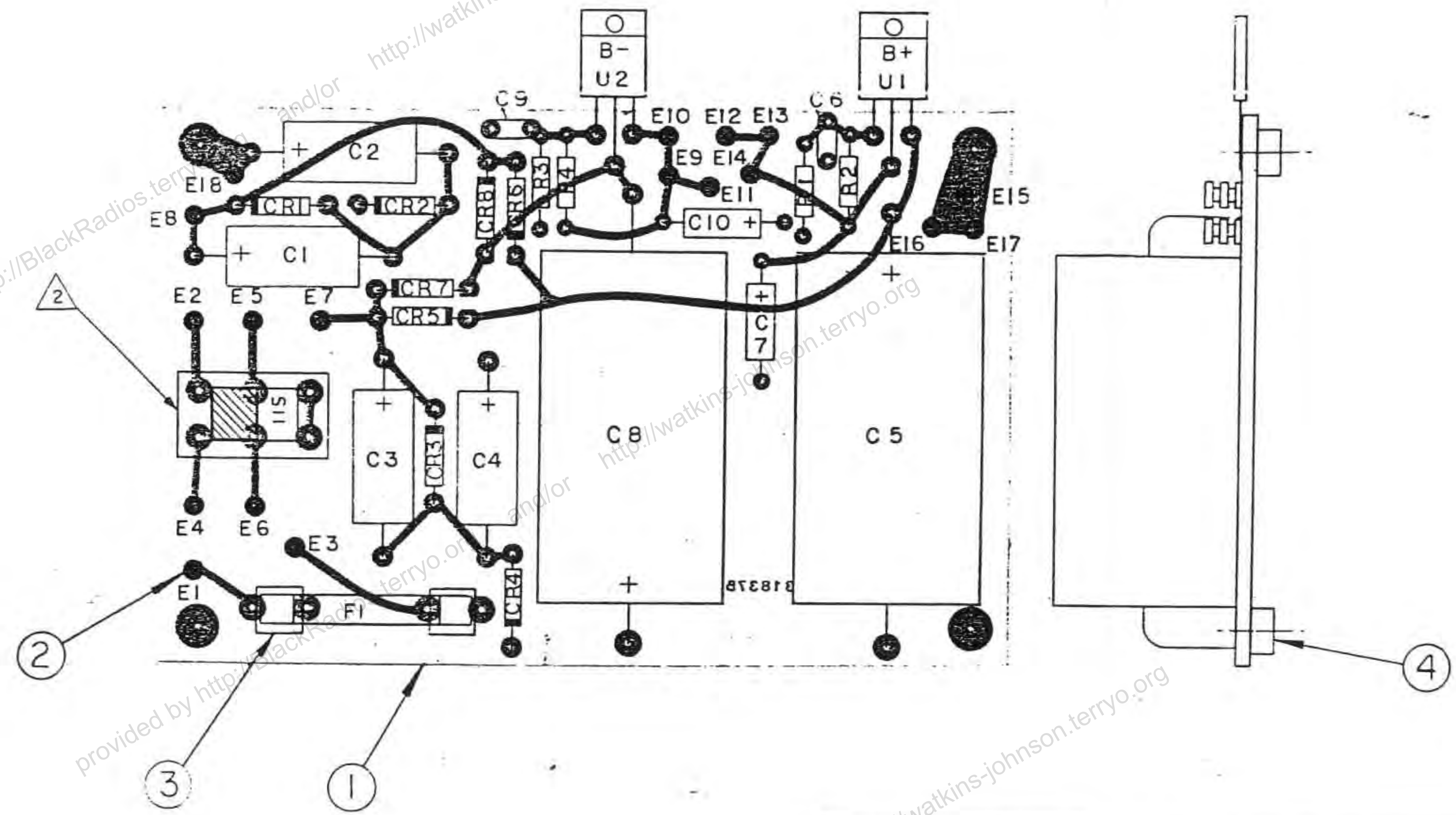
DRAWING NUMBER 32207-XX

DRAWING NUMBER

ZONE	REV.	DESCRIPTION	DATE	APPROVED
	B	SEE ECN 684	6-87	[illegible]
	C	SEE ECN 716	9-87	[illegible]



NOTES

1. MODEL 410-2, SERIAL NOS. 101-200 HAVE 31838 STAMPED ON THE BOARD AS THE ASSEMBLY NO. ALL FURTHER BOARDS SHOULD REFERENCE 32207.
2. REMOVE MOUNTING TABS FROM S1.

TABULATION	
DASH NO.	ASSY. INSTRUCTIONS
-02	INCLUDE ALL COMPONENTS
-01	OMIT C1, C2, C3, C4

P.C. ASSY	(32207)
SCHEMATIC	32205
DRILL DWG	31837
ARTWORK	31840
MODEL NO.	410-2
NEXT ASSY	41032

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES

MODEL NO. 410-2
BY J. O'BRIEN

REACTION INSTRUMENTS — RESTON, VA. FSCM 31887

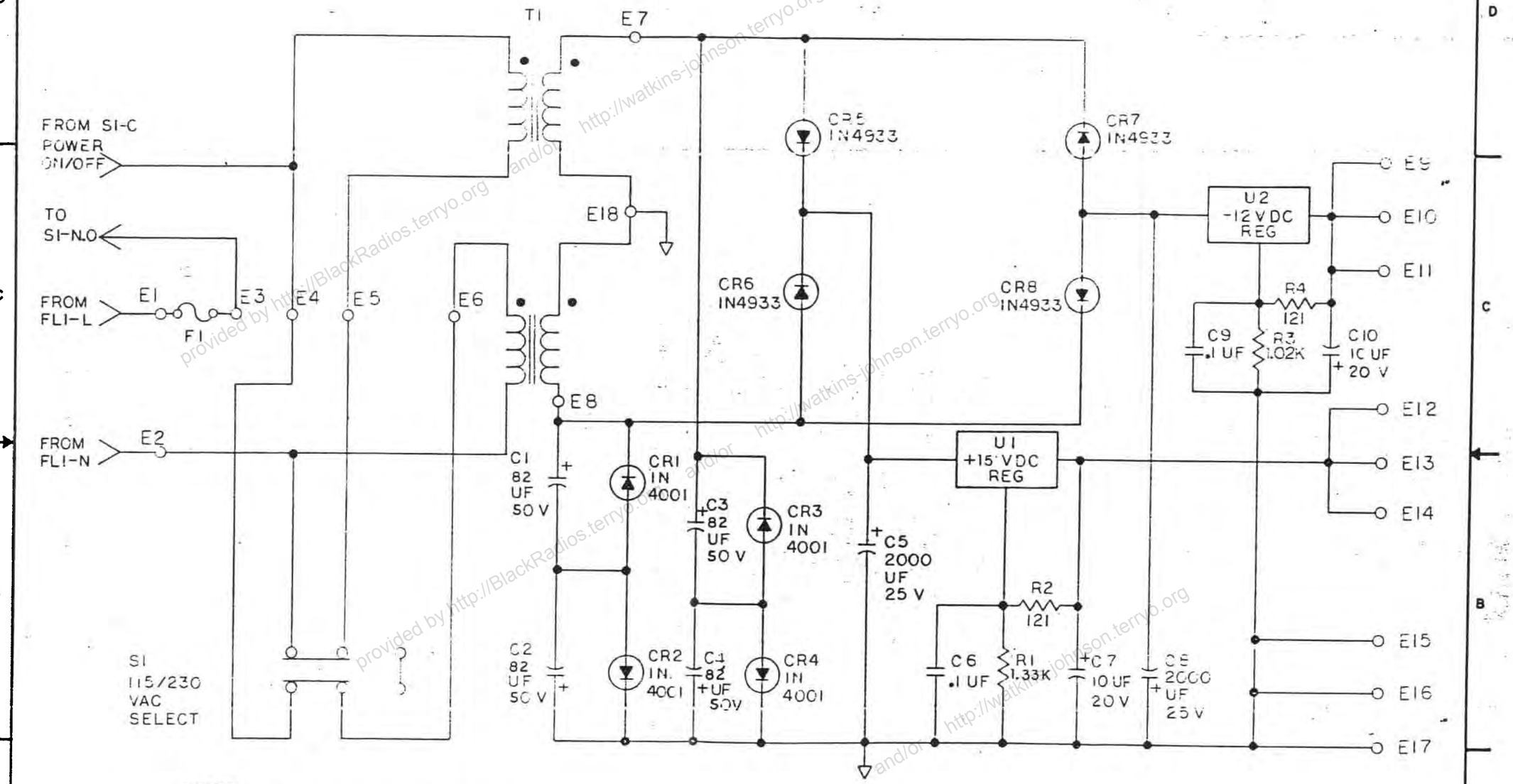
P.C. ASSEMBLY +15/-12VDC POWER SUPPLY A2

SHEET 1 OF 1 — SCALE 2:1 — SIZE C — DWG NO 32207-XX — REV C

DRAWING NUMBER
32205-XX
PLANTRONICS CORPORATION • IRVINE, CALIFORNIA
REORDER BY NUMBER AS SHOWN

DRAWING NUMBER
PLANTRONICS CORPORATION • IRVINE, CALIFORNIA
REORDER BY NUMBER AS SHOWN

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	SEE ECN 716	9-25-87	



NOTES:
1. SI SHOWN IN THE 115 VAC POSITION.
2. ALL RESISTORS ARE IN OHMS ±17o.
3. FOR 115VAC OPERATION, F1=0.5A.
4. FOR 230VAC OPERATION F1=0.25A

TABULATION	
DASH NO.	ASSY. INSTRUCTIONS
-01	INCLUDE ALL COMPONENTS
-02	OMIT C1, C2, C3, C4

P.C. ASST	32207	
SCHEMATIC	(32205)	
DRILL DWG	31837	
ARTWORK	31840	
410-2	41038	
MODEL NO.	NEXT ASST	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOL: .XX ± .01, .XXX ± .005, ∠'s ± 30'
FINISH
MATERIAL

MODEL NO. 410-2
JOB NO. —
BY J. OBRIEN
CHK
P.E. Gault 11-82

REACTION INSTRUMENTS RESTON, VA. FSCM 31887

SCHEMATIC
+15/-12VDC POWER SUPPLY
A2

SHEET	SCALE	SIZE	DWG NO.	REV
1 OF 1	—	C	32205-XX	A

32205

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