ORTEC 402H POWER SUPPLY

1. DESCRIPTION

The ORTEC 402H Power Supply is designed to be mounted in the space provided on the rear of the 401A(B) Modular System Bin. The Supply was designed to exceed the recommended power supply specifications, Appendix A of TID-20893 (Rev. 3), Type V-H, adopted by the AEC Committee on Nuclear Instrument Modules.

The 402H was designed for worldwide usage. Input voltage mains of 115 V ac or 230 V ac, 47-63 Hz, may be used. A convenience indicating switch clearly identifies the intended main to use.

The Supply furnishes six standard dc voltages, +24 V at 1 A, -24 V at 1 A, +12 V at 2 A, -12 V at 2 A, +6 V at 8 A and -6 V at 8 A, with a maximum power capability of 132 W at 50°C. The dc outputs are regulated, short-circuit protected, current limited, and thermal protected.

The 115 V ac is supplied to the Bin connector independent of input mains. The 115-V ac power available is limited only by the Power Supply fuse when operating from 115-V ac mains. When operating from 230-V ac mains, the 115 V ac is derived by autotransformer action and is limited to 60 VA output with a dc load on the Power Supply of 132 W.

A control panel is provided on the ORTEC 401A(B) Bin for operating and monitoring the 402H Power Supply. An On-Off switch, a power indicating lamp, a thermal warning lamp, and convenience dc monitor jacks are provided. The thermal warning lamp is lighted when the internal temperature rises to within 20°C of the maximum safe operating temperature. The Power Supply is automatically cut off by an internal switch should the temperature exceed the maximum safe operating temperature.

The power transistors are virtually indestructible due to their power handling capability, current limiting, and short-circuit protection. Silicon semiconductors, 85°C capacitors with conservative working voltage ratings, high-quality-carbon resistors, and metal film resistors are combined to produce the 402H Power Supply, which exceeds the TID-20893 (Rev.) requirements.

The dc output voltages are adjustable through holes in the top of the Power Supply cover plate, over a ±2% range from their nominal ratings. The adjustment potentiometers are 20-turn cermet potentiometers for superior adjustment resolution and resettability of the output voltages.

2. SPECIFICATIONS

INPUT 100 to 129 V ac, 57-63 Hz, or 200 to 258 V ac, 47-53 Hz. Input current at 117 V is 3.5 A for a 132-W dc output.

DC OUTPUTS The Supply provides six simultaneous dc outputs with the following current ratings:

VOLTAGE (V)	CURRENT (A)
+24.00	0 to 1
−24.00	0 to 1
+12.00	0 to 2
−12.00	0 to 2
+ 6.00	0 to 8
− 6.00	0 to 8

Maximum output power from 0 to 50°C ambient is 132 W. Operation to 60°C ambient, with current derated not more than 3%/°C for temperatures above 50°C.

115-V AC OUTPUT 115-V ac output is limited only by the Supply fuses when operating from 115-V ac mains. Output is limited to 60 VA at 132-W dc load while operating from 230-V ac mains.

REGULATION ±0.1% (typically ±0.05%) for ±12 V and ±24 V, and ±0.2% (typically ±0.1%) for ±6 V over the combined range of zero to full load and input voltage of 100 to 129 V ac or 200 to 258 V ac, when measurements are made within a period of 1 min.

±0.3% (±12 V and ±24 V) and ±0.6% (±6 V) over any 24-hr period at constant ambient temperature over the combined range of no load to full load and input voltage of 100 to 129 V ac or 200 to 258 V ac, after a 60-min warmup.

STABILITY Long-term stability over a 6-month period is better than ±0.5% after a 1-hr warmup at constant load, line, and ambient temperature.

OUTPUT IMPEDANCE <0.15Ω for the ±6-V outputs and <0.3Ω for all other outputs at any frequency to 100 kHz.

TEMPERATURE COEFFICIENT <0.02%/°C over a range of 0 to 60°C.

THERMAL PROTECTION A thermal warning switch will close when the supply temperature approaches within 20°C of the safe operating value. A thermal cutout switch disables the Power Supply when the temperature exceeds the safe operating value.

NOISE AND RIPPLE <3 mV peak to peak for all six outputs, as observed on a 50-MHz bandwidth oscilloscope.

VOLTAGE ADJUSTMENTS ±2% minimum range, resettability ±0.05% of Supply voltage.

RECOVERY TIME <100 μsec to return to within ±0.1% of rated voltage for all six outputs for any change in input voltage and load current from 10% to 100% full load.

CIRCUIT PROTECTION Both sides of the input line to the power supply are fused. In addition, output current foldback limiting to prevent damage to the Supply and automatic recovery when the demand is removed are provided by electronic circuitry.

All six supplies are protected so that any one can be shorted to any other one without resulting in permanent damage.

Overvoltage protection is provided on ±6 V so that these outputs will not exceed 7.5 V maximum.

OUTPUT CONNECTOR All power and control circuits terminate in a connector, specified by TID-20893 (Rev. 3), which mates the Bin interface connector, completing the necessary control and Power Supply wiring.

DIMENSIONS Conform to AEC drawing ND-515 and paragraph L, page A-10, of TID-20893 (Rev. 3).

WEIGHT 20 lb (8.9 kg) net; with 401A(B) Bin 36 lb (16 kg) net. Shipping weight for 401A(B)/402H 43 lb (19.3 kg) gross.

3. INSTALLATION

The 402H Power Supply is normally supplied factory-connected to an ORTEC 401A(B) Modular System Bin. However, the Supply is designed to TID-20893 (Rev.) specifications and may be attached, in the space provided, to any bin manufactured to TID-20893 (Rev.) specifications.

For attachment to other than an ORTEC 401A(B) Bin, refer to the appropriate instruction manual. The On-Off switch and other controls necessary to operate the supply are part of the Bin and are not furnished with the Power Supply.

For attachment to the ORTEC 401A(B) Bin the following steps are advised:

1. Place the Bin on a table with the back part facing you. Place the Power Supply in the proper mounting position, leaving enough space between it and the Bin to attach the interface connector.

2. Mate the interface connector, being careful to align the polarizing pins. Fold and form all wiring close to the connector edges to prevent any wires from being pinched and producing a short circuit in succeeding steps.

3. Mount the Supply to the Bin by securely tightening the four 10-32 screws, being careful not to pinch any wires or to use undue force on any parts.

4. OPERATING INSTRUCTIONS

4.1. POWER SUPPLY LIMITATIONS

The available current from the Power Supply is given in Section 2. Care must be used to ensure natural convection of heat dissipated by the heat sinks and power transformer.

For best results, when using at maximum power loadings the Bin and Power Supply should be in an open space, placed upon blocks at least 1 in. off the table mounting surface to allow maximum ventilation. When used in a rack, maximum attention should be paid to placement of other heat-generating equipment. Adequate unobstructed space on all sides is necessary for convection ventilation and cooling. If the Bin contains other heat-generating equipment, a blower may be advisable to remove the dissipated heat.

When it is necessary to rack-mount several bins and power supplies, especially when other heat-generating equipment is located within the rack, the term "ambient temperature" becomes less clearly defined. A better guide to maximum power loading capability is to monitor the heat sink temperature. In no case allow the heat sink temperature to continuously run above 100°C. Although this is not the maximum operation temperature, any additional temperature rise due to other conditions of the system may force the Supply out of tolerance and may cause it to automatically shut down operation. Should your operation produce a temperature of 100°C, a blower to remove the dissipated heat is indicated.

4.2. 6-V POWER SUPPLIES CROWBAR OPERATION

Both the +6-V and the -6-V outputs are protected against overvoltage. If for any reason one of these output voltages exceeds 7.5 V maximum in absolute value an internal "crowbar circuit" is triggered, which places a short-circuit across the output of the corresponding voltage. Since this circuit contains an SCR, normal operation, after suppression of the cause of the overvoltage, can be resumed only by turning the power switch of the 401 Bin to Off for a couple of seconds, and then turning it to On again.

If in normal operation it is suddenly discovered that the +6-V or -6-V output is missing, first check whether it can be restored by following this procedure, after having removed all the modules from the Bin. The crowbar protection circuit of the corresponding voltage may have been triggered by a temporary fault in one module or even by a strong spurious voltage transient.

5. CIRCUIT DESCRIPTION

5.1. GENERAL DESCRIPTION

The 402H Power Supply produces six dc output voltages. A power transformer transforms the input ac line voltage into six separate low voltage sources. The sources or windings are full-wave rectified, capacitor filtered, and regulated by electronic series regulator circuits. Each regulator consists of an integrated circuit voltage regulator and one or two boost transistors. In order to improve the combined line-load regulation, the input voltage to the integrated circuit regulators of the positive supplies is provided by an additional supply, which will be referred to hereafter as "reference supply." The input voltage to the regulators of the negative supplies is taken directly from the output of one of the positive supplies.

The six series regulators have a similar operation; they differ only in component values and some circuit details. The regulator essentially operates in two modes. First and normal is the voltage regulation mode. Second is the current foldback or current limiting protection mode.

The regulator will operate in the voltage regulation mode at any current output up to and including the full rated output of a particular supply. When current output beyond the rated output is required, which includes a direct short across the output terminals, the regulator automatically shifts into a current foldback mode. When excessive current demands are removed, the regulator resumes the voltage regulation mode.

5.2. REFERENCE SUPPLY (ASSEMBLY A1)

The reference supply contains a very simple regulator, located on the +24-V and +12-V assembly (drawing 402H-0201-S1). It consists of a Darlington series element (Q1 and Q2), a single stage comparison amplifier (Q3), and a zener diode (D1). One side of the regulated output is clamped to ground through two diodes so as to provide two output voltages. The -1.5-V output furnishes the negative voltage needed to keep the current limiting circuits of the positive supplies biased in case of a short-circuit. The second output, +30 V with respect to ground, is used as a prefiltered and preregulated voltage at the input of the +24-V, +12-V, and +6-V voltage regulators, and biases the current sources of their current limiting circuits.

5.3. +24-V AND +12-V REGULATORS (ASSEMBLY A1)

The operation of these two regulators, shown on drawing 402H-0201-S1, is very similar, and so for convenience only the +24-V regulator will be discussed here.

In the normal voltage regulation mode the integrated circuit voltage regulator IC1 provides from its output (pin 1) the base drive needed by the series element, transistor Q200, to equalize both the output voltage and the level shifted voltage. The output voltage is sensed directly at the load by pin 5 of IC1 through a separate remote sense lead, and the level shifted voltage is built up across resistors R13, R14, and the +24-V Adjust variable resistor R12 (pins 6, 9, and 8 of IC1).

Capacitor C5, connected to the compensation lead (pin 4) of IC1, provides the roll-off necessary to stabilize the regulator at all frequencies. Capacitor C4 is connected to a high impedance node of the regulator (pin 7) and filters the noise generated by its internal zener diode.

In the current foldback mode, resistor R18, in series with the output, senses the output current level and produces a proportional voltage rise. The sense voltage is compared to the voltage drop across R16 at the input of a differential long-tail pair (Q7, Q8) fed by a 2-mA current source (Q9) and followed by a second differential stage (Q6, Q15). For output currents less than or equal to the rated output, Q8 and Q6 remain back-biased and will have no effect on the regulator performance. However, when the output current exceeds the rated output, Q8 becomes forward-biased and conducts, causing Q6 to turn on and to derive current from pin 4 of IC1, which is the driving point of the series element contained inside the integrated circuit regulator, thereby reducing the base drive current to the series pass transistor. As a result the output voltage is reduced, which in turn decreases the voltage drop across R16. This produces the current foldback characteristic and less current than was initially needed is now required to maintain Q8 and Q6 conducting.

5.4. +6-V AND –6-V REGULATORS (ASSEMBLY A2)

These circuits, shown on drawing 402H-0301-S1, are very similar to the ones just described. The main differences are the use of a Darlington configuration at the output of both integrated circuit voltage regulators to provide the rated output current of 8 A and the addition of an overvoltage protection circuit on both outputs. For the +6-V Supply, for instance, this "crowbar" circuit consists of a transistor Q56 and the silicon controlled rectifier D51. If the output voltage, measured at the sense input (pin 5) of the corresponding voltage regulator (IC50), exceeds by more than one junction drop the voltage of zener diode D56 (6.5 V max), Q56 turns on and triggers the gate of the SCR (D51), which acts almost as a short circuit across the output to the supply.

5.5. –24-V AND –12-V REGULATORS (ASSEMBLY A3)

These circuits are very similar to the +24-V and +12-V Regulators and will not be described here in more detail (see drawing 402H-0401-S1).

6. MAINTENANCE INSTRUCTIONS

6.1. SUGGESTIONS FOR TROUBLESHOOTING

Five possible sources of trouble are described below, and suggestions are given for remedying the trouble.

6.1.1. All Output Voltages Missing Check to see whether +30 V is present on TP1 of A1, all outputs being unloaded. It it disappears when one of the positive outputs is loaded, the corresponding integrated circuit voltage regulator is very likely damaged and must be replaced.

6.1.2. One of the Output Voltages Missing If operation of this supply resumes when its load is removed, check to see that the connection between the filter capacitor and the collector of the series pass transistor corresponding to that voltage supply is not interrupted or if the boost transistor is not damaged. Otherwise, check the correct setting of the 100Ω trim potentiometer used to balance the short-circuit current sensing amplifier associated with this output. The procedure to readjust this potentiometer is as follows:

1. Turn the 1-turn potentiometer fully counterclockwise, looking at it from the top edge of the board.

2. Load the output of the corresponding supply to 1.3 A (for ±24 V), 2.4 A (for ±12 V), or 8.6 A (for ±6 V).

3. Turn the potentiometer slowly clockwise while observing the output voltage with a digital voltmeter. Stop turning when the voltage just starts to drop.

6.1.3. +6-V or –6-V Output Missing Turn off power switch of the Bin and wait a couple of seconds before turning on again. This ensures that the crowbar protection circuit is disabled, in case it had been triggered accidentally. If voltage does not resume, apply the procedure of Section 6.1.2.

6.1.4. All Three Negative Outputs Missing The trouble most probably lies in the +12-V supply. Apply procedure described in Section 6.1.2.

6.2. TYPICAL VOLTAGES

Table 6.1 lists typical voltages that were measured with respect to ground potential and they are given here for ease of maintenance.

The voltages given in Table 6.1 are typical values for 115 or 230 main voltage and all outputs unloaded.

Table 6.1.

Assembly A1 (+24 V and +12 V)

Checkpoint	DC Voltage	Checkpoint	DC Voltage	Checkpoint	DC Voltage	Checkpoint	DC Voltage
Q1e	+30.5 V	Q5e	+24.4 V	Q15e	-13 mV	Q12e	+12.5 V
Q1b	+31.0 V	Q5b	+24.4 V	Q15b	+0.62 V	Q12b	+11.9 V
Q1c	+43.8 V*	Q5c	+25.8 V	Q15c	0	Q12c	+0.63 V
Q3e	+13.6 V	Q6e	-13 mV	IC2 pin 1	+12.6 V	Q13e	+12.5 V
Q3b	+14.1 V	Q6b	-1.27 V	2	0	Q13b	+12.0 V
Q3c	+31.6 V	Q6c	+25.8 V	3	+17.6 V	Q13c	-1.19 V
TP1	+30.0 V	Q7e	+24.4 V	4	+14.0 V	Q14e	+16.5 V
TP2	-1.36 V	Q7b	+23.8 V	5	+12.0 V	Q14b	+15.9 V
IC1 pin 1	+24.4 V	Q7c	+0.62 V	6&9	+12.0 V	Q14c	+12.6 V
2	0	Q8e	+24.5 V	8	+3.5 V	Q16e	-13 mV
3	+29.6 V	Q8b	+24.0 V	Q10e	+12.6 V	Q16b	+0.63 V
4	+25.8 V	Q8c	-1.27 V	Q10b	+12.6 V	Q16c	0
5	+24.0 V	Q9e	+26.9 V	Q10c	+14.0 V	PC Board Connector:	
6&9	+24.0 V	Q9b	+26.3 V	Q11e	-13 mV	pin 1	+21.6 V*
8	+3.5 V	Q9c	+24.5 V	Q11b	-1.19 V	9	340.7 V*
				Q11c	+14.0 V	21	-1.36 V

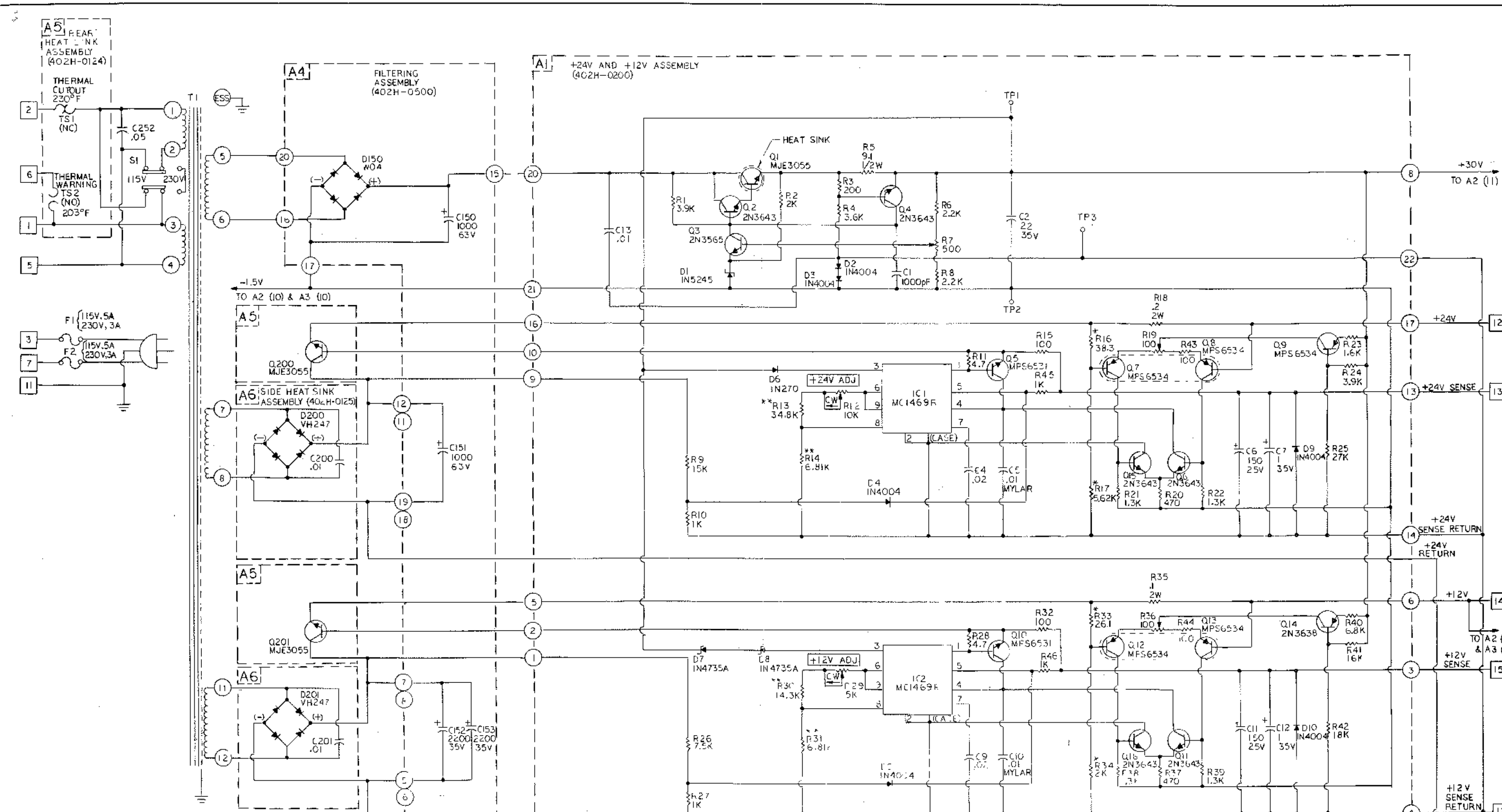
Assembly A2 (+6 V and -6 V)

Checkpoint	DC Voltage	Checkpoint	DC Voltage	Checkpoint	DC Voltage	Checkpoint	DC Voltage
IC50 pin 1	+7.05 V	Q52c	+8.41 V	Q63c	0	Q59b	-1.12 V
2	0	Q53e	+6.46 V	IC51 pin 1	+1.03 V	Q59c	+2.38 V
3	+13.5 V	Q53b	+5.85 V	2	-6.00 V	Q60e	+0.51 V
4	+8.41 V	Q53c	+0.64 V	3	+12.0 V	Q60b	-0.13 V
5	+5.99 V	Q54e	+6.55 V	4	+2.38 V	Q60c	+0.47 V
6&9	+6.00 V	Q54b	+6.00 V	5	-7 mV	Q61e	+0.55 V
8	+3.5 V	Q54c	-1.16 V	6&9	+7 mV	Q61b	0
Q50e	+7.04 V	Q55e	+16.4 V	8	-2.52 V	Q61c	-1.12 V
Q50b	+7.05 V	Q55b	+15.7 V	Q57e	+1.02 V	Q62e	0
Q50c	+8.41 V	Q55c	+6.6 V	Q57b	+1.03 V	Q62b	+22 mV
Q51e	+6.53 V	Q56e	+6.00 V	Q57c	+2.38 V	Q62c	-6.00 V
Q51b	+7.04 V	Q56b	+6.08 V	Q58e	+0.53 V	Q64e	-0.15 V
Q51c	+14.4 V*	Q56c	0	Q58b	+1.02 V	Q64b	+0.47 V
Q52e	-11 mV	Q63e	-11 mV	Q58c	+8.46 V*	Q64c	0
Q52b	-1.16 V	Q63b	+0.64 V	Q59e	-0.15 V		

Assembly A3 (-24 V and -12 V)

Checkpoint	DC Voltage	Checkpoint	DC Voltage	Checkpoint	DC Voltage	Checkpoint	DC Voltage
IC100 pin 1	+0.58 V	Q101c	+1.93 V	3	+8.45 V	Q106b	-0.14 V
2	-24.0 V	Q102e	+0.50 V	4	+1.94 V	Q106c	+0.48 V
3	+8.4 V	Q102b	-0.14 V	5	-6 mV	Q107e	+0.58 V
4	+1.93 V	Q102c	+0.47 V	6&9	+6 mV	Q107b	0
5	-6 mV	Q103e	+0.55 V	8	-8.62 V	Q107c	-1.10 V
6&9	+11 mV	Q103b	0	Q104e	+0.56 V	Q109e	-0.16 V
8	-20.5 V	Q103c	-1.19 V	Q104b	+0.59 V	Q109b	+0.48 V
Q100e	+0.55 V	Q108e	-0.15 V	Q104c	+1.94 V	Q109c	0
Q100b	+0.68 V	Q108b	+0.47 V	Q105e	-0.16 V	PC Board Connector:	
Q100c	+1.93 V	Q108c	0	Q105b	-1.10 V	pin 2	+10.1 V*
Q101e	-0.15 V	IC101 pin 1	+0.59 V	Q105c	+1.94 V	10	-1.35 V
Q101b	-1.19 V	2	-12.0 V	Q106e	+0.51 V	11	+17.5 V*

*dc average



SYM	A1	A4	A5	A6	CHASSIS
C	1-13	150-153		200,201	252
D	1-10	150		200,201	
R	1-46				
Q	1-16		200,201		
IC	1,2				

NOT USED:
C3; C8

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE CC,5%, 1/4W
2. RESISTORS MARKED * ARE MF, 1%, 1/8W, T0
3. ALL CAPACITORS ARE IN µF
4. RESISTORS MARKED ** ARE MF, 1%, 1/8W, T2

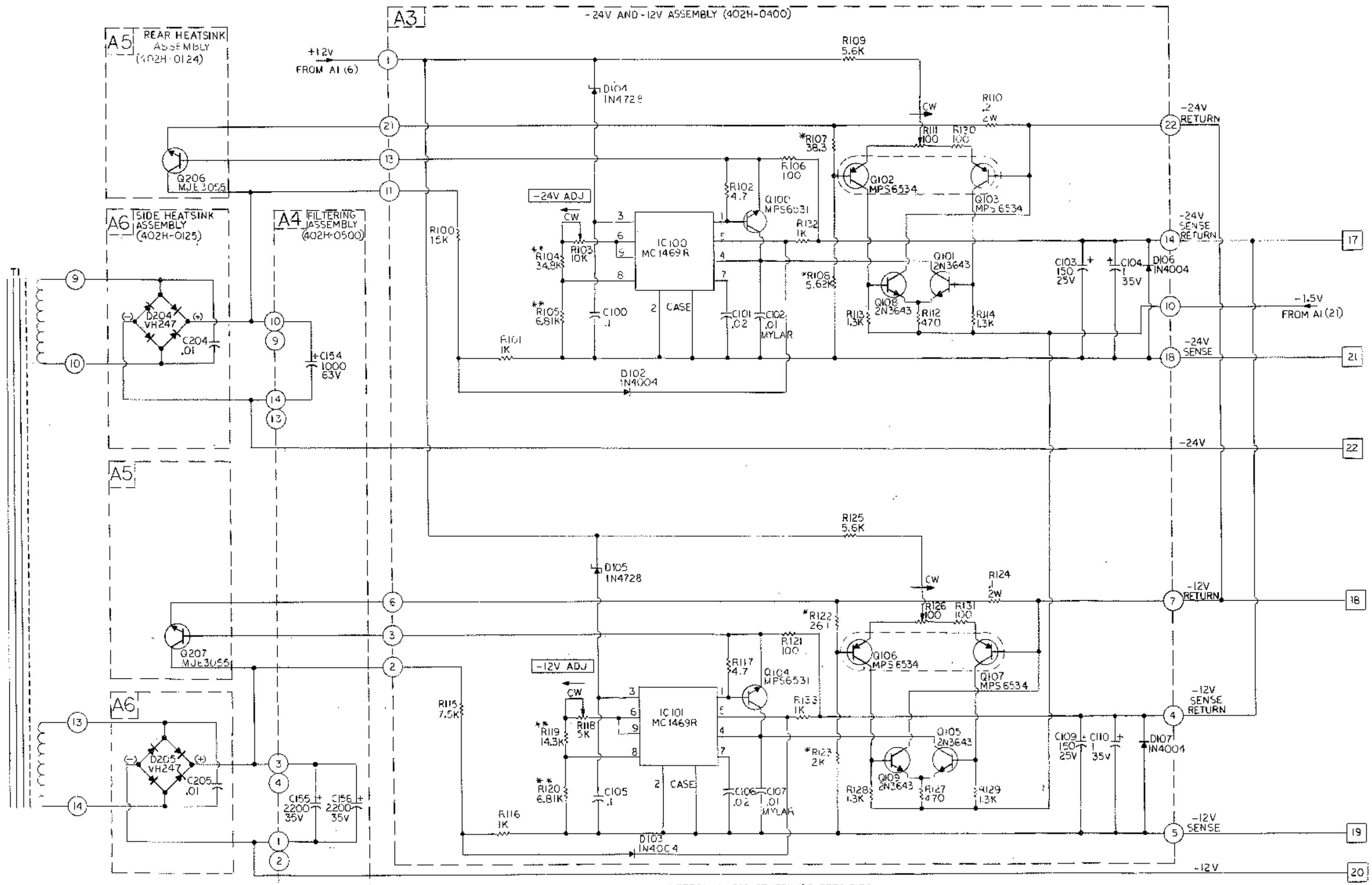
UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES TOLERANCES

ORTEC INCORPORATED
100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830

MODEL 402H
POWER SUPPLY (+12V & +24V)

J.DW 9-25-70 E. Ostertag

402H-0201-S1



NOTES: UNLESS OTHERWISE SPECIFIED:
1 ALL RESISTORS ARE CC, 5%, 1/4W
2 RESISTORS MARKED * ARE MF, 1%, 1/8W, TO
3 ALL CAPACITORS ARE IN µF
4 RESISTORS MARKED ** ARE MF, 1%, 1/8W TC

SYM	A3	A4	A5	A6
C	100-110	154-156		204,205
D	102-107			204,205
R	100-133			
Q	100-109		206, 207	
IC	100, 101			

NOT USED
C108
D100-D101

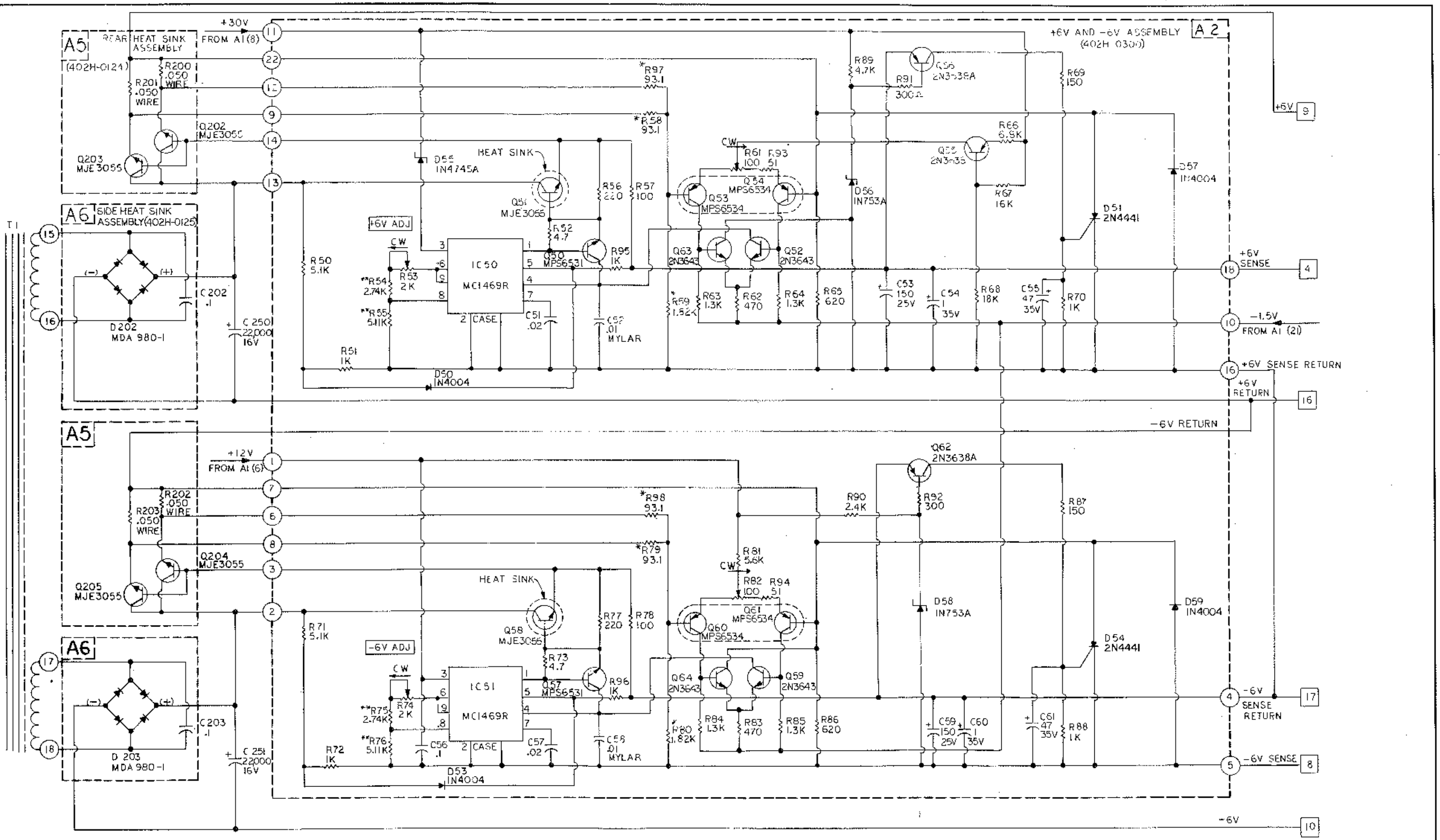
REV	ECO	DATE
A	402H-2	1-22-71
B	402H-4	2-17-71
C	402H-5	6-4-71
D	402H-6	6-26-71
E	402H-8	
F	402H-9	9-8-71
G	402H-10	10-...

UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES

ORTEC INCORPORATED
100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830

MODEL 402H
POWER SUPPLY (-12V & -24V)

DRAFTSMAN RWV DATE 9-24-70 RESPONSIBLE ENGINEER E. OSTERTAG
DATE 12-4-70
SCALE NONE
DATE 11-27-70
DRAWING NO 402H-0401-S1



SYM	A2	A5	A6	CHASSIS
C	50-61		202,203	250,251
D	50-59		202,203	
R	50-98	200-203		
Q	50-64	202-205		
IC	50,51			

NOT USED
R60
D52
C50

NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE CC, 5%, 1/4W
2. RESISTORS MARKED * ARE MF, 1%, 1/8W TO
3. ALL CAPACITORS ARE IN μF
4. RESISTORS MARKED** ARE MF, 1% 1/8W T2

REV	EO	DATE
A	402H-1	12-18-70 EOs
B	402H-2	1-22-71 EOs
C	402H-3	1-29-71 EOs
D	402H-4	2-1-71 EOs
E	402H-5	5-4-71 EOs
F	402H-6	5-26-71 EOs
G	402H-6	8-5-71 EOs
H	402H-9	9-8-71 EOs

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES TOLERANCES

ORTEC INCORPORATED
100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830

MODEL 402H
POWER SUPPLY (±6V)

DRAFTSMAN D. NOE 9-24-70
RESPONSIBLE ENGINEER F. OSTERTAG
SCALE NONE
DRAWING NO. 402H-0301-S1