Model 433A
Dual Sum and Invert Amplifier
Operating and Service Manual

This manual applies to instruments
"Rev 02" (on rear panel)

Printed in U.S.A.

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STANDARD WARRANTY FOR ORTEC INSTRUMENTS

ORTEC warrants that the items will be delivered free from defects in material or workmanship. ORTEC makes no other warranties, express or implied, and specifically **NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.**

ORTEC's exclusive liability is limited to repairing or replacing at ORTEC's option, items found by ORTEC to be defective in workmanship or materials within one year from the date of delivery. ORTEC's liability on any claim of any kind, including negligence, loss or damages arising out of, connected with, or from the performance or breach thereof, or from the manufacture, sale, delivery, resale, repair, or use of any item or services covered by this agreement or purchase order, shall in no case exceed the price allocable to the item or service furnished or any part thereof that gives rise to the claim. In the event ORTEC fails to manufacture or deliver items called for in this agreement or purchase order, ORTEC's exclusive liability and buyer's exclusive remedy shall be release of the buyer from the obligation to pay the purchase price. In no event shall ORTEC be liable for special or consequential damages.

QUALITY CONTROL

Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

REPAIR SERVICE

If it becomes necessary to return this instrument for repair, it is essential that Customer Services be contacted in advance of its return so that a Return Authorization Number can be assigned to the unit. Also, ORTEC must be informed, either in writing or by telephone [(615) 482-4411], of the nature of the fault of the instrument being returned and of the model, serial, and revision ("Rev" on rear panel) numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. The ORTEC standard procedure requires that instruments returned for repair pass the same quality control tests that are used for new-production instruments. Instruments that are returned should be packed so that they will withstand normal transit handling and must be shipped **PREPAID** via Air Parcel Post or United Parcel Service to the nearest ORTEC repair center. The address label and the package should include the Return Authorization Number assigned. Instruments being returned that are damaged in transit due to inadequate packing will be repaired at the sender's expense, and it will be the sender's responsibility to make claim with the shipper. Instruments not in warranty will be repaired at the standard charge unless they have been grossly misused or mishandled, in which case the user will be notified prior to the repair being done. A quotation will be sent with the notification.

DAMAGE IN TRANSIT

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify ORTEC of the circumstances so that assistance can be provided in making damage claims and in providing replacement equipment if necessary.

ORTEC 433A DUAL SUM INVERT AMPLIFIER

1. DESCRIPTION

The ORTEC 433A Dual Sum and Invert Amplifier is a versatile instrument for general purpose use. It has two inverting operational amplifiers, each of which has multiple inputs to permit summation of signals from separate circuits. By cascading the two amplifier sections, its function becomes a noninverted summation of up to four inputs. Alternatively, each amplifier section may be used to invert its inputs with no crosstalk between the two sections.

Amplifier A has four inputs through type BNC connectors, two of which are on the front panel and two on the rear panel. Any one input, any combination of inputs, or all four inputs may be used, and the summed and inverted signal is furnished through Output A on the front panel. The gain from each input to the output is unity. The amplifier does not include any shaping. It has a rise time of less than 100 nsec and a bandwidth from dc to 3.5 MHz. The output impedance is less than 0.1Ω for line drive and fanout capability.

Amplifier B has only two inputs, both located on the front panel. The characteristics for this section are otherwise identical to those for the Amplifier A section of the instrument.

2. SPECIFICATIONS

PERFORMANCE

VOLTAGE GAIN Unity for each input; tolerances ≤±2%.

BANDWIDTH dc to 3.5 MHz (τ_r ≤100 nsec).

INTEGRAL NONLINEARITY <0.05%.

NOISE <20 μV rms, each network.

TEMPERATURE STABILITY

Gain 0.005%/°C.
Output DC Level 0.1 mV/°C.

INPUTS

Four identical inputs for Amplifier A and two for Amplifier B; each accepts 0 to 10 V rated span, 12 V max, positive or negative, unipolar or bipolar; Z_{in} ~1 kΩ, dc-coupled; Inputs A1, A2, B1, and B2 on front panel, Inputs A3 and A4 on rear panel; all type BNC connectors.

OUTPUTS

One output for each Amplifier, A and B, completely independent from each other; range 0 to ±10 V linear; Z_0 <0.1Ω; Outputs A and B on front panel, type BNC connectors.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS

+24 V, 65 mA; -24 V, 60 mA;
+12 V, 0 mA; -12 V, 0 mA.

WEIGHT (Shipping) 5 lb (2.2 kg).

WEIGHT (Net) 2 lb (0.9 kg).

DIMENSIONS Standard single-width NIM module (1.35 by 8.714 in.) per TID-20893 (Rev.).

3. INSTALLATION

3.1. GENERAL

The 433A, used in conjunction with a 401/402 Series Bin and Power Supply, is intended for rack mounting. It is necessary to ensure that the 433A has sufficient cooling air circulating to prevent any localized heating of the all-transistor circuitry used throughout the module. The temperature of equipment mounted in racks can easily exceed the recommended maximum unless precautions are taken. The 433A should not be subjected to temperatures in excess of 120°F (50°C).

3.2. CONNECTION TO POWER

The 433A contains no internal power supply and must therefore obtain power from a Nuclear Standard Bin and Power Supply such as the ORTEC 401A/402A. The Bin power supply should be turned off when modules are inserted or removed. The ORTEC 400 Series is designed so that it is not possible to overload the Bin power supply with a full complement of modules in the Bin; since, however, this may not be true when the Bin contains modules other than those of ORTEC design, the Power Supply voltage should be checked after the modules are inserted. The ORTEC 401A/402A has test points on the Power Supply control panel to monitor the dc voltages. When using the 433A outside the 401A/402A Bin and Power Supply, be sure that the jumper cable used properly accounts for the Power Supply grounding circuits set forth in the recommended AEC standards of TID-20893 (Rev.). Both high-quality and power-return ground connections are provided to ensure proper reference feedback into the Power Supply, and these must be preserved in remote cable installations. Be careful to avoid ground loops when the module is operated outside the Bin.

3.3. SIGNAL CONNECTIONS TO THE 433A INPUTS

The 433A inputs are compatible with all output signals of the ORTEC 400 and 700 Series modular electronic instruments. The signal range of the Input is from 0 to 10 V. The input can range from dc to pulses as narrow as 200 nsec. The 433A characteristics of low noise, dc coupling, and wide bandwidth make it ideal for following preamplifiers or baseline restorers.

The input connector should be terminated in the characteristic impedance of the connecting coaxial cable when cable lengths exceed approximately 5 ft. The input impedance of each input is approximately 1000Ω.

It is recommended that RG-62/U or RG-63/U coaxial cable be used due to their relatively higher impedances (93Ω and 125Ω, respectively). If 50Ω coaxial cable must be used, be sure that the driving source can drive terminated 50Ω cable. Normally, nonlinearity of a system will vary directly with the amount of power being driven; therefore quite often the best method of linearly driving 50Ω coaxial cable which needs to be terminated is that of series drive. For example, a series resistance of 50Ω is placed between the driving source and the coaxial line, for sources whose driving impedance is less than 2Ω. When the line is terminated at the receiving end, the output signal will be divided and only half of it will appear at the receiving end; however, the receiving end may be left open-circuited, and the cable is terminated back at the driving impedance end. In this case, the driven power is very low and the signal is not attenuated.

3.4. LINEAR OUTPUT SIGNAL CONNECTIONS AND TERMINATING IMPEDANCE

There are three general methods of termination that are used. The simplest of these is shunt termination at the receiving end of the cable. A second method is series termination at the sending end. The third is a combination of series and shunt termination, where the cable impedance is matched both in series at the sending end and in shunt at the receiving end. The most effective method is the combination, but terminating by this method reduces the amount of signal strength at the receiving end to 50% of that which is available in the sending instrument.

To use shunt termination at the receiving end of the cable, connect the 1Ω output of the sending device through 93Ω cable to the input of the receiving instrument. Then use a BNC tee connector to accept both the interconnecting cable and a 100Ω resistive terminator at the input connector of the receiving instrument. Since the input impedance of the receiving instrument is normally 1000Ω or more, the effective instrument input impedance with the 100Ω terminator will be of the order of 93Ω, and this correctly matches the cable impedance.

For series termination, use the 93Ω output of the sending instrument for the cable connection. Use 93Ω cable to interconnect this into the input of the receiving instrument. The 1000Ω (or more) normal input impedance at the input connector represents an essentially open circuit, and the series impedance in the sending instrument now provides the proper terimination for the cable.

For the combination of series and shunt termination, use the 93Ω output in the sending instrument for the cable connection and use 93Ω cable. At the input for the receiving instrument, use a BNC tee to accept both the interconnecting cable and a 100Ω resistive terminator. Note that the signal span at the receiving end of this type of receiving circuit will always be reduced to 50% of the signal span furnished by the sending instrument.

For your convenience, ORTEC stocks the proper terminators and BNC tees, or you can obtain them from a variety of commercial sources.

4. OPERATING INSTRUCTIONS

The 433A is typically used in a linear system following the main pulse shaping amplifier(s). However, it may be used as a summing amplifier prior to pulse shaping in the main amplifier or as a fan-in for logic signals. It has no controls and will simply provide in each output the inverted sum of the related inputs whenever these occur.

The connotation of Summing Amplifier is true only when there is a time coincidence of arrival of the input pulses. If the input signals do not arrive in time coincidence, the inputs may be considered a linear fan-in unit. The 433A is directly compatible with and can be driven from any of the ORTEC 400 or 700 Series linear or logic output signals or it can be used to sum the outputs from preamplifiers, either shaping or nonshaping. Unless the charge conversion gain of each preamplifier is quite high, some degradation in the signal-to-noise ratio may be expected in high resolution systems when summing the preamplifier outputs since the noise from each unit must be summed in quadrature.

5. CIRCUIT DESCRITPION

The ORTEC 433A Dual Sum and Invert Amplifier contains two inverting operational amplifiers. These circuits are identical except that Amplifier A has four inputs and Amplifier B has only two inputs. The Amplifier A output can be connected directly as an Amplifier B input and the Amplifier B output will then be a noninverted sum of the Amplifier A inputs.

In Amplifier A the gain from any input (A1, A2, A3, or A4) to the output is approximately 1. The gain from A1 to the output is set by the ratio of R9 to R2. The risetime of the amplifier is less than 100 nsec and is controlled by the product of C1 and R9. The printed circuit board is designed to accommodate a potentiometer in series with R2 to permit an optional gain adjustment for the A1 input only; this could be desirable in order to precisely match the gain of the A1 input to any of the other A inputs. Ensure that the components selected have temperature coefficients of approximately 50 ppm and replace R2 with a resistor of 1.78 kΩ and a potentiometer of 500Ω connected in series.

The output impedance of Amplifier A is approximately 0.1Ω and the output circuit is short-circuit protected by transistors Q1 and Q2. If a higher output impedance is desired, a resistor with the desired impedance can be inserted in series from pin 10 of Amplifier A to the A Output connector; do not place this impedance in series with R9.

The Amplifier B portion of the 433A is designed the same as Amplifier A except that it includes only two input circuits and has no provision on the printed circuit board for an adjustable gain on either input.

6. MAINTENANCE

6.1. TESTING PERFORMANCE OF THE DUAL SUM AND INVERT AMPLIFIER

The following information is intended as an aid in the installation and checkout of the 433A. These instructions present information on waveforms at test points and output connectors.

Test Equipment The following, or equivalent, test equipment is needed:

1. ORTEC 419 or 448 Pulse Generator
2. Tektronix Model 580 Series Oscilloscope
3. 100Ω BNC terminators
4. High-impedance dc voltmeter
5. ORTEC 451 or 452 Amplifier
6. Schematic and block diagrams for the 433A

Preliminary Procedures The module should first be checked for possible damage due to shipment. The other preliminary procedures are as follows:

1. Connect ac power to the Bin and Power Supply, ORTEC 401A/402A. Turn off power.

2. Plug the module into the Bin and check for proper mechanical alignment.

3. Switch on the ac power and check the dc power supply voltages at the test points on the 402A Power Supply control panel.

Amplifiers A and B There are no internal adjustments to be made on the 433A; therefore testing is simply a matter of observation of input and output waveforms, as follows:

1. Feed the output of the Pulse Generator into the input of the 410 Amplifier.

2. Set the Amplifier controls as follows:

Gain	~5
Time Constants	0.5 or 1 μs

3. Feed the Bipolar Output of the amplifier to the A1 Input of the 433A through RG-62/U cable, and terminate the cable at the input of the 433A with a 100Ω terminator.

4. Adjust the Pulse Generator for an output of 500 mV from the amplifier.

5. The output at Output A of the 433A should be 500 mV and should come out promptly with respect to the input signal.

6. Move the input signal and terminator from the A1 Input, and connect it to the A2 Input.

7. Again, the output should be 500 mV and prompt with respect to the input. Repeat steps 5 and 6 for Inputs A3 and A4. Raise the amplitude of the signal from the amplifier to check the output under high signal conditions. The amplifier should saturate at approximately 11 V.

8. Repeat steps 3 through 7 for the Inputs B1 and B2, testing the results at Output B.

6.2. SUGGESTIONS FOR TROUBLESHOOTING

In situations where the 433A is suspected of malfunction, it is essential to verify such malfunction in terms of simple pulse generator pulses at the input and output. The 433A must be disconnected from its position in any system, and routine diagnostic analysis performed with a test pulse generator and an oscilloscope. It is imperative that testing not be performed with a source and detector until the Dual Sum and Invert Amplifier performs satisfactorily with the test pulse generator. The testing instructions given in Section 6.1 of this manual and the circuit descriptions in Section 5 should provide assistance in locating and repairing the malfunction. The side plates can be removed completely from the module to permit oscilloscope and voltmeter observation with a minimal chance of accidentially short-circuiting portions of the etched board. Table 6.1 is also presented here as a typical set of dc voltage measurements against which any unit can be tested.

6.3. FACTORY SERVICE

This instrument can be returned to the ORTEC factory for service and repair at a nominal cost. Our standard procedure for repair ensures the same quality control and checkout that are used for a new instrument. Always contact the Customer Service Department at ORTEC, (615) 482-4411, before sending in an instrument for repair to obtain shipping instructions and so that the required Return Authorization Number can be assigned to the unit. Write this number on the address label and on the package to ensure prompt attention when it reaches the ORTEC factory.

6.4. TABULATED TEST POINT VOLTAGES ON ETCHED BOARD

The following voltages indicate the dc voltages measured on the etched circuit board. In some instances the circuit will perform satisfactorily even though, due to component variations, there may be some voltages that measure outside the given limits; therefore the voltages given here should not be taken as absolute values, but rather are intended to serve as an aid in troubleshooting.

Table 6.1

LOCATION	VOLTAGE
Q1e	13.5
Q1c	21.5
Q2e	-13.5
Q2c	-21.5
Amp A Pin 1	23.5
3	12.5
4	0
5	- 0.66
6	- 0.66
7	0
8	- 0.88
9	-23.5
10	0
Q3e	13.5
Q3c	21.5
Q4e	-13.5
Q4c	-21.5
Amp B Pin 1	23.5
3	12.5
4	0
5	- 0.66
6	- 0.66
7	0
8	- 0.88
9	-23.5
10	0

APPENDIX

REPLACEABLE PARTS

ORDERING INFORMATION

The Replaceable Parts List shown below contains information needed for ordering spare and/or replacement parts. Each listing indicates the reference designator number, the part number, a description of the component, and the part manufacturer and manufacturer's part number.

All inquiries concerning spare and/or replacement parts and all orders for same should include the model serial, and revision ("Rev" on rear panel) numbers of the instruments involved and should be addressed to the Customer Service Department at 100 Midland Road, Oak Ridge, Tennessee 37830. The Manager of Customer Services can be reached by telephone at (615) 482-4411. The minimum order for spare and/or replacement parts is $25.00.

ORDERING INFORMATION FOR PARTS NOT LISTED

In order to facilitate the ordering of a part not listed below, the following information should be submitted to the Customer Service Department:

1. the instrument model number,
2. the instrument serial number,
3. revision ("Rev" on rear panel) number,
4. a description of the part,
5. information as to the function and location of the part.

The solid-state-device (diodes, transistors, and integrated circuits) types installed in your instrument may differ from those shown in the schematic diagram and parts list. In such cases, necessary replacements can be made with either the type shown or the type actually installed in the instrument.

Replaceable Parts List

REFERENCE DESIGNATOR	ORTEC PART NO.	DESCRIPTION	MFR.	MFR. PART NO.
433A-0100	5004 46557			
19	9097 41339	Connector, BNC	95712	DGE UG1094/U
R45	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R46	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R47	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R48	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R49	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R50	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
433A-0200	5007 46558			
C1	9059 40883	22 pf 5% 500V D.M.	84171	ARC DM15-220D
C2	9065 40948	6.8 uf 20% 35V Tan	80183	SPR 150D685X0035B2
C3	9065 40948	6.8 uf 20% 35V Tan	80183	SPR 150D685X0035B2
C4	9065 40948	6.8 uf 20% 35V Tan	80183	SPR 150D685X0035B2
C5	9065 40948	6.8 uf 20% 35V Tan	80183	SPR 150D685X0035B2
C6	9059 40883	22 pf 5% 500V D.M.	84171	ARC DM15-220D
C7	9065 40948	6.8 uf 20% 35V Tan	80183	SPR 150D685X0035B2
C8	9065 40948	6.8 uf 20% 35V Tan	80183	SPR 150D685X0035B2
C9	9065 40948	6.8 uf 20% 35V Tan	80183	SPR 150D685X0035B2
C10	9065 40948	6.8 uf 20% 35V Tan	80183	SPR 150D685X0035B2
C11	9059 40886	100 pf 2% 500V D.M.	84171	ARC DM15-101G

Replaceable Parts (continued)

REFERENCE DESIGNATOR	ORTEC PART NO.	DESCRIPTION	MFR.	MFR. PART NO.
433A-0200	5007 46558			
Cont'd				
C12	9059 40886	100 pf 2% 500V D.M.	84171	ARC DM15-101G
C13	9059 40882	15 pf 5% 500V D.M.	84171	ARC DM15-150J
C14	9059 40882	15 pf 5% 500V D.M.	84171	ARC DM15-150J
Q1	9078 43655	Transistor - MPS6531	80211	MOT
Q2	9078 43650	Transistor - MPS6534	80211	MOT
Q3	9078 43655	Transistor - MPS6531	80211	MOT
Q4	9078 43650	Transistor - MPS6534	80211	MOT
R1	9027 40522	2 K 1/8W 1% MF	IRC	CEA
R2	9026 46771	2 K 1/8W 1% MF	IRC	CEA (T-2)
R3	9027 40522	2 K 1/8W 1% MF	IRC	CEA
R4	9026 46771	2 K 1/8W 1% MF	IRC	CEA (T-2)
R5	9027 40522	2 K 1/8W 1% MF	IRC	CEA
R6	9026 46771	2 K 1/8W 1% MF	IRC	CEA (T-2)
R7	9027 40522	2 K 1/8W 1% MF	IRC	CEA
R8	9026 46771	2 K 1/8W 1% MF	IRC	CEA (T-2)
R9	9026 46771	2 K 1/8W 1% MF	IRC	CEA (T-2)
R10	9015 40204	22 Ω 1/4W 5% C	01121	ABC CB
R11	9017 40354	300 Ω 1/2W 5% C	01121	ABC EB
R12	9015 40267	4.3 K 1/4W 5% C	01121	ABC CB
R13	9015 40259	6.2 K 1/4W 5% C	01121	ABC CB
R14	9027 40484	51.1 Ω 1/8W 1% MF	IRC	CEA
R15	9027 40484	51.1 Ω 1/8W 1% MF	IRC	CEA
R16	9015 40202	10 Ω 1/4W 5% C	01121	ABC CB
R17	9015 40202	10 Ω 1/4W 5% C	01121	ABC CB
R18	9015 40204	22 Ω 1/4W 5% C	01121	ABC CB
R19	9027 40510	511 Ω 1/8W 1% MF	IRC	CEA
R20	9017 40354	300 Ω 1/2W 5% C	01121	ABC EB
R21	9015 40267	4.3 K 1/4W 5% C	01121	ABC CB
R22	9015 40259	6.2 K 1/4W 5% C	01121	ABC CB
R23	9027 40522	2 K 1/8W 1% MF	IRC	CEA
R24	9026 46771	2 K 1/8W 1% MF	IRC	CEA
R25	9027 40522	2 K 1/8W 1% MF	IRC	CEA
R26	9026 46771	2 K 1/8W 1% MF	IRC	CEA (T-2)
R27	9026 46771	2 K 1/8W 1% MF	IRC	CEA (T-2)
R28	9015 40204	22 Ω 1/4W 5% C	01121	ABC CB
R29	9017 40354	300 Ω 1/2W 5% C	01121	ABC CB
R30	9015 40267	4.3 K 1/4W 5% C	01121	ABC CB
R31	9015 40259	6.2 K 1/4W 5% C	01121	ABC CB
R32	9015 40202	10 Ω 1/4W 5% C	01121	ABC CB
R33	9027 40484	51.1 Ω 1/8W 1% MF	IRC	IRC CEA
R34	9027 40484	51.1 Ω 1/8W 1% MF	IRC	IRC CEA

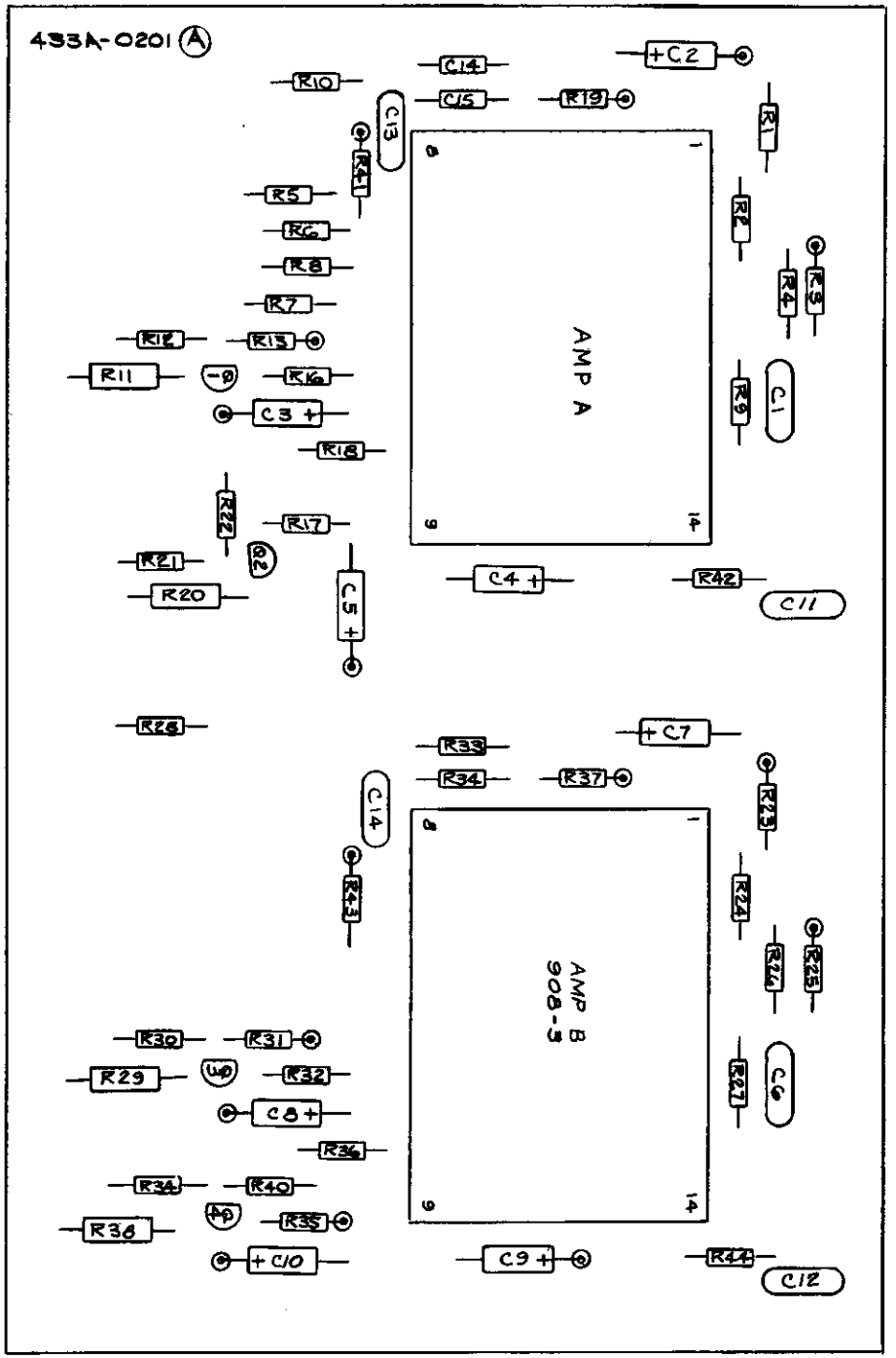
Replaceable Parts (continued)

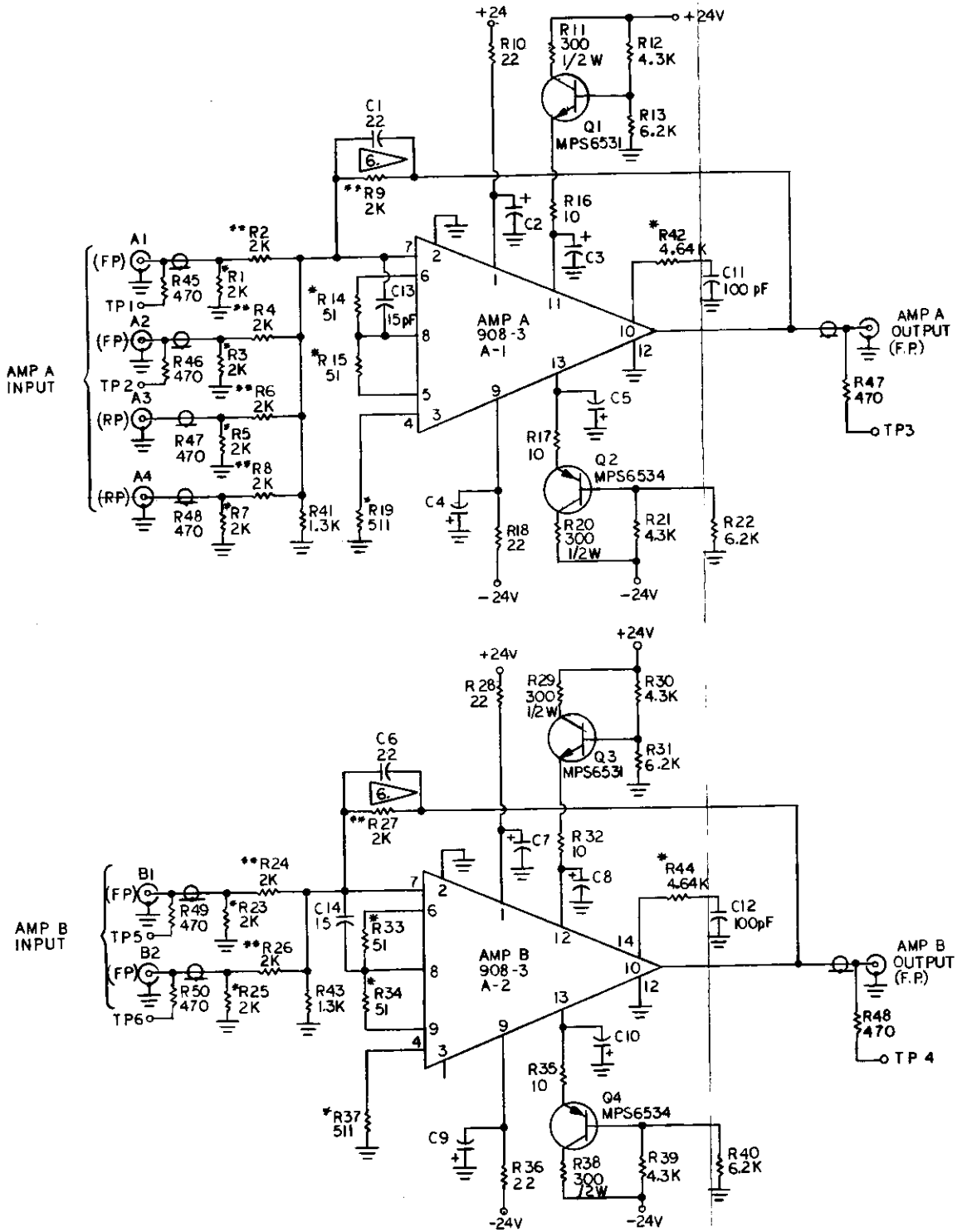
REFERENCE DESIGNATOR	ORTEC PART NO.	DESCRIPTION	MFR.	MFR. PART NO.
433A-0200	5007 46558			
Cont'd				
R35	9015 40202	10 Ω 1/4W 5% C	01121	ABC CB
R36	9015 40204	22 Ω 1/4W 5% C	01121	ABC CB
R37	9027 40510	511 Ω 1/8W 1% MF	IRC	IRC CEA
R38	9017 40354	300 Ω 1/2W 5% C	01121	ABC EB
R39	9015 40267	4.3 K 1/4W 5% C	01121	ABC CB
R40	9015 40259	6.2 K 1/4W 5% C	01121	ABC CB
R41	9015 40287	1.3 K 1/4W 5% C	01121	ABC CB
R42	9027 40533	4.64 K 1/8W 1% MF	IRC	IRC CEA
R43	9015 40287	1.3 K 1/4W 5% C	01121	ABC CB
R44	9027 40533	4.64 K 1/8W 1% MF	IRC	IRC CEA
4	5007 46357	Operational Amplifier	ORTEC	908-3

BIN/MODULE CONNECTOR PIN ASSIGNMENTS FOR AEC STANDARD NUCLEAR INSTRUMENT MODULES PER TID-20893

Pin	Function	Pin	Function
1	+3 volts	23	Reserved
2	−3 volts	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 volts
7	Coaxial	*29	−24 volts
8	200 volts dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 volts	32	Spare
*11	−6 volts	*33	115 volts ac (Hot)
12	Reserved Bus	*34	Power Return Ground
13	Spare	**35	Reset (Scaler)
14	Spare	**36	Gate
15	Reserved	**37	Reset (Auxiliary)
*16	+12 volts	38	Coaxial
*17	−12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	115 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

Pins marked (*) are installed and wired in ORTEC 401A and 401B Modular System Bins.
Pins marked (*) and (**) are installed and wired in EG&G/ORTEC–HEP M250/N and M350/N NIMBINS.


433A-0201 A
AMP A
AMP B
908-3
+C2
C14
C15
R10
R19
C13
R41
R5
R6
R8
R7
R12
R15
R11
-9
R16
C3 +
R18
R22
R17
R21
Q2
R20
C5 +
C4 +
R42
C11
R1
R2
R4
R3
C1
R9
R26
+C7
R33
R34
R37
C14
R43
R30
R31
R29
+9
R32
C8 +
R36
R39
R40
R38
+9
R35
+C10
C9 +
R44
C12
R25
R24
R24
R23
C9
R27
1
8
9
14



NOTES: UNLES OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 1/4 WC, VALUE IN OHMS
2. ALL RESISTORS MARKED * ARE 1/8W MFT0 (150PPM)
3. ALL RESISTORS MARKED** ARE 1/8W MFT2 (150PPM)
4. ALL CAPACITORS WITH POLARITY INDICATED ARE 6.8 µF, 35V TANT.
5. ALL CAPACITORS ARE DM, VALUE IN pF
6. CHANGES FOR MODEL 433AL
   1. C1 AND C6 ARE 10
   2. R9 AND R27 ARE 20K

C	GC-125	2-5-73	JRS
B	433A-2	1-8-73	JRS
A	433A-1	4-30-71	JD

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
TOLERANCES

ORTEC INCORPORATED
100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830

MODEL 433A
DUAL SUM AND INVERT SCHEMATIC

RYDER 2-9-71	K MILAM	
SH 4-30-71		433A-0101-S1