ORTEC
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TWX 810-572-1078

INSTRUCTION MANUAL

406A SINGLE CHANNEL ANALYZER

AN EG&G COMPANY

INSTRUCTION MANUAL
406A
SINGLE CHANNEL ANALYZER

Serial No. ______________________

Purchaser ______________________

Date Issued ______________________

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100 MIDLAND ROAD
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Printed in U.S.A.

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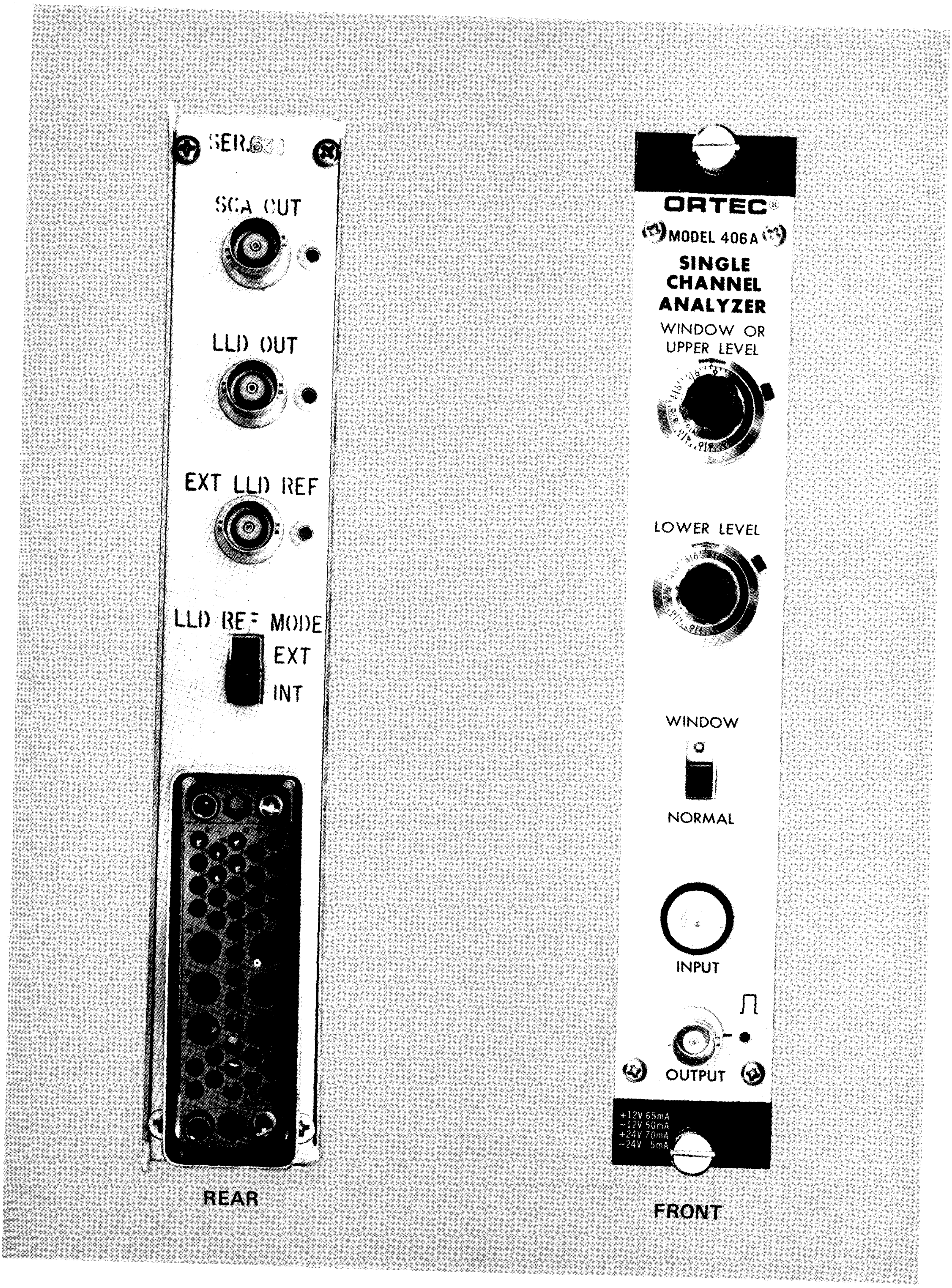

SCA OUT
LLD OUT
EXT LLD REF
LLD REF MODE
EXT
INT
ORTEC
MODEL 406A
SINGLE
CHANNEL
ANALYZER
WINDOW OR
UPPER LEVEL
LOWER LEVEL
WINDOW
NORMAL
INPUT
OUTPUT
+12V 65mA
−12V 50mA
+24V 70mA
−24V 5mA
REAR
FRONT

ORTEC 406A
SINGLE CHANNEL ANALYZER

1. DESCRIPTION

1.1 General Description

The ORTEC 406A Single Channel Analyzer has the exceptionally wide dynamic range and the high stability and resolution necessary for use in high resolution counting experiments - particularly those experiments employing Ge(Li) semiconductor detectors or gas ionization chambers. Because of these features,the 406A will also perform equally well with scintillation counters and other type nuclear detectors. The unit is contained in a single unit wide NIM module and employs integrated circuit discriminators and anticoincidence logic to assure superior reliability and minimum size.

The 406A Single Channel Analyzer will accept either unipolar or bipolar input pulses having either RC or delay line pulse shaping waveforms. The output pulse is positive and conforms to NIM standard specifications. The instrument,in general,is designed to meet the recommended interchangeability standards of USAEC Report TID-20893 (Rev.). The ORTEC 401A/402A Bin and Power Supply provides all the necessary power through the rear module power connector. All signal levels and impedances are compatible with other modules in the ORTEC 400 Series.

1.2 Modes of Operation

1.2.1 Single Channel Analysis

In the WINDOW mode,the unit operates as a high resolution,narrow (0 to 10%) window single channel analyzer. Since the 0-10% window is adjustable by a 10-turn potentiometer, the very narrow windows required for high resolution spectroscopy can be easily and reproducibly obtained.

For wide window applications, the NORMAL mode is used. In this mode, the upper level and lower level controls are independently variable from 0 to 10 volts and an output pulse is generated for pulses analyzed between these levels. This mode is useful for gross counting experiments and for defining the upper and lower bounds of a spectrum being analyzed. In both the WINDOW and NORMAL modes,provision is made via a rear panel two-position slide switch labeled LLD REF MODE (lower level discriminator reference mode) for external control of the lower level discriminator. When used in the EXT mode, the front panel lower level control is disabled, and bias to the lower level discriminator is made through a rear panel BNC connector (CN-1), labeled EXT LLD REF (external lower level discriminator reference). This feature is useful for experiments in which a window is swept through an energy range, and count rate is recorded as a function of energy.

The output pulse from the 406A in the WINDOW and NORMAL modes occurs when the trailing edge of the pulse being analyzed crosses the lower level threshold; therefore, the 406A cannot be effectively used for crossover timing.

1.2.2 Leading Edge Timing

Through use of the rear panel LLD OUT output, the 406A can operate as a stable, wide dynamic range integral discriminator which is capable of analyzing pulses between 50mV and 10V. The LLD OUT output pulse occurs at the leading edge of the input pulse when the lower level discriminator triggers. Therefore, this output can be used for experiments employing leading edge timing or for pulse routing into multichannel analyzers. In any mode of operation, the LLD OUT output can be used to monitor the number of input pulses which cross the lower level threshold.

2. SPECIFICATIONS

2.1 General

The 406A is housed in a one module wide Nuclear Standard Module. Refer to USAEC Report TID-20893 (Rev.). The module contains no internal power supply, and therefore, must obtain the necessary operating power from the Nuclear Standard Bin and Power Supply, ORTEC 401A/402A. The 406A inputs and outputs are via BNC connectors.

2.2 Specifications

INPUT: Positive, unipolar or bipolar, 0 to 10V linear range, 25V maximum, 0.2 to 10μsec width, 1000 ohms input impedance.

EXT LLD REF INPUT: 0 to -10V, 1000 ohms input impedance

OUTPUTS:

OUTPUT (front panel): 5V, 0.5μsec width
SCA OUT (rear panel): Identical with front panel output
LLD OUT (rear panel): 5V, 0.5μsec width
OUTPUT IMPEDANCE: ⩽10 ohms on all outputs

LOWER LEVEL: When used in INT mode, 0 to 10V with 10-turn potentiometer; when used in EXT mode, 0 to 10V corresponding to 0 to -10V input on BNC connector CN-1 (EXT LLD REF)

UPPER LEVEL: 0 to 10V with 10-turn potentiometer

WINDOW: 0 to 1V with 10-turn potentiometer

MAXIMUM ZERO OFFSET: Less than 0.5% of full scale (10V) for lower level discriminator

WINDOW WIDTH CONSTANCY: Less than 10 mV width variation over the linear 0 to 10V range

NONLINEARITY: <±0.25% of full scale (integral) for both discriminators

DYNAMIC RANGE: 200:1

PULSE PAIR RESOLVING TIME: 0.75μsec

TEMPERATURE STABILITY: 0.01%/°C

TEMPERATURE RANGE: 0 to 50°C

POWER REQUIREMENTS:	+24V	70mA	+12V	65mA
	-24V	5mA	-12V	50mA

MECHANICAL: One module wide and designed to meet the recommended interchangeability standards set out in USAEC Report TID-20893 (Rev.); 1.35 inches wide, 8.714 inches high, and 9.75 inches long.

3. INSTALLATION

3.1 General Installation Considerations

The 406A, used in conjunction with ORTEC 401A/402A Bin and Power Supply, is intended for rack mounting,and therefore,it is necessary to ensure that vacuum tube equipment operating in the same rack has sufficient cooling air circulating to prevent any localized heating of the all-transistor circuitry used throughout the 406A. The temperature of equipment mounted in racks can easily exceed the recommended maximum unless precautions are taken; the 406A should not be subjected to temperatures in excess of 120°F (50°C).

3.2 Connection to Power - Nuclear Standard Bin, ORTEC 401A/402A

The 406A contains no internal power supply,and therefore,must obtain power from a Nuclear Standard Bin and Power Supply such as ORTEC 401A/402A. It is recommended that the bin power supply be turned off when inserting or removing modules. 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; however, this may not be true when the Bin contains modules other than those of ORTEC design, and in such instances, power supply voltages should be checked after the insertion of modules. The 401A/402A has test points on the power supply control panel to monitor dc voltages.

When using the 406A outside the 401A/402A Bin and Power Supply, be sure that the jumper cable used properly accounts for the power supply grounding circuits provided as per the recommended AEC standards outlined in TID-20893 (Rev.). Both high quality and power return ground connections are provided to ensure proper reference voltage feedback into the power supply, and these must be preserved in remote cable installations. Care must also be exercised to avoid ground loops when the module is not physically in the Bin.

3.3 Connection to Linear Amplifier

The signal input to the 406A is on the front panel INPUT BNC connector. The input is compatible with all linear amplifiers capable of producing unipolar or bipolar output signals, of which the positive excursion is leading, into a 1000-ohm load. The input operating range is from threshold, typically less than 50 millivolts to 10 volts. The input is ac-coupled so that any dc offset in the amplifier output will not affect the discriminator levels. The outputs of biased amplifiers such as ORTEC 408,linear gates such as ORTEC 409, and other linear signals are compatible with the input requirements of the 406A.

3.4 Output Connections

The positive 5-volt outputs of the 406A are compatible with all ORTEC scalers,counting rate meters, and other instruments and conforms to NIM standards. The output impedance is sufficiently low to drive parallel inputs up to at least 10, 1000 ohm inputs.

4. OPERATING INSTRUCTIONS

4.1 Front Panel Controls

When used as a single channel analyzer, the 406A has two modes of operation, WINDOW and NORMAL. In the WINDOW mode, the unit operates as a high resolution, narrow (0 to 10%) window single channel analyzer. For wide window applications, the NORMAL mode is used. In this mode, the upper level and lower level controls are independently variable from 0 to 10V and an output (OUTPUT on front panel and SCA OUT on rear panel) is generated for pulses analyzed between the levels.

LOWER LEVEL - The LOWER LEVEL control is a 10-turn potentiometer adjustable from 0 to 10V,which determines the threshold setting for the lower level discriminator. When the LLD REF MODE switch (S-1, rear panel) is in the EXT position, the LOWER LEVEL control is disabled, and discriminator bias is provided from the EXT LLD REF input BNC connector (CN-1) on the rear panel. (An input of 0 to -10V on this connector corresponds to a range of 0 to 10V for the lower level discriminator setting.)

WINDOW or UPPER LEVEL - The WINDOW or UPPER LEVEL control is a 10-turn potentiometer that determines the window width in the WINDOW mode, or the upper level threshold in the NORMAL mode. The control is variable from 0 to 1V in the WINDOW mode and from 0 to 10V in the NORMAL mode.

4.2 Rear Panel Controls

LLD REF MODE: The LLD REF MODE (switch S-2) is a two position slide switch which selects the biasing arrangement for the lower level discriminator. In the INT position bias is provided internally, and is set by the front panel LOWER LEVEL control. In the EXT position, bias for the lower level is provided through the rear panel BNC connector CN-1.

4.3 Initial Testing and Observation of Pulse Waveforms

Refer to Section 6 of this manual for information on testing performance and observing waveforms.

4.4 Connector Data

INPUT: The INPUT BNC connector (CN-2) provides an input to the 406A with an input impedance of 1000 ohms. The input will accept positive pulses, either unipolar or bipolar, having a 0 to 10V linear range and a 25V maximum pulse height. The input is ac-coupled to the discriminators so that a dc offset voltage is allowable on the input signal.When a long cable is connector to the 406A input,the input should be terminated in the characteristic impedance of the cable in order to avoid undesirable reflections.

OUTPUT: The OUTPUT BNC connector (CN-3) on the front panel provides an output for the 406A with an output driving source impedance of 10 ohms or less. It is dc-coupled and provides a pulse of 5V amplitude, 0.5μsec width.

SCA OUT: The SCA OUT BNC connector (CN-4) is wired in parallel to the front panel OUTPUT, and thus provides the same output signal as the OUTPUT BNC (CN-4). Both the SCA OUT and the OUTPUT pulses occur when the trailing edge of the input signal crosses the lower level threshold.

LLD OUT: The LLD OUT BNC connector (CN-5) provides an output pulse of 5V amplitude,0.5μsec width whenever the input pulse crosses the lower level threshold. CN-6 is dc-coupled with a driving source impedance of 10 ohms or less. With the LLD OUT output, the 406A can be operated as a stable, wide dynamic range integral discriminator for leading edge timing or for pulse routing.

EXT LLD REF: The EXT LLD REF connector (CN-1) can be used to provide external bias to the lower level discriminator whenever the LLD REF MODE switch is in the EXT position. This BNC connector is dc-coupled into an impedance of 1000 ohms. A 0 to -10V range on CN-1 corresponds to a LOWER LEVEL threshold range of 0 to +10V.

POWER CONNECTOR: The NIM standard power connector is on the rear of the module.

4.5 Typical Applications

4.5.1 Typical Use With Semiconductor Detectors

Typical operation of the 406A in the narrow window mode in a semiconductor detector spectroscopy system is shown in Figure 4.1. The exceptionally wide dynamic range and the high stability and resolution of the 406A provide the capabilities necessary for long-term experiments of this nature.

4.5.2 Typical Use For X-Ray Diffraction

A typical application in an X-ray diffraction experiment is shown in Figure 4.2. The capability of the 406A to accept a wide variety of input signals as well as its wide dynamic range and high stability make the 406A particularly useful for this application. The small size of the 406A allows the total X-ray diffraction electronics to be contained in a single bin and power supply with a resultant savings in both cost and space.

4.5.3 Routing For Pulse Height Analyzers

A number of 406A Single Channel Analyzers using the LLD OUT to generate routing signals for a multichannel analyzer in an experiment requiring subdividing of the memory on a pulse-to-pulse basis or in a multiparameter analysis experiment is shown in Figure 4.3. This block diagram also demonstrates the flexibility of the ORTEC modular instruments in a wide vareity of unusual applications.

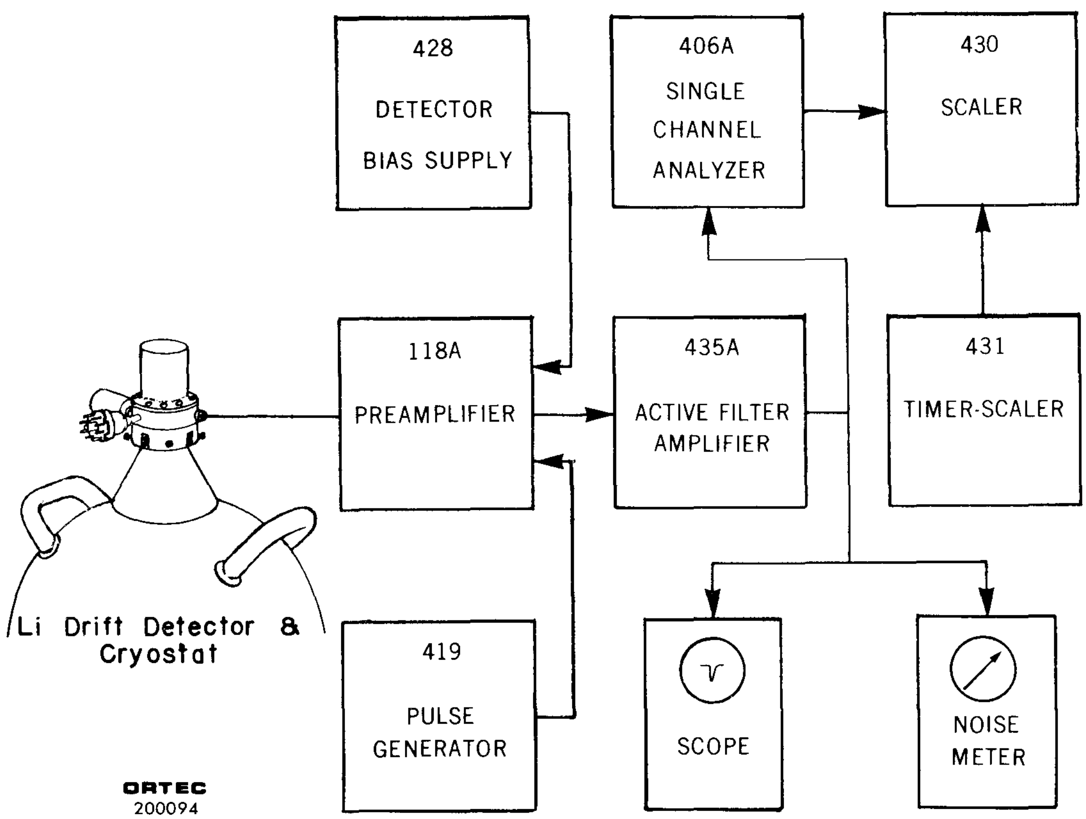


Figure 4-1. Ge(Li) Gamma Spectroscopy System Using 406A

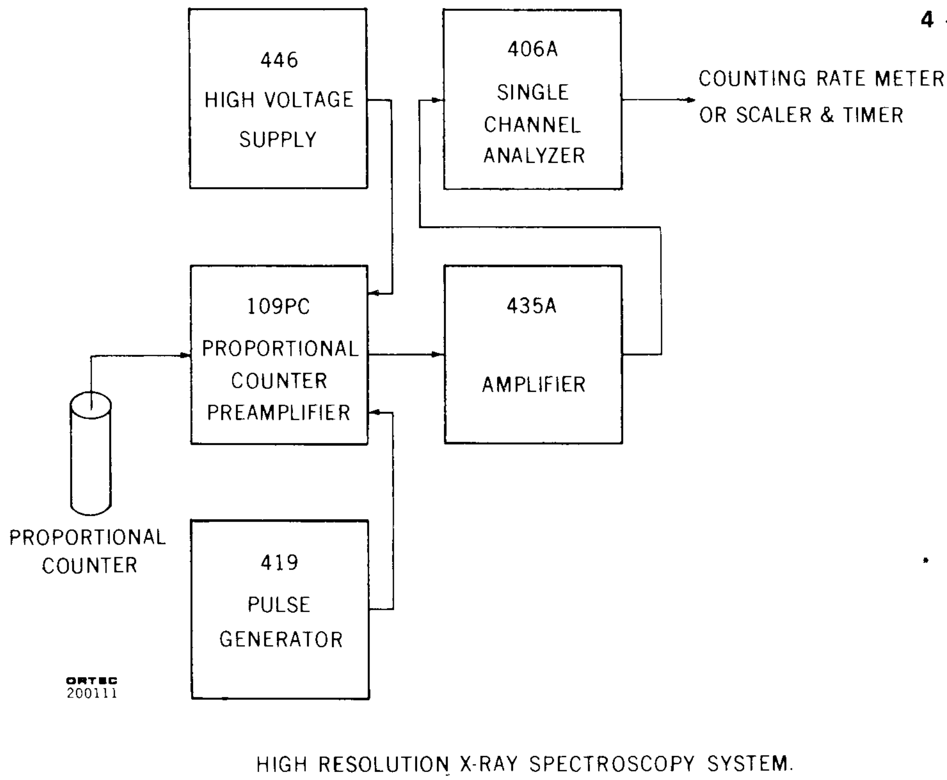


Figure 4-2. System for Use in X-ray Diffraction Experiments

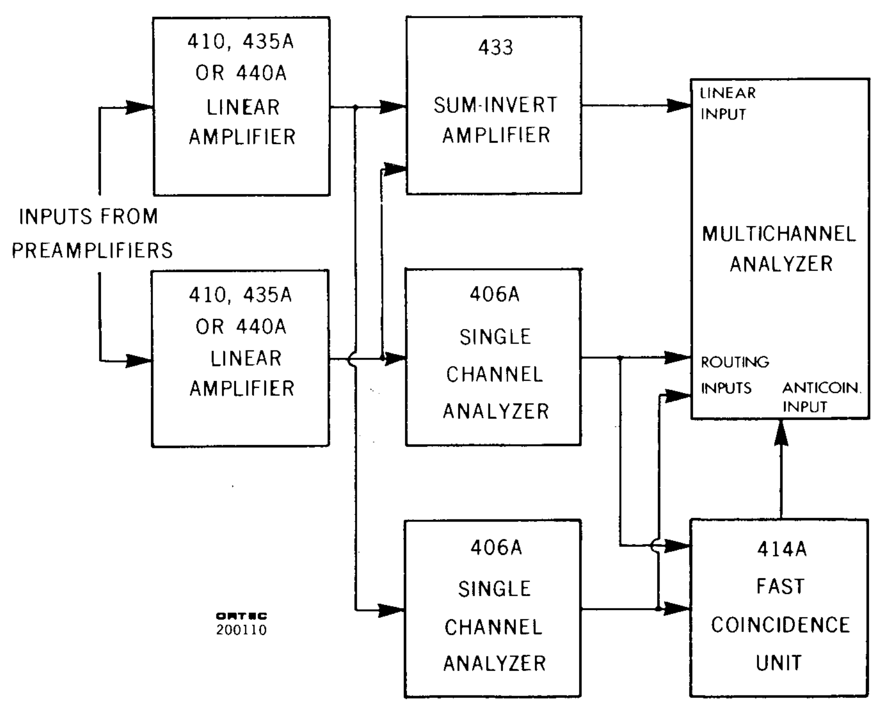


Figure 4-3. Use of the 406A in Multichannel Analyzer Routing

5. CIRCUIT DESCRIPTION

5.1 Integrated Circuits

IC1 and IC2 are high gain differential voltage comparators which function as discriminators by operating in a biased amplifier mode,i.e.,the non-inverting input is biased negative with respect to the inverting input. When an input pulse exceeds the bias threshold, the IC acts as a very high gain direct coupled amplifier generating an output for an input which just exceeds the biased threshold by a few millivolts. IC's 3, 4, 5, 6, and 7 are NOR logic packages, each consisting of two dual input NOR gates employing RTL (Resistor Transistor Logic). The circuit functions as a NOR gate for positive input signals generating a negative (ground) output whenever either input is positive, and as a NAND gate for negative (ground) input generating a positive output only when both inputs are at ground.

5.2 Discriminator Biasing Block Diagrams

The biasing arrangement for the NORMAL mode of the 406A is shown in Figure 5.1. In this mode, the upper level discriminator (ULD) and the lower level discriminator (LLD) have separate independent controls which are variable from ground to -5V. The inverting inputs of both operational amplifiers are grounded, and therefore, ground is the reference threshold. When the input signal exceeds the reference thresholds of the operational amplifiers (starting from the negative voltage determined by the level controls), the operational amplifiers conduct generating positive outputs which trigger the trigger pairs.

The bias arrangement for the WINDOW mode is shown in Figure 5.2. In this mode both inputs are biased to the same level by the lower level control, the lower level discriminator operational amplifier referenced to ground,and the upper level discriminator operational amplifier is referenced to the window control which is variable from ground to +0.5V. Therefore, regardless of where the lower level control is set, the upper level discriminator cannot trigger until the input pulse has exceeded the lower level reference voltage plus the voltage determined by the window control. Therefore,this biasing arrangement provides for a fixed window over the lower level control range. The actual range of control for all controls is twice the voltage on the control since the input signals are attenuated by a factor of two. This makes the control range for the lower level and upper level 0 to 10V and for the window 0 to 1V.

An emitter follower buffer isolates the input from the two operational amplifiers by presenting a very low common mode driving impedance. The buffer is essential for the window mode of operation to obtain narrow, constant window widths over the entire linear range.

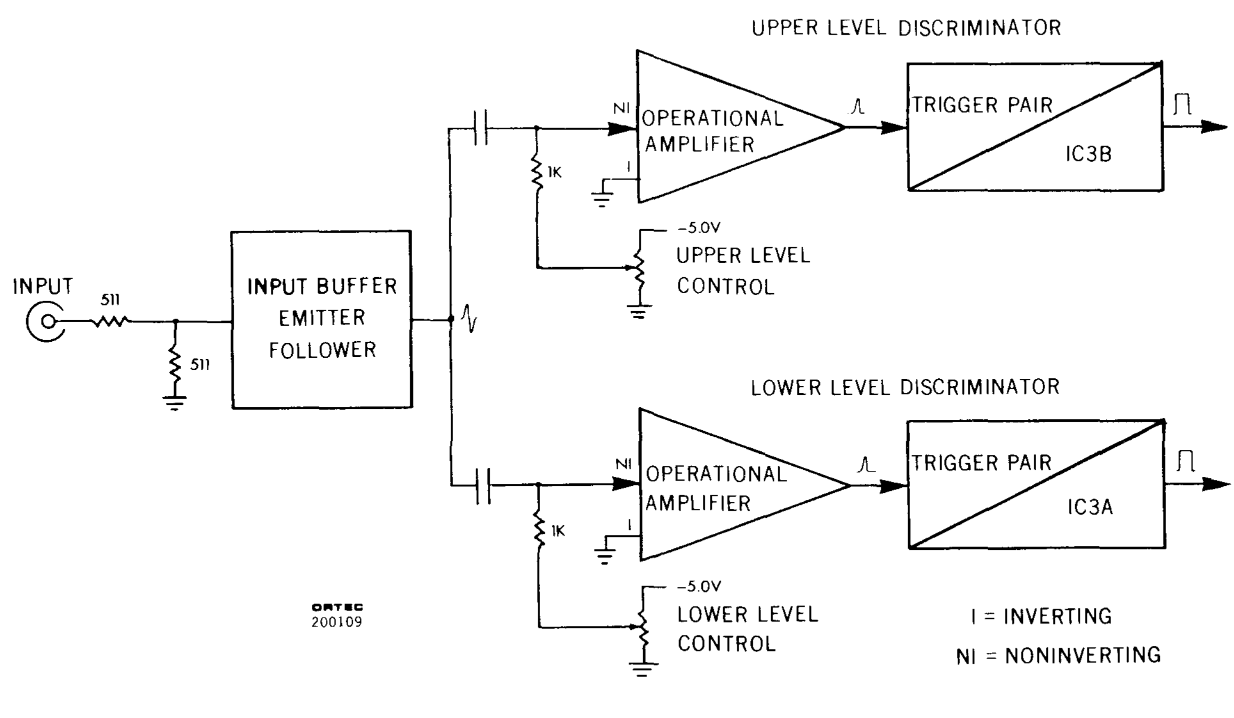


Figure 5-1. Bias Arrangement for NORMAL MODE

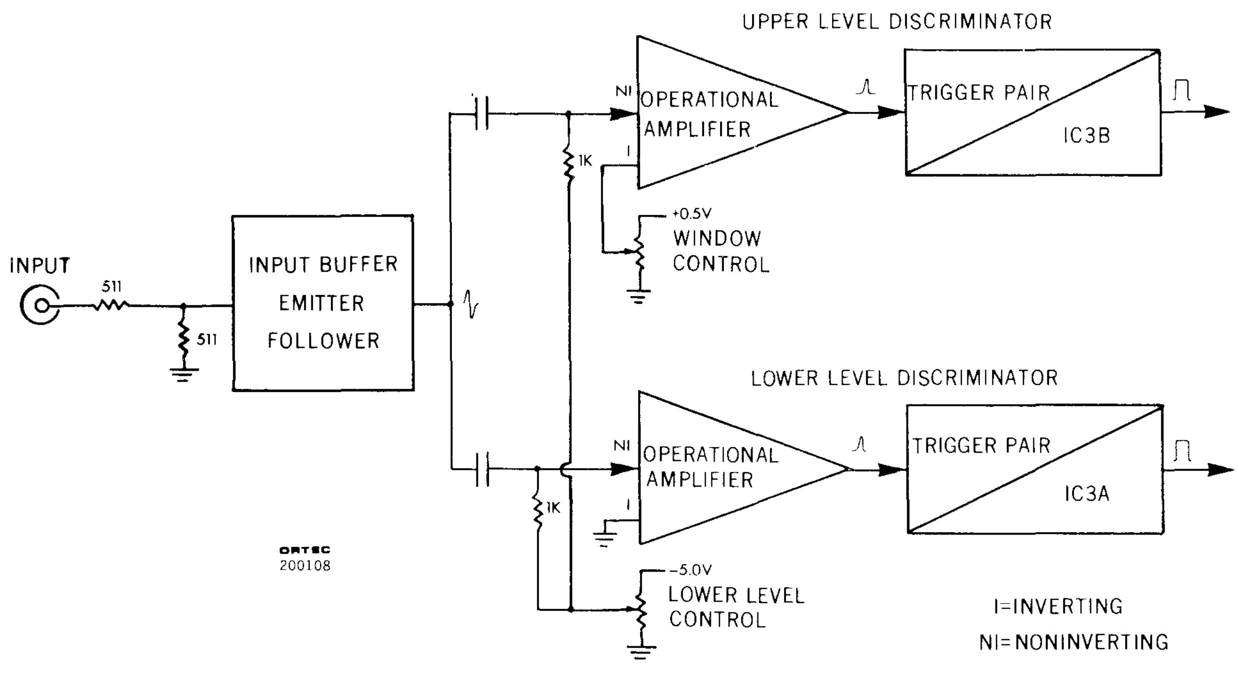


Figure 5-2. Bias Arrangement for WINDOW MODE

5.3 Circuit Analysis

Refer to Drawing 406A-0101-S1 (schematic diagram). Whenever the leading edge of an input pulse exceeds the lower level threshold of IC1, a positive output is generated which causes NOR gate IC3A to conduct, generating a negative output at the emitter of Q2. This negative pulse is coupled through R14 and C8 cutting off Q4,and thereby generating a positive output at the collector of Q4,which is then fed back to IC3A to close the loop on the trigger pair. Q4 remains cut off until the trigger pair time constant capacitor C8 is discharged (about 0.2μsec),and therefore,a positive pulse is generated at the collector of Q4. This positive pulse triggers and one-shot multivibrator comprised of IC7,Q5, and Q6 which provides the LLD OUT output pulse. The LLD OUT output pulse has a pulse height set the resistive voltage divider R17 and R19 (5V) and a width set by the time constant associated with C11 and resistor R22.

If the input pulse also exceeds the upper level threshold, there is also a negative output from IC3B. This negative output is coupled through C19, cutting off Q7, resulting in a positive output at the collector of Q7 which is fed back to IC3B, thereby closing the loop on the trigger pair. The positive output at the collector of Q7 remains positive until C19 has time (0.5μsec) to charge through R28 to the point where Q7 comes back on, returning the positive output to zero.

The negative output from IC3B and the negative output from the emitter of Q2, which are in time coincidence, are fed into NAND IC4A, generating a positive output. This positive output sets the flip-flop consisting of IC4B and IC5A. When the flip-flop sets, the output of IC5 goes positive and the gate IC6A is closed by the positive input at Pin 2. When the trailing edge of the input drops below the lower level threshold, the negative output at the emitter of Q2 goes positive, causing a negative transition at the collector of Q2. The waveform at the emitter of Q3,then,is a positive pulse which is positive for the time that the input is above the lower level threshold. This pulse is differentiated by C9 and approximately R31. The resulting negative pulse, occuring at the trailing edge of the input pulse at the time when the input pulse crosses the lower level discriminator, is fed to integrated circuits IC5B and IC6A. This negative back edge pulse causes a positive output from IC5B which resets the flip-flop IC5A and IC4B. The negative back edge pulse would also cause a positive output from IC6B if the flip-flop had not been set, and there were not a positive input at Pin 2 of IC6A. The delay network consisting of C20 and R30 holds the positive blocking signal at the input of IC6A positive for a short time after the flip-flop has been reset in order to continue to block the negative back edge pulse.

If the input pulse had not exceeded the upper level threshold, the flip-flop would not have been set, and therefore, there would not be a positive blocking input on Pin 2 of IC6A. In this case, the negative back edge signal from the lower level discriminator would cause a positive output from IC6A which would trigger the one-shot multivibrator comprised of IC6B, Q9, and Q10. This one-shot multivibrator provides the OUTPUT (front panel) output pulse and the SCA OUT (rear panel) output pulse at a time when the input pulse to the 406A recrosses the lower level threshold. The amplitude of this output is 5V and the pulse width is 0.5μsec.

6. MAINTENANCE INSTRUCTIONS

6.1 Testing Performance

6.1.1 Introduction

The following test descriptions are intended as an aid in the original installation and any succeeding checkout of the 406A.

6.1.2 Test Equipment

The following test equipment is recommended for testing the 406A. Equivalent equipment can be used if appropriate changes are made in the test procedure.

1. ORTEC 419 Precision Pulse Generator
2. ORTEC 435A Active Filter Amplifier
3. ORTEC 401A/402A Bin and Power Supply
4. Tektronix Model 580 Series or 540 Series oscilloscope with type 1A1 plug-in unit
5. 100 ohm BNC terminators (2 each)

6.1.3 Preliminary Procedures

1. Visually check module for possible damage due to shipment.
2. Plug module into bin and check for proper mechanical alignment.
3. Connect ac power to the Nuclear Standard Bin, e.g., ORTEC 401A/402A.
4. Switch on ac power and check the dc power voltages at the test points on the 401A power supply control panel.

6.1.4 Operational Tests

Connect the test equipment as shown in Figure 6.1. With the gain controls of the 419 and the 435A, normalize the output of the 435A (BIPOLAR or UNIPOLAR) to 10V, such that a PULSE HEIGHT reading of 1000 on the 419 corresponds to a 10V output pulse from the 435A. Set the 406A LOWER LEVEL dial to 200 and the UPPER LEVEL dial to 800. Connect one probe of the oscilloscope to the LLD OUT connector (CN-5) of the 406A. Observe that in both the WINDOW and NORMAL modes,as the 419 PULSE HEIGHT dial is taken from 0V (000) to full scale 10V (1000), the LLD OUT output pulse from the 406A just appears at 2V and remains throughout the rest of the range.

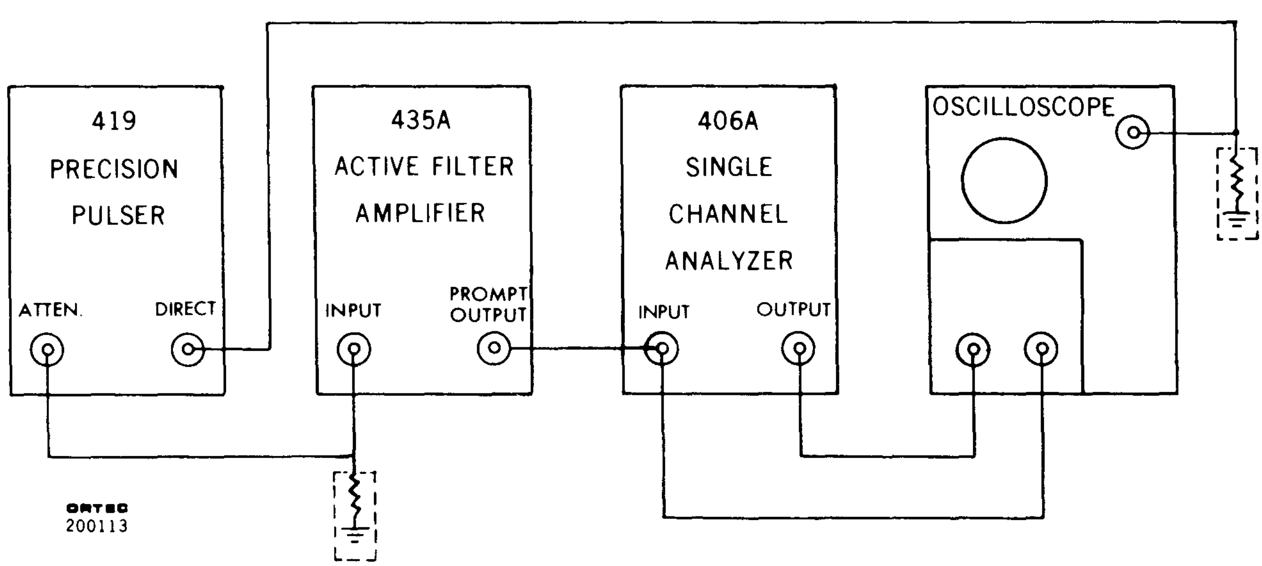


Figure 6-1. Test Setup

Set the 406A mode switch in the WINDOW position. Connect one oscilloscope probe to the front panel OUTPUT of the 406A. Observe that as the 419 PULSE HEIGHT dial is turned from 0V to 10V the 406A OUTPUT pulse just appears at 2V and disappears at 2.8V. Repeat this procedure for the NORMAL mode. Observe that in the NORMAL mode of operation the 406A OUTPUT pulse just appears at 2V and disappears at 8V.

6.2 Tabulated Test Point Voltages

The following voltages are intended to indicate maximum dc voltage variations as a means of fault detecting in the event of instrument failure. These voltages are recorded during the initial checkout of the instrument and placed on file for future reference.

Before making voltage checks, check to see that all 401A/402A line voltages are within 0.05 volts of their proper value. Next measure and record the following voltage using a digital voltmeter. Test points followed by a number (7), etc., indicate voltage test points marked on the printed circuit board. Set both UPPER and LOWER LEVEL dials on full scale and use the indicated positions of the mode switch.

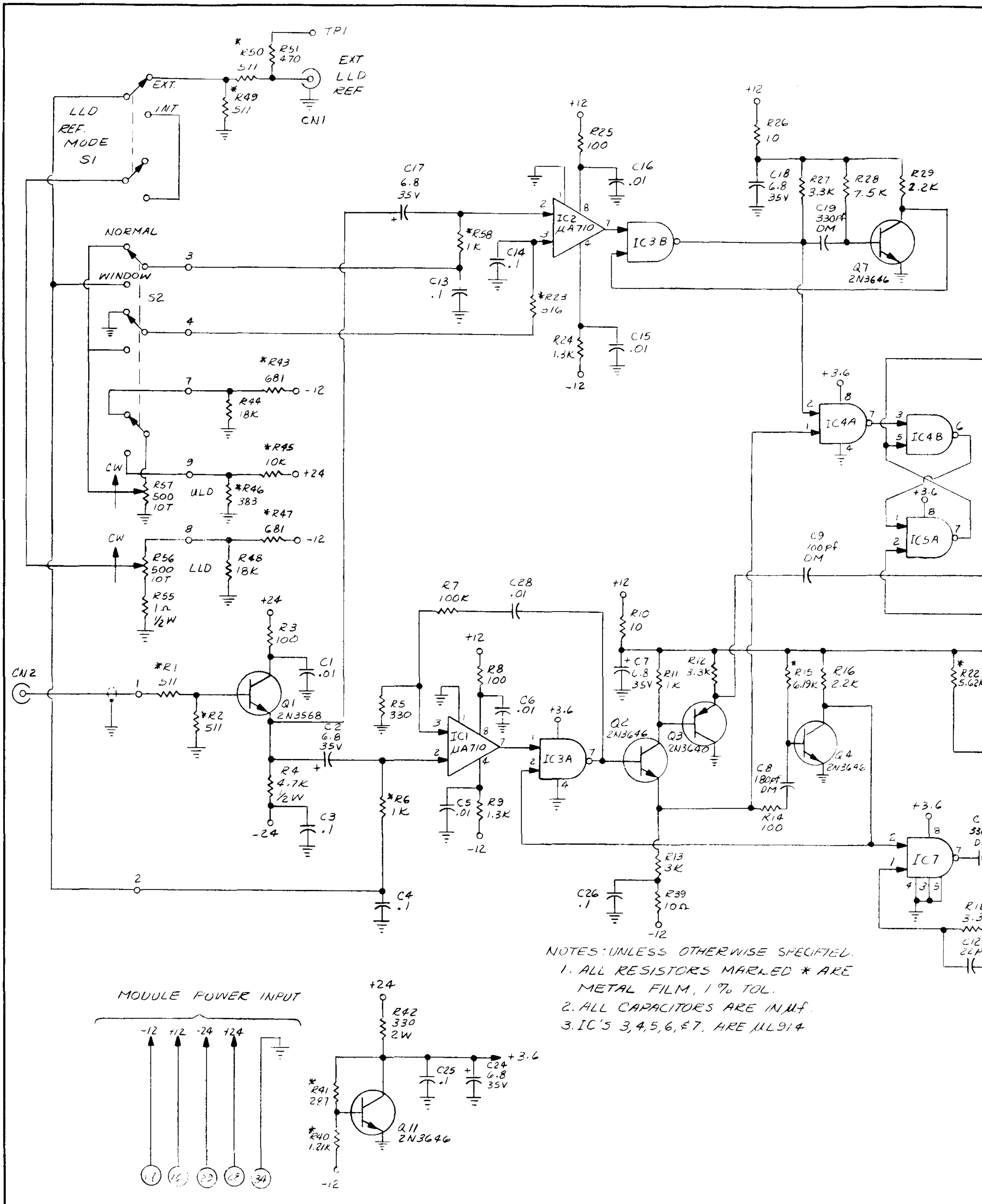
Test Point	Mode Switch	Average Voltages
Test Point 2	NORMAL-WINDOW	- 5.00
Test Point 3	NORMAL-WINDOW	- 5.00
Test Point 4	NORMAL	0.00
	WINDOW	+ 0.50
Pin 8 IC-1		+ 11.3
Pin 4 IC-1		- 6.2
Pin 8 IC-2		+ 11.3
Pin 4 IC-2		- 6.2
Collector Q11		+ 3.8

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	Carry No. 2
*10	+6 volts	32	Spare
*11	- 6 volts	*33	115 volts ac (Hot)
12	Reserved Bus	*34	Power Return Ground
13	Carry No. 1	35	Reset
14	Spare	36	Gate
15	Reserved	37	Spare
*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		

**These pins are installed and wired in parallel in the ORTEC 401A Modular System Bin.*

The transistor types installed in your instrument may differ from those shown in the schematic diagram. In such cases, necessary replacements can be made with either the type shown in the diagram or the type actually used in the instrument.

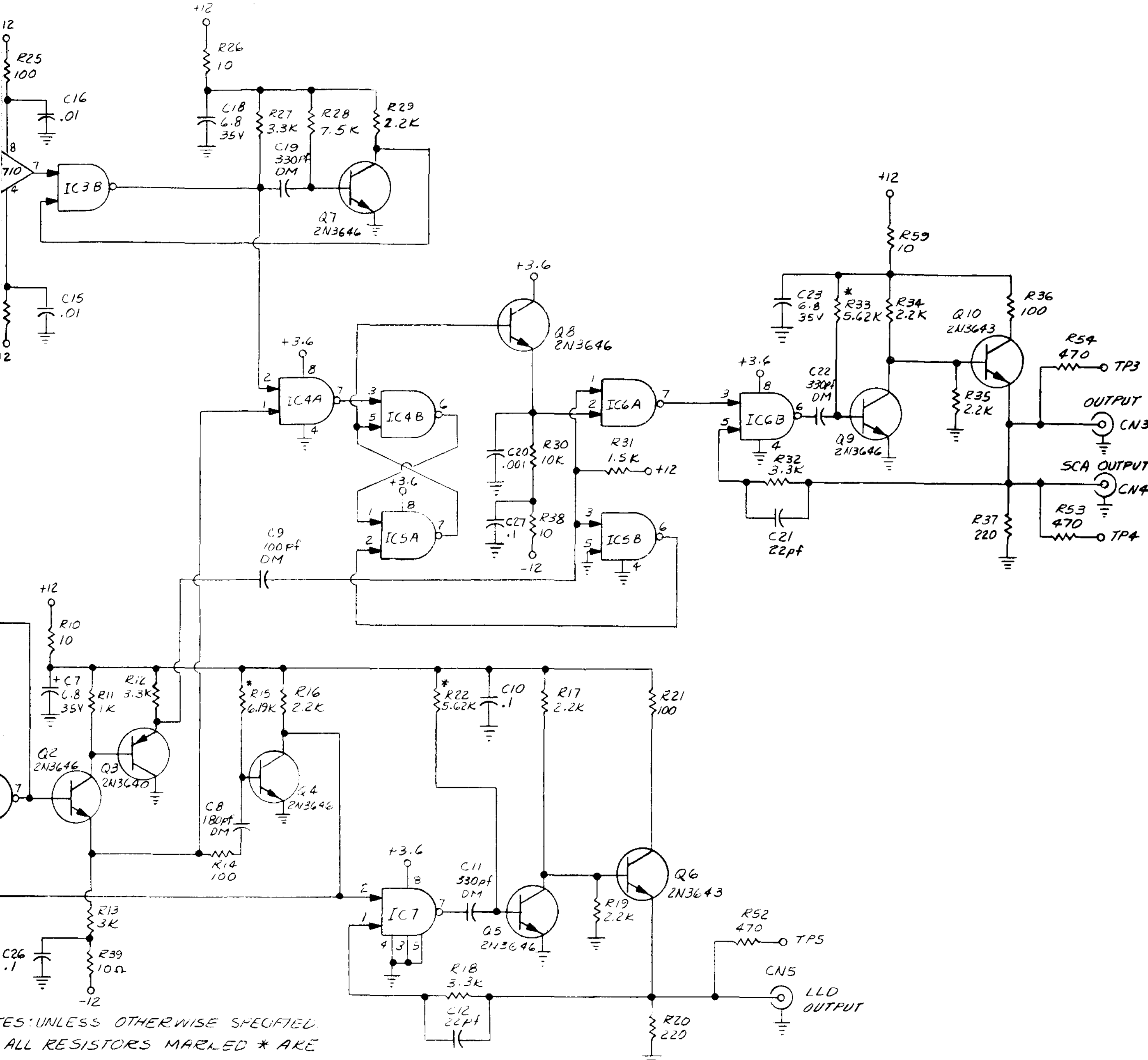


MODULE POWER INPUT

-12 +12 -24 +24

NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS MARKED * ARE METAL FILM, 1% TOL.
2. ALL CAPACITORS ARE IN μf.
3. IC'S 3, 4, 5, 6, & 7. ARE μL914



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- ALL CAPACITORS ARE IN µf.
- IC'S 3,4,5,6,&7. ARE µL914

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES TOLERANCES	ORTEC INCORPORATED
FRACTIONS ±1/64; DECIMALS XX ±.01 XXX ±.005; ANGLES ±0°30; FINISH √ RMS	100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830
MATERIAL	TITLE 406A SINGLE CHANNEL ANALYZER
DRAFTSMAN C.D. WEBB	RESPONSIBLE ENGINEER
CHECKED	ENG APPROVAL D. Britton DATE 7/11/68
SCALE	MFG APPROVAL MGN DATE 7-18-68
DWG ISSUED	RELEASED FOR MFG / DRAWING NO 406A-0101-S1

REVISIONS