GOOD ENOUGH
for
GOVERNMENT WORK BOX
A MANUAL
Instructions for a Black Box
Constructed by

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AN OPEN FILE REPORT
for the Geochemistry Section
Kansas Geological Survey

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"GOOD ENOUGH FOR GOVERNMENT WORK" Box
constructed by Rich Dalle-Molle, Dept. of Chemistry
University of Kansas, for the Kansas Geological Survey,
Geochemistry Section

GENERAL DESCRIPTION

The box has been designed to serve as an interface between the scanning monochromator attachment of the Survey's Inductively Coupled Argon Plasma (ICAP) Spectrometer and any standard 10 millivolt strip chart recorder.

The box allows both scanning and fixed wavelength measurement to be made. It provides twelve switch selectable gain settings and continuously adjustible signal offset control.

Two switch selectable filters are provided to aid in the reduction of PMT shot noise contributions.

CURRENT-TO-VOLTAGE TRANSDUCER

The current to voltage (I-V) transformation is performed by an operational amplifier "current follower". This circuit has three apparent advantages over the simpler "dropping resistor" circuits.

1. There is no possibility of loading the signal source.

2. The amplifier's response time is not diminished at high sensitivities.

3. The potential of the anode is held constant, independent of the signal, increasing the linearity of the response vs signal.

GAIN STAGES

This section is comprised of two amplifiers. The first amplifier is the same as the I-V transducer. This amplifier has a battery of six gain setting resistors which can be switched singly into place to provide gains of 1, 2.5, 5, 100, 250, and 500. The second amplifier provides a gain of either 1 or 10. The combination therefore, provides gains of x1, x2.5, x5, x10, x25, x50, x100, x250, x500, x1000, x2500, and x 5000.

The least sensitive (x1) would require an input current of 100 uAmps to give a full scale (10 mV) output to the strip chart recorder. The other scales provide increased sensitivity in proportion to their assigned values of gain.

OFFSET SECTION

The offset is generated as a current and is sent directly to the signal input of the box. This allows the full dynamic range of the box to be utilized even when offsetting large signals.

The offset is grossly adjusted by a 3-position switch which selects full scale offsets of 150 uAmps (x1), 1.5 uAmps (x10), and 15 uAmps (x100). Within each range, the offset is fine-adjusted by a 10-turn helipot. The offset adjustment extends below zero current so that zero may be accurately set. (For example, on the 150 uAmp scale, the offset may be adjusted over a range extending from -15 uAmps to +150 uAmps).

FILTER SECTION

Two filters are provided in the box. The first (corresponding to the 'out' position of the filter switch) is an active 3-pole filter with 'Bessell' type response having a maximum undamped frequency of about 2 Hz (-3Db pt. about 10 Hz). This filter is essentially 'invisible' when the box is used with a recorder of pen response of a half a second or slower. It should however, provide the strip chart recorder with functionally clean signals i.e., there should be no signals passed unattenuated from the box to which the

recorder cannot respond.

The second filter is a passive single-pole (R-C) filter with a nominal time constant of 3 seconds. This filter corresponds to the "in" position of the filter switch. This filter is provided to greatly attinuate signal noise in cases where frequency response of the system is not critical e.g., quantitative measurements at fixed wavelength.

Note that it will not be possible to scan spectra at any reasonable speed when this filter is engaged. The recorder pen will take about 12 to 15 seconds to settle after any change in signal intensity when using this option.

DIVIDER/"OUTPUT BUFFER SECTION

Since this box is intended to be used with 10 mV full scale recorders, and since the operational amplifiers used in this box are about 10 V. full scale devices, it was necessary to divide the output of the active filter section by 1000 to make the divices compatible. This is accomplished using a resistive voltage divider. Since the divider is susceptible to loading errors if too much current is drawn from it, a low input current amplifier is provided between the divider and the actual output line. This so-called buffer amplifier will provide sufficient current to drive any common strip chart recorder without any change of loading the divider and causing error.

OPERATING PROCEDURE

1. Plug the box into an outlet as close as possible (physically) to the outlets used for the strip chart recorder and the ICAP. This will tend to minimize "ground loop" currents flowing through the equipment.

2. Turn the box and strip chart recorder "on" and let them warm up for about 5 minutes.

3. Before hooking the box output to the strip chart recorder input, short the recorder's + and - inputs and zero the recorder. This should be the only time you will find it necessary to use the zero knob on the recorder. From now on use the offset adjust on the box to adjust the pen position.

4. Hook up the photomultiplier tube (PMT) input and 10 mV output.

5. Adjust the baseline as necessary with the offset control on the box, and you're ready to go!

It is suggested that you start the day with the offset switch in the '1' position, and the gain switch at '500' (x1). This should allow you to find 'zero' quickly and precisely.

The reason for zeroing the recorder prior to hooking up the box is that if the recorder 'zero' circuitry is very far off zero, you will have to nullify that offset using part of the box's output range. Doing so will limit the box's output range and may cause clipping of otherwise on-scale peaks.

The box's offset circuitry does not effect it's output range, and may thus be used with no sacrifice (and no clipping).

Power Supply →

SPECIFICATIONS
D-15-100

INPUT VOLTAGE AND FREQUENCY
105-125 VAC AT 50-440 Hz

OUTPUT VOLTAGE
14.85 — 15.15 Vdc

OUTPUT CURRENT
100 mA

REGULATION
LINE & LOAD 0.05%

TEMPERATURE COEFFICIENT
0.02%/°C

NOISE AND RIPPLE
1 mV RMS

TRANSIENT RESPONSE
8 μsec

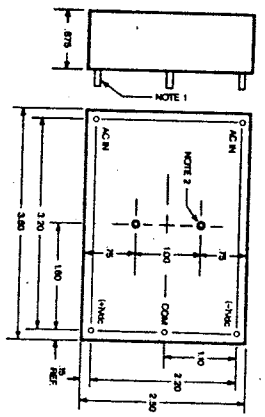
OUTPUT IMPEDANCE @ 30 KHz
200 Milliohms

OPERATING TEMPERATURE RANGE
-25°C TO +71°C

STORAGE TEMPERATURE RANGE
-25°C TO +85°C

SHORT CIRCUIT PROTECTED
YES

D-15-100
DUAL OUTPUTS



NOTES:

1. FIVE PINS GOLD PLATED 0.040 DIA X 0.20 LG
2. TWO MTG INSERTS 84-40 X 0.15 DP

CHEM 103

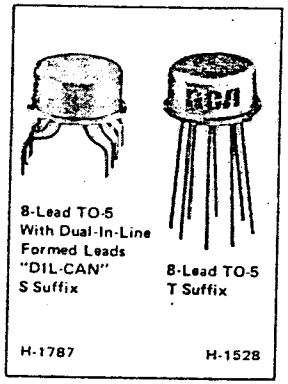
RCA Solid State Division

Linear Integrated Circuits

Monolithic Silicon

CA3140BT CA3140AT CA3140T
CA3140BS CA3140AS CA3140S

File Number 957



BiMOS Operational Amplifiers

With MOS/FET Input, Bipolar Output

Features:

- MOS/FET Input Stage
  - (a) Very high input impedance (Z_{IN}) — 1.5 TΩ typ.
  - (b) Very low input current (I_I) — 10 pA typ. at ± 15 V
  - (c) Low input-offset voltage (V_{IO}) — to 2 mV max.
  - (d) Wide common-mode input-voltage range (V_{ICR}) — can be swung 0.5 volt below negative supply-voltage rail
  - (e) Output swing complements input common-mode range
  - (f) Rugged input stage — bipolar diode protected
- Directly replaces industry type 741 in most applications

The CA3140B, CA3140A, and CA3140 are integrated-circuit operational amplifiers that combine the advantages of high-voltage PMOS transistors with high-voltage bipolar transistors on a single monolithic chip. Because of this unique combination of technologies, this device can now provide designers, for the first time, with the special performance features of the CA3130 COS/MOS operational amplifiers and the versatility of the 741 series of industry-standard operational amplifiers.

The CA3140, CA3140A, and CA3140 BiMOS operational amplifiers feature gate-protected MOS/FET (PMOS) transistors in the input circuit to provide very-high-input impedance, very-low-input current, and high-speed performance. The CA3140B operates at supply voltages from 4 to 44 volts; the CA3140A and CA3140 from 4 to 36 volts (either single or dual supply). These operational amplifiers are internally phase-compensated to achieve stable operation in unity-gain follower operation, and, additionally, have access terminals for a supplementary external capacitor if additional frequency roll-off is desired. Terminals are also provided for use in applications requiring input offset-voltage nulling.

The use of PMOS field-effect transistors in the input stage results in common-mode input-voltage capability down to 0.5 volt below the negative-supply terminal, an important attribute for single-supply applications. The output stage uses bipolar transistors and includes built-in protection against damage from load-terminal short-circuiting to either supply-rail or to ground.

The CA3140 Series has the same 8-lead terminal pin-out used for the "741" and other

- Includes numerous industry operational amplifier categories such as general-purpose, FET input, wideband (high slew rate)
- Operation from 4-to-44 volts Single or Dual supplies
- Internally compensated
- Characterized for ± 15-volt operation and for TTL supply systems with operation down to 4 volts
- Wide bandwidth — 4.5 MHz unity gain at ± 15 V or 30 V; 3.7 MHz at 5 V
- High voltage-follower slew rate — 9 V/μs
- Fast settling time — 1.4 μs typ. to 10 mV with a 10-V_{p-p} signal
- Output swings to within 0.2 volt of negative supply
- Strobable output stage

Applications:

- Ground-referenced single-supply amplifiers in automobile and portable instrumentation
- Sample and hold amplifiers
- Long-duration timers/multivibrators (microseconds—minutes—hours)
- Photocurrent instrumentation
- Peak detectors
- Active filters
- Comparators
- Interface in 5 V TTL systems & other low-supply voltage systems
- All standard operational amplifier applications
- Function generators
- Tone controls
- Power supplies
- Portable instruments
- Intrusion alarm systems

Printed in USA/5-76

Operational Amplifiers/Buffers

LM741/LM741A/LM741C/LM741E operational amplifier

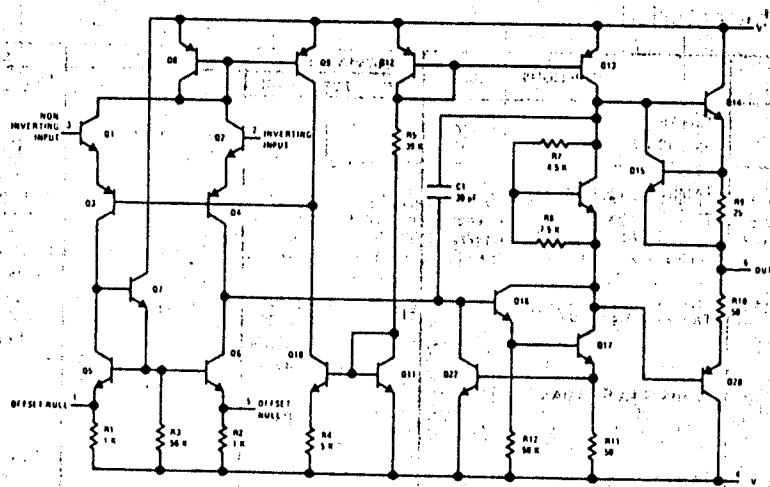
general description

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

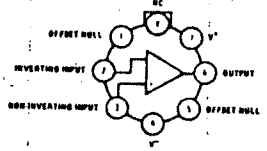
The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM741C/LM741E are identical to the LM741/LM741A except that the LM741C/LM741E have their performance guaranteed over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

schematic and connection diagrams (Top Views)



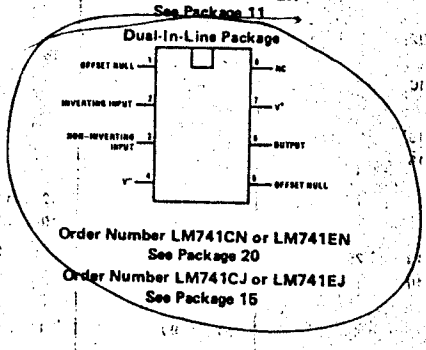
Metal Can Package



Note: Pin 4 connected to case.

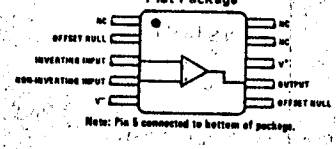
Order Number LM741H, LM741AH, LM741CH or LM741EH
See Package 11

Dual-In-Line Package



Order Number LM741CN or LM741EN
See Package 20
Order Number LM741CJ or LM741EJ
See Package 15

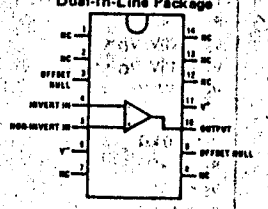
Flat Package



Note: Pin 5 connected to bottom of package.

Order Number LM741F or LM741AF
See Package 3

Dual-In-Line Package



Order Number LM741CD, LM741D, LM741AD or LM741ED
See Package 2B
Order Number LM741CN-14
See Package 22
Order Number LM741J-14, LM741AJ-14 LM741CJ-14 or LM741EJ-14
See Package 16

industry-standard operational amplifiers.They are supplied in either the standard 8-lead TO-5 style package (T suffix), or in the 8-lead dual-in-line formed-lead TO-5 style package "DIL-CAN" (S suffix). The CA3140B is intended for operation at supply voltages ranging from 4 to 44 volts, for applications requiring premium-grade specifications and with electrical limits established for operation over the range from −55°C to + 125°C. The CA3140A and CA3140 are for operation at supply voltages up to 36 volts (±18 volts). The CA3140 and CA3140A can also be operated safely over the temperature range from −55°C to + 125°C, although specification limits for their electrical parameters do not apply when they are operated beyond their specified temperature ranges.

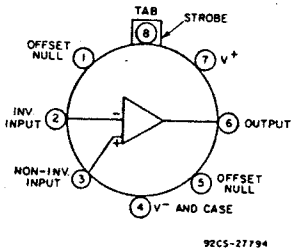


Fig.1 — Functional diagram of CA3140 series.

TYPICAL ELECTRICAL CHARACTERISTICS

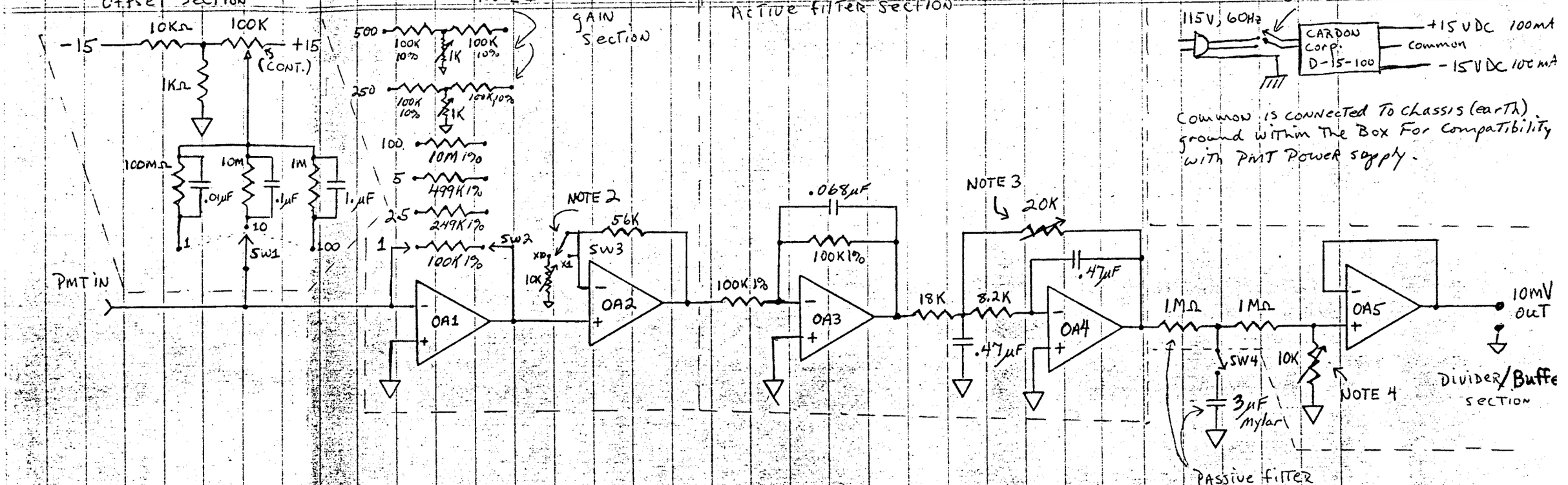
CHARACTERISTIC		TEST CONDITIONS V^+ = +15 V, V^- = −15 V, T_A = 25°C		CA3140B	CA3140A	CA3140	UNITS
Input Offset Voltage Adjustment Resistor		Typ.Value of Resistor Between Term. 4 and 5 or 4 and 1 to Adjust Max. V_{IO}		43	18	4.7	kΩ
Input Resistance	R_I			1.5	1.5	1.5	TΩ
Input Capacitance	C_I			4	4	4	pF
Output Resistance	R_O			60	60	60	Ω
Equivalent Wideband Input Noise Voltage (See Fig.41)	e_n	BW = 140 kHz, R_S = 1 MΩ		48	48	48	μV
Equivalent Input Noise Voltage (See Fig.10)	e_n	f = 1 kHz	R_S = 100 Ω	40	40	40	nV/√Hz
		f = 10 kHz		12	12	12	
Short-Circuit Current to Opposite Supply	Source I_{OM^+}			40	40	40	mA
	Sink I_{OM^-}			18	18	18	mA
Gain-Bandwidth Product, (See Figs. 5 &18)	f_T			4.5	4.5	4.5	MHz
Slew Rate, (See Fig.6)	SR			9	9	9	V/μs
Sink Current From Terminal 8 To Terminal 4 to Swing Output Low				220	220	220	μA
Transient Response: Rise Time	t_r	R_L = 2 kΩ, C_L = 100 pF		0.08	0.08	0.08	μs
Overshoot (See Fig. 40)				10	10	10	%
Settling Time at 10 V_{p-p}, (See Fig.17)	1 mV / 10 mV t_s	R_L = 2 kΩ, C_L = 100 pF, Voltage Follower		4.5	4.5	4.5	μs
				1.4	1.4	1.4	

ELECTRICAL CHARACTERISTICS FOR EQUIPMENT DESIGN

At V^+ = 15 V, V^- = 15 V, T_A = 25°C Unless Otherwise Specified

CHARACTERISTIC	CA3140B Min.	CA3140B Typ.	CA3140B Max.	CA3140A Min.	CA3140A Typ.	CA3140A Max.	CA3140 Min.	CA3140 Typ.	CA3140 Max.	UNITS
Input Offset Voltage, $\|V_{IO}\|$	–	0.8	2	–	2	5	–	5	15	mV
Input Offset Current, $\|I_{IO}\|$	–	0.5	10	–	0.5	20	–	0.5	30	pA
Input Current, I_I	–	10	30	–	10	40	–	10	50	pA
Large-Signal Voltage Gain, A_{OL}●	50 k	100 k	–	20 k	100 k	–	20 k	100 k	–	V/V
(See Figs. 4,18)	94	100	–	86	100	–	86	100	–	dB
Common-Mode Rejection Ratio, CMRR	–	20	50	–	32	320	–	32	320	μV/V
(See Fig.9)	86	94	–	70	90	–	70	90	–	dB
Common-Mode Input-Voltage Range, V_{ICR} (See Fig.20)	−15	−15.5 to +12.5	12	−15	−15.5 to +12.5	12	−15	−15.5 to +12.5	11	V
Power-Supply Rejection Ratio, PSRR $\Delta V_{IO}/\Delta V$	–	32	100	–	100	150	–	100	150	μV/V
(See Fig.11)	80	90	–	76	80	–	76	80	–	dB
Max. Output Voltage■ V_{OM^+}	+12	13	–	+12	13	–	+12	13	–	V
(See Figs.13,20) V_{OM^-}	−14	−14.4	–	−14	−14.4	–	−14	−14.4	–	
Supply Current, I^+ (See Fig.7)	–	4	6	–	4	6	–	4	6	mA
Device Dissipation, P_D	–	120	180	–	120	180	–	120	180	mW
Input Current, I_I▲ (See Fig.19)	–	10	30	–	10	–	–	10	–	nA
Input Offset Voltage V_{IO}▲	–	1.3	3	–	3	–	–	10	–	mV
Large-Signal Voltage Gain, A_{OL}▲	20 k	100 k	–	–	100 k	–	–	100 k	–	V/V
(See Figs.4,18)	86	100	–	–	100	–	–	100	–	dB
Max. Output Voltage,★ V_{OM^+}	+19	+19.5	–	–	–	–	–	–	–	V
V_{OM^-}	−21	−21.4	–	–	–	–	–	–	–	
Large-Signal Voltage Gain, A_{OL}♦★	20 k	50 k	–	–	–	–	–	–	–	V/V
	86	94	–	–	–	–	–	–	–	dB

● At V_O = 26V_{p-p}, +12V, −14V and R_L = 2 kΩ.
■ At R_L = 2 kΩ.
▲ At T_A = −55°C to +125°C, V^+ = 15 V, V^- = 15 V, V_O = 26V_{p-p}, R_L = 2 kΩ.
★ At V^+ = 22 V, V^- = 22 V.
♦ At V_O = +19 V, −21 V, and R_L = 2 kΩ.



NOTE 1: Equivalent Resistance for position "250" is 25 MΩ; For "500", 50MΩ. 1K Variable resistor used to trim circuit to exact value desired.

$$R_{xy} = \frac{R_A \cdot R_B}{R_C} + R_A + R_B$$

NOTE 2

10K Variable resistor trimmed to give exact gain of 10 when switch SW3 is in X10 position. Switch shorted to (−) input in X1 position

NOTE 3

20K variable resista trimmed to give exact

NOTE 4

10K Variable resistor trimmed to divide output of OA4 by exactly 1000.

OA1, OA2, OA5	CA3140 (RCA)
OA3, OA4	741 (Teledyne)
SW1, SW2	Centralab SP3T, DP6T
SW3, SW4	Subminiature SPDT
SW5	Subminiature DPDT

all OA's powered by ±15V. Power Supply bypassed AT EACH OA power pin by .1μF ceramic capicitor. Each OA is offset Nulled w/ 10K-1-turn pot.

6-11-78

RDM