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OPERATIONAL AMPLIFIER SUPPLY REJECTION TEST

Purpose: To determine the affect of asymmetric power supply variation on the + and - regions of the characteristic curves for analog devices amplifiers 120A and μA741C.

I. 120A: A conventional operational amplifier feedback circuit was employed with a gain of ten.

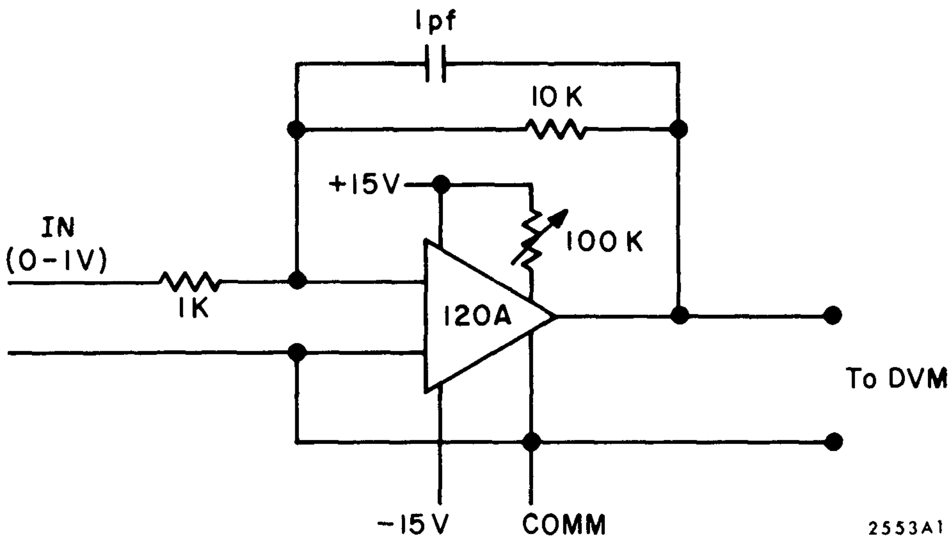


Figure 1

The power supply was provided by two Power Design DC precision power sources, tied together in common,with each side separately variable to ±20V. The input was a DC calibration reference standard varied between 0 and 2 volts. The output was measured by a Hewlett Packard integrating digital voltmeter sampling at a rate of once per second. The region of linearity, under symmetrical power supply voltage measured as a function of supply voltage is shown in Figure 2.

The 120A was subject to an uncontrollable temperature drift that introduced an offset voltage to the input. The effect of this drift will be handled as an error and discussed in a following section.

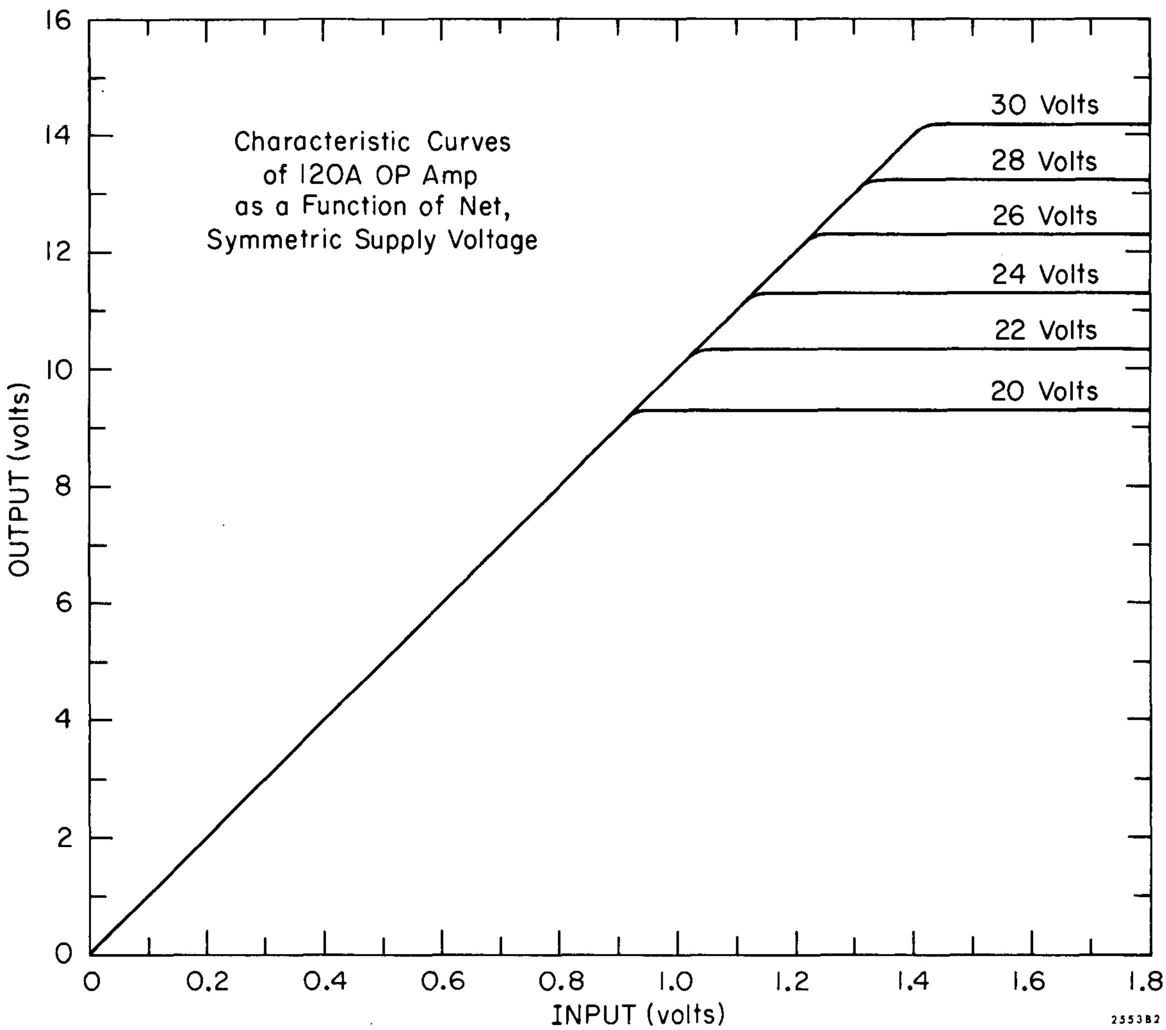

16
14
12
10
8
6
4
2
0
OUTPUT (volts)
Characteristic Curves
of 120A OP Amp
as a Function of Net,
Symmetric Supply Voltage
30 Volts
28 Volts
26 Volts
24 Volts
22 Volts
20 Volts
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
INPUT (volts)
255382

Figure 2 -

Power supply variation and readout: The + and - DC supplies could be varied symmetrically or asymmetrically to within -001 volt, with by (1) preserving the total 30 volt operating bias across the device (the 120A specs call for 30-32 volts) or (2) by varying the net power supply voltage by as much as 30%. Under both of these conditions, input voltage over + and - linear regions was plotted against output voltage. Circuit and DVM drift was minimized by two hour warming periods before the reading of any data, and the calibration of the DVM was checked for consistency throughout the experimental runs.

Power voltages were varied asymmetrically with a constant 30 volt supply: -15.5, +14.5; -16, +14; -16.5, +13.5 and -17, +13 volts... and asymmetrically with a variable supply: +15, -14.5, +15, -14.0; +15, -13.5 and +15, -13 , a maximum variation of 20% in the net supply voltage.

Extreme variations both above and below this point were made. At the inferior voltages, the effect on the characteristic curve was to decrease the linear region by a voltage proportional to the decrease in the net supply voltage below some constant amount, roughly 30%. All power supply variations discussed hereafter were less than this amount.

Error: There were four sources of measurable error. (1) "Background" error in the DVM, amounting to $\pm$ .0001 volt, the highest resolution of the instrument; (2) DC calibration reference standard polarity error, due to either the DC source or the DVM, measured as the uncertainty in saying $+V_i = -V_i$ for any voltage input into the amplifier, = $\pm$ .0002 volts; (3) error in zero calibration due to temperature drift: as great as $\pm$ .0013 volts, with a wide standard deviation over the range of the experiment. The drift required a resetting of the zero point in the amplifier after each measurement of the characteristic curve. The fluctuation in the values of "residual" voltage left at the zero input of the amplifier can be taken as an estimate of the random error component, whatever systematic shift of output voltage with temperature is involved. The magnitude of this random error is no larger than .0012 volt. (4) A permanent offset existed between

+ and - input voltages due only to the amplifier itself. The magnitude of the offset had a maximum value of .0017 and a mean value of about .0010 - it was therefore difficult to distinguish it from temperature drift. This offset did not appear to be a function of changes in power supply.

Results: For the specific variations in power supply listed earlier, and for a specific input voltage of a given polarity, the greatest deviation in output voltage from the linear for any supply voltage change was .014 volts.

Between input polarities, the largest variation from the linear for any change in power supply voltage was .0017 volts in amplifier output.

Since these mganitudes are in line with the magnitudes of two possible sources of error, they are not considered significant. Both temperature drift and +, - voltage offset account for the size of the differences between characteristic curves measured for different power supply voltages. Variations in the data gathering were tried, for instance measuring $\pm V_i$ pairwise during a small time interval of ~ 5 seconds was one attempt to neutralize temperature drift errors. Usually a substantial fraction of the original difference between $+ V_i$ and $- V_i$, measured over a longer time interval, resulted, and $(+ V_i) - (- V_i)$ was usually never larger than .0010 volt.

The fact that all of these uncertainties are the same order of magnitude as the random error in the output calibration supports the conclusion that there are no significant changes in characteristic curves due to asymmetric shifts in power supply by as much as 20%.

II. <u>μA741C</u>:

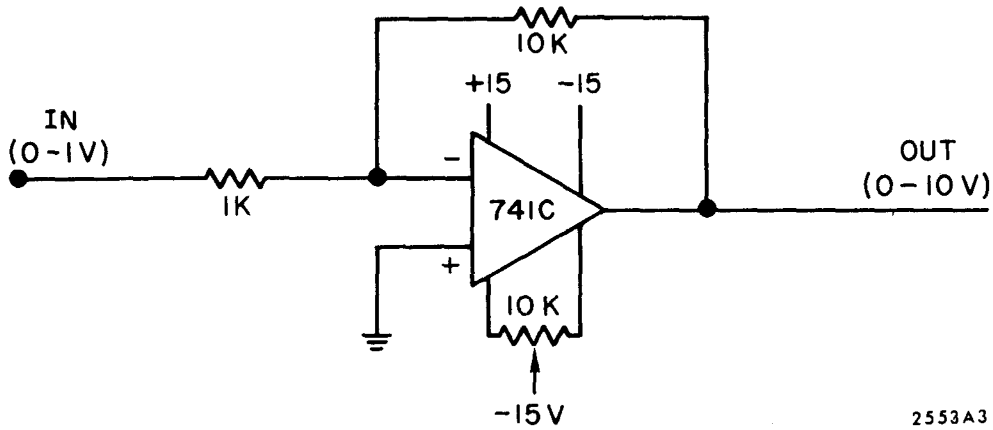


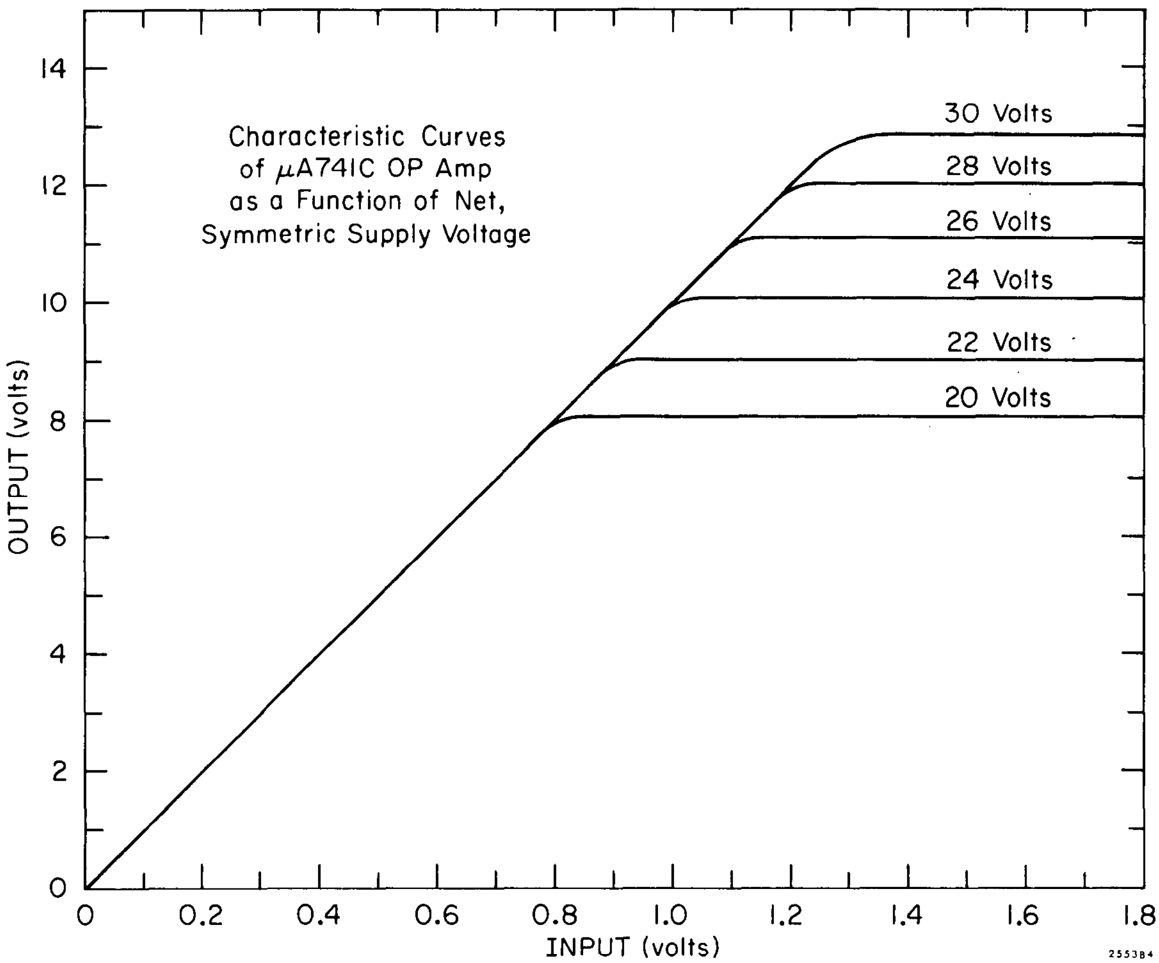
Figure 3

(See characteristic curves Figure 4.)

A gain of 10 was again employed over an input range of 0-1 volt. While the 120A exhibited temperature drift over even short time intervals of a few seconds, the μA741C was stable under wide temperature changes, for long periods of time. Under steady input and power supply conditions, the drift error in the time span of hours was no larger than the $\pm$.0001 V instability in the DVM. This fact reduced the greatest uncertainty in the measurements, and increased the significance of the results for this particular device.

The same variations in power supply used for the 120A were repeated. Sources of error in each of the experiments were three: (1) Background DVM uncertainty of $\pm$.0001 volt; (2) polarity error due to calibration standard and DVM, $\pm$ .0002 volt; and (3) a voltage offset between + and - outputs due just to the device itself, no larger than .0013V. The latter voltage offset, again, was not influenced by changes in power supply.

Without temperature drift effects, the data taken from the μA741C were much more stable than for the 120A. Over periods of hours, without any adjustment of the zero point, the same characteristic curves could be replicated.


Characteristic Curves
of μA741C OP Amp
as a Function of Net,
Symmetric Supply Voltage
30 Volts
28 Volts
26 Volts
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22 Volts
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OUTPUT (volts)
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
INPUT (volts)
255384

Figure 4 -

Results: For the same variations of power supply listed for the 120A, and for a specific input voltage of a given polarity, the greatest deviation in output voltage from the linear predicted value was $\pm$ .0003 volts.

Between input polarities, the greatest deviation $(+V_i) - (-V_i)$ from linearity was $\pm$.0013 V. This offset was not a function of changing power supply conditions, but could be expressed as a linear function of the input voltage, and was always the order of microvolts.

In other words, for any power supply variation tested, the characteristic curve could always be predicted as the sum of (1) the linear gain of the amplifier with a gain factor of 10, (2) a linear offset factor with a gain of about .00001 volt per volt input in the direction of negative output voltage, and (3) an error attributed to the instrumentation no larger than $\pm$.0002 volts.