μA725
INSTRUMENTATION OPERATIONAL AMPLIFIER
FAIRCHILD LINEAR INTEGRATED CIRCUITS

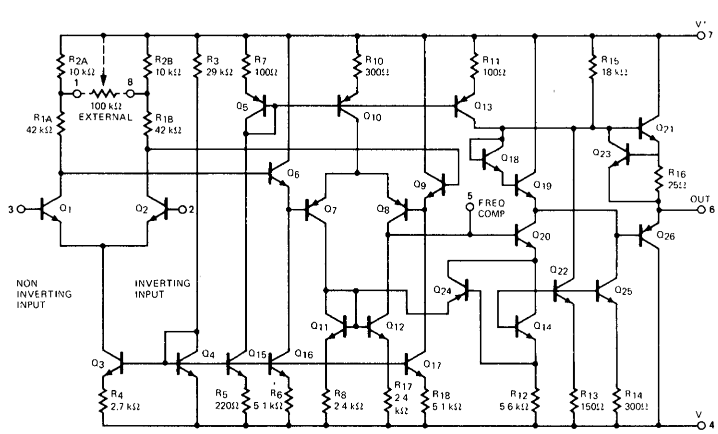
GENERAL DESCRIPTION – The μA725 is an instrumentation operational amplifier constructed on a single silicon chip using the Fairchild Planar* epitaxial process. It is intended for precise, low level signal amplification applications where low noise, low drift and accurate closed loop gain are required. The offset null capability, low power consumption, very high voltage gain as well as wide power supply voltage range provide superior performance for a wide range of instrumentation applications. The μA725 is pin compatible with the popular μA741 operational amplifier.

- **LOW INPUT NOISE CURRENT . . . . . . 0.15 pA √Hz**
- **HIGH OPEN LOOP GAIN 3,000,000**
- **LOW INPUT OFFSET CURRENT . . . . . 2 nA**
- **LOW INPUT VOLTAGE DRIFT . . . . . . 0.6 μV/°C**
- **HIGH COMMON MODE REJECTION . . . 120 dB**
- **HIGH INPUT VOLTAGE RANGE . . . . . ±14 V**
- **WIDE POWER SUPPLY RANGE . . . . . . ±3 V TO ±22 V**
- **OFFSET NULL CAPABILITY**

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±22 V
Internal Power Dissipation (Note 1)	
Metal Can	500 mW
Ceramic DIP	670 mW
Differential Input Voltage (Note 2)	±22 V
Input Voltage (Note 3)	±22 V
Voltage Between Offset Null and V^+	±0.5 V
Storage Temperature Range	
Metal Can, Ceramic DIP	−65°C to +150°C
Operating Temperature Range	
Military (312 grade)	−55°C to +125°C
Instrument (333 grade)	−20°C to +85°C
Commercial (393 grade)	0°C to +70°C
Lead Temperature	
Metal Can, Ceramic DIP (Soldering, 60 Seconds)	300°C

EQUIVALENT CIRCUIT

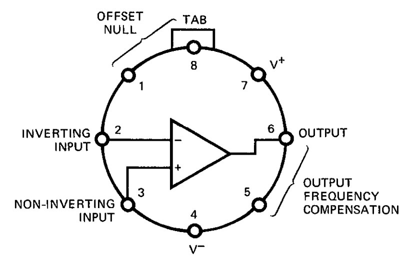


Pin numbers are shown for Metal Can only.

Notes on following pages.

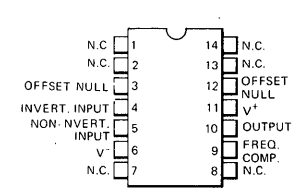
CONNECTION DIAGRAM

8 LEAD METAL CAN
(TOP VIEW)



ORDER PART NOS.:
U5T7725312
U5T7725333
U5T7725393

14 LEAD DIP
(TOP VIEW)



FOR CERAMIC DIP
ORDER PART NOS.:
U6A7725312
U6A7725333
U6A7725393

*Planar is a patented Fairchild process.

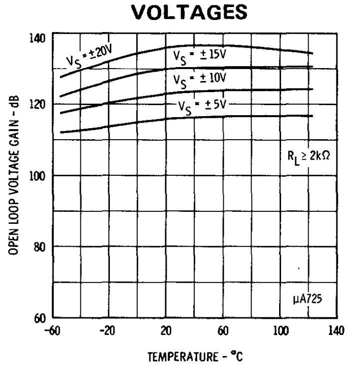
312 GRADE

ELECTRICAL CHARACTERISTICS (V_S = ±15 V, T_A = 25°C unless otherwise specified)

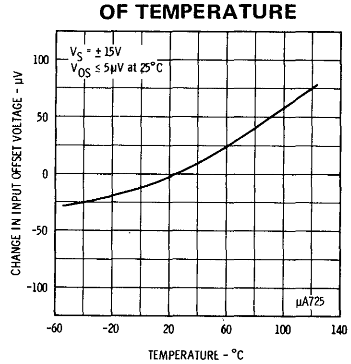
PARAMETER	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage (Without external trim)	$R_S \leq 10$ kΩ		0.5	1.0	mV
Input Offset Current			2.0	20	nA
Input Bias Current			42	100	nA
Input Noise Voltage	f_o = 10 Hz		15		nV/ $\sqrt{Hz}$
	f_o = 100 Hz		9.0		nV/ $\sqrt{Hz}$
	f_o = 1 kHz		8.0		nV/ $\sqrt{Hz}$
Input Noise Current	f_o = 10 Hz		1.0		pA/ $\sqrt{Hz}$
	f_o = 100 Hz		0.3		pA/ $\sqrt{Hz}$
	f_o = 1 kHz		0.15		pA/ $\sqrt{Hz}$
Input Resistance			1.5		MΩ
Input Voltage Range		±13.5	±14		V
Large Signal Voltage Gain	$R_L \geq$ 2 kΩ V_O = ±10 V	1,000,000	3,000,000		V/V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	110	120		dB
Power Supply Rejection Ratio	$R_S \leq 10$ kΩ		2.0	10	µV/V
Output Voltage Swing	$R_L \geq 10$ kΩ	±12	±13.5		V
	$R_L \geq$ 2 kΩ	±10	±13.5		V
Output Resistance			150		Ω
Power Consumption			80	105	mW
The following specifications apply for $-55°C \leq T_A \leq +125°C$ unless otherwise specified:					
Input Offset Voltage (Without external trim)	$R_S \leq 10$ kΩ			1.5	mV
Average Input Offset Voltage Drift (Without external trim)	R_S = 50Ω		2.0	5.0	µV/°C
Average Input Offset Voltage Drift (With external trim)	R_S = 50Ω		0.6		µV/°C
Input Offset Current	T_A = +125°C		1.2	20	nA
	T_A = −55°C		7.5	40	nA
Average Input Offset Current Drift			35	150	pA/°C
Input Bias Current	T_A = +125°C		20	100	nA
	T_A = −55°C		80	200	nA
Large Signal Voltage Gain	$R_L \geq 2$ kΩ, T_A = +125°C	1,000,000			V/V
	$R_L \geq 2$ kΩ, T_A = −55°C	250,000			V/V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	100			dB
	$R_S \leq 10$ kΩ			20	µV/V
	$R_L \geq$ 2 kΩ	±10			V

TYPICAL PERFORMANCE CURVES
312 GRADE

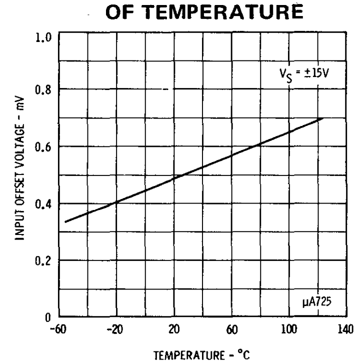
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF TEMPERATURE FOR VARIOUS SUPPLY VOLTAGES



NULLED INPUT OFFSET VOLTAGE AS A FUNCTION OF TEMPERATURE



UNNULLED INPUT OFFSET VOLTAGE AS A FUNCTION OF TEMPERATURE



333 GRADE

ELECTRICAL CHARACTERISTICS ($V_S = \pm 15$ V, $T_A = 25°C$ unless otherwise specified)

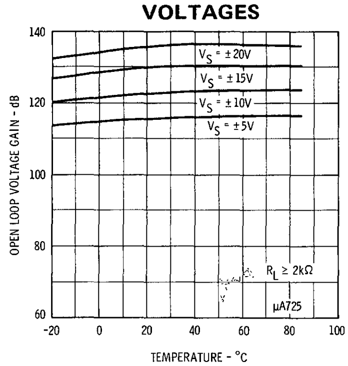
PARAMETER	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage (Without external trim)	$R_S \leq 10\ k\Omega$		0.5	1.5	mV
Input Offset Current			2.0	20	nA
Input Bias Current			50	100	nA
Input Noise Voltage	$f_o = 10$ Hz		15		$nV/\sqrt{Hz}$
	$f_o = 100$ Hz		12		$nV/\sqrt{Hz}$
	$f_o = 1$ kHz		8.0		$nV/\sqrt{Hz}$
Input Noise Current	$f_o = 10$ Hz		1.0		$pA/\sqrt{Hz}$
	$f_o = 100$ Hz		0.8		$pA/\sqrt{Hz}$
	$f_o = 1$ kHz		0.6		$pA/\sqrt{Hz}$
Input Resistance			1.5		MΩ
Input Voltage Range		±13.5	±14		V
Large Signal Voltage Gain	$R_L \geq 2\ k\Omega$, $V_{OUT} = \pm 10$ V	500,000	3,000,000		V/V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	100	120		dB
Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$		2.0	10	µV/V
Output Voltage Swing	$R_L \geq 10\ k\Omega$	±12	±13.5		V
	$R_L \geq 2\ k\Omega$	±10	±13.5		V
Output Resistance			150		Ω
Power Consumption			80	120	mW
The following specifications apply for $-20°C \leq T_A \leq +85°C$ unless otherwise specified:					
Input Offset Voltage (Without external trim)	$R_S \leq 10\ k\Omega$			2.5	mV
Average Input Offset Voltage Drift (Without external trim)	$R_S = 50\Omega$		2.0	10	µV/°C
Average Input Offset Voltage Drift (With external trim)	$R_S = 50\Omega$		0.6		µV/°C
Input Offset Current	$T_A = +85°C$		2.0	20	nA
	$T_A = -20°C$		5.0	40	nA
Average Input Offset Current Drift				300	pA/°C
Input Bias Current	$T_A = +85°C$			100	nA
	$T_A = -20°C$			200	nA
Large Signal Voltage Gain	$R_L \geq 2\ k\Omega$, $T_A = +85°C$	500,000			V/V
	$R_L \geq 2\ k\Omega$, $T_A = -20°C$	250,000			V/V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	100			dB
Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$			20	µV/V
Output Voltage Swing	$R_L \geq 2\ k\Omega$	±10			V

NOTES

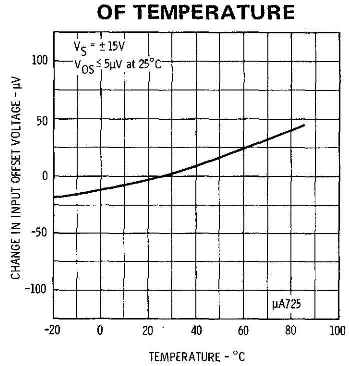
1. Rating applies to ambient temperatures up to 70°C. Above 70°C ambient derate linearly at 6.3 mW/°C for Metal Can and 8.3 mW/°C for Ceramic DIP package.
2. Rating applies for 5 ms pulses with 10% duty cycle, derate to ±5 V for continuous operation.
3. For supply voltages less than ±22 V, the absolute maximum input voltage is equal to the supply voltage.

TYPICAL PERFORMANCE CURVES
333 GRADE

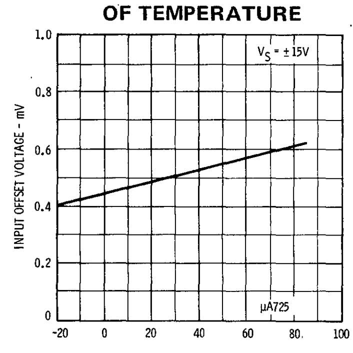
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF TEMPERATURE FOR VARIOUS SUPPLY VOLTAGES



NULLED INPUT OFFSET VOLTAGE AS A FUNCTION OF TEMPERATURE



UNNULLED INPUT OFFSET VOLTAGE AS A FUNCTION OF TEMPERATURE



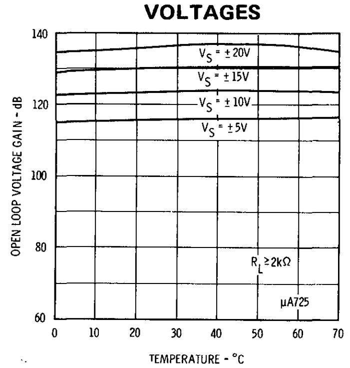
393 GRADE

ELECTRICAL CHARACTERISTICS (V_S = ±15 V, T_A = 25°C unless otherwise specified)

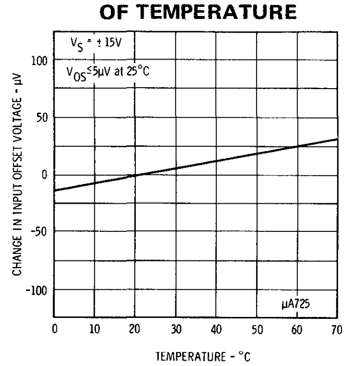
PARAMETER	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage (Without external trim)	$R_S \leq 10$ kΩ		0.5	2.5	mV
Input Offset Current			2.0	35	nA
Input Bias Current			42	125	nA
Input Noise Voltage	f_o = 10 Hz		15		nV/ $\sqrt{Hz}$
	f_o = 100 Hz		9.0		nV/ $\sqrt{Hz}$
	f_o = 1 kHz		8.0		nV/ $\sqrt{Hz}$
Input Noise Current	f_o = 10 Hz		1.0		pA/ $\sqrt{Hz}$
	f_o = 100 Hz		0.3		pA/ $\sqrt{Hz}$
	f_o = 1 kHz		0.15		pA/ $\sqrt{Hz}$
Input Resistance			1.5		MΩ
Input Voltage Range		±13.5	±14		V
Large Signal Voltage Gain	$R_L \geq 2$ kΩ, V_{OUT} = ±10 V	250,000	3,000,000		V/V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	94	120		dB
Power Supply Rejection Ratio	$R_S \leq 10$ kΩ		2.0	35	μV/V
Output Voltage Swing	$R_L \geq 10$ kΩ	±12	±13.5		V
	$R_L \geq 2$ kΩ	±10	±13.5		V
Output Resistance			150		Ω
Power Consumption			80	150	mW
The following specifications apply for 0°C ≤ T_A ≤ +70°C unless otherwise specified:					
Input Offset Voltage (Without external trim)	$R_S \leq 10$ kΩ			3.5	mV
Average Input Offset Voltage Drift (Without external trim)	R_S = 50Ω		2.0		μV/°C
Average Input Offset Voltage Drift (With external trim)	R_S = 50Ω		0.6		μV/°C
Input Offset Current	T_A = +70°C		1.2	35	nA
	T_A = 0°C		4.0	50	nA
Average Input Offset Current Drift			10		pA/°C
Input Bias Current	T_A = +70°C			125	nA
	T_A = 0°C			250	nA
Large Signal Voltage	$R_L \geq 2$ kΩ, T_A = +70°	125,000			V/ V
	$R_L \geq 2$ kΩ, T_A = 0°C	125,000			V/ V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ		115		dB
Power Supply Rejection Ratio	$R_S \leq 10$ kΩ		20		μV/V
Output Voltage Swing	$R_L \geq 2$ kΩ	±10			V

TYPICAL PERFORMANCE CURVES 393 GRADE

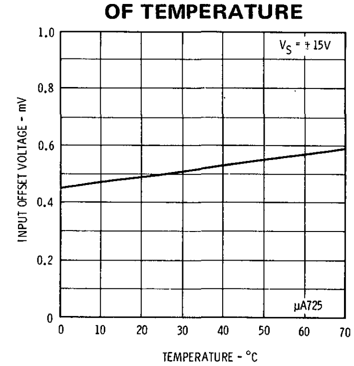
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF TEMPERATURE FOR VARIOUS SUPPLY VOLTAGES



NULLED INPUT OFFSET VOLTAGE AS A FUNCTION OF TEMPERATURE

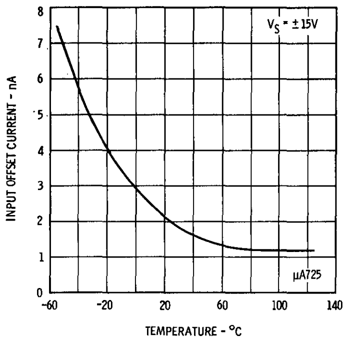


UNNULLED INPUT OFFSET VOLTAGE AS A FUNCTION OF TEMPERATURE

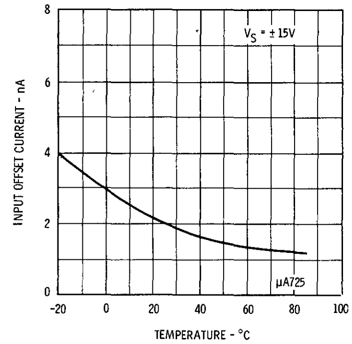


TYPICAL PERFORMANCE CURVES FOR ALL GRADES (Unless Otherwise Specified)

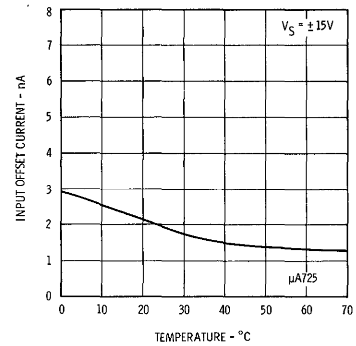
INPUT OFFSET CURRENT AS A FUNCTION OF TEMPERATURE 312 GRADE



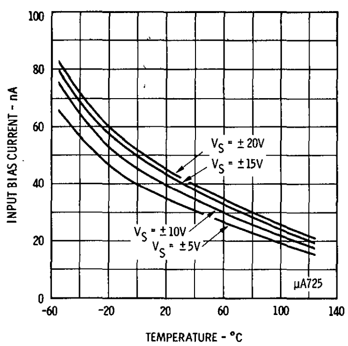
INPUT OFFSET CURRENT AS A FUNCTION OF TEMPERATURE 333 GRADE



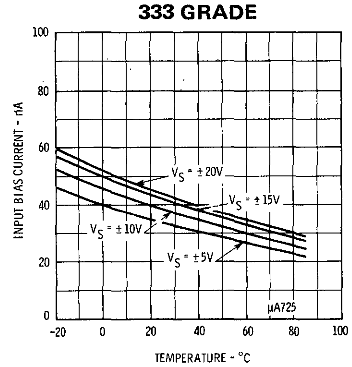
INPUT OFFSET CURRENT AS A FUNCTION OF TEMPERATURE 393 GRADE



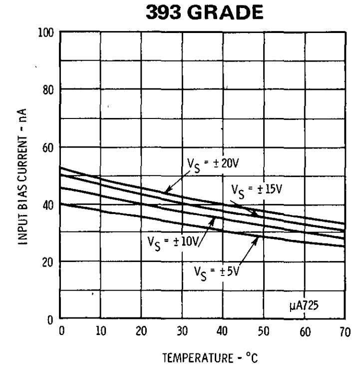
INPUT BIAS CURRENT AS A FUNCTION OF TEMPERATURE 312 GRADE



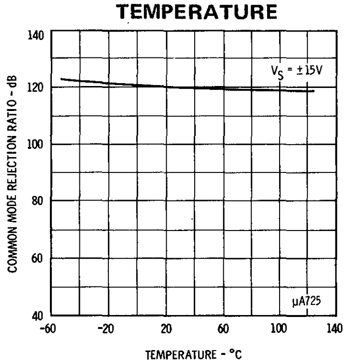
INPUT BIAS CURRENT AS A FUNCTION OF TEMPERATURE 333 GRADE



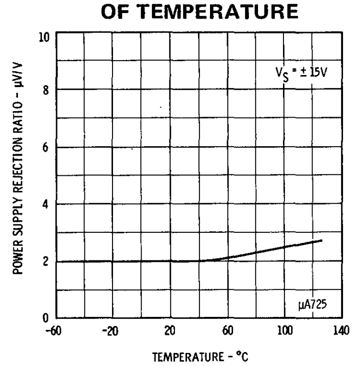
INPUT BIAS CURRENT AS A FUNCTION OF TEMPERATURE 393 GRADE



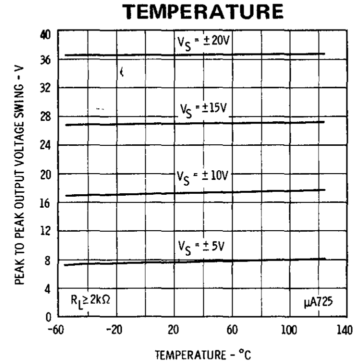
COMMON MODE REJECTION RATIO AS A FUNCTION OF TEMPERATURE



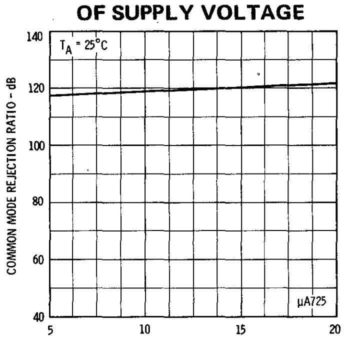
SUPPLY VOLTAGE REJECTION RATIO AS A FUNCTION OF TEMPERATURE



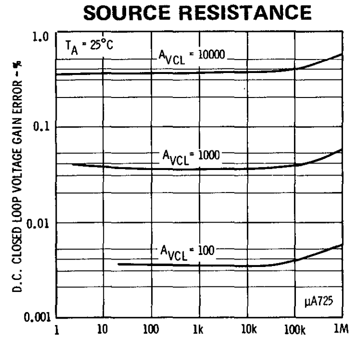
OUTPUT VOLTAGE SWING AS A FUNCTION OF TEMPERATURE



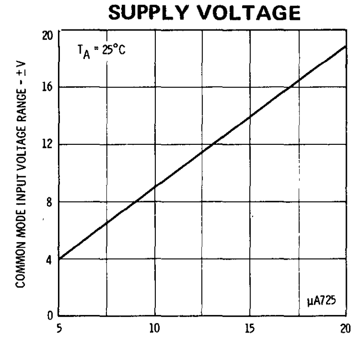
COMMON MODE REJECTION RATIO AS A FUNCTION OF SUPPLY VOLTAGE



D.C. CLOSED LOOP VOLTAGE GAIN ERROR AS A FUNCTION OF SOURCE RESISTANCE

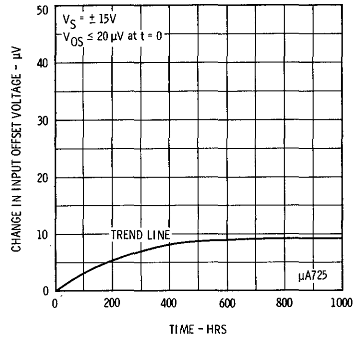


COMMON MODE INPUT VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE

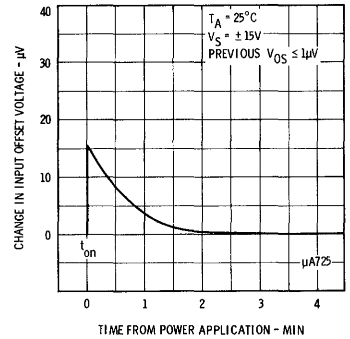


TYPICAL PERFORMANCE CURVES FOR ALL GRADES (Unless Otherwise Specified)

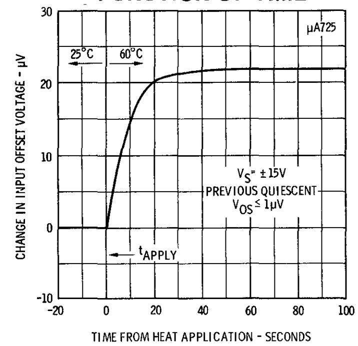
INPUT OFFSET VOLTAGE DRIFT AS A FUNCTION OF TIME



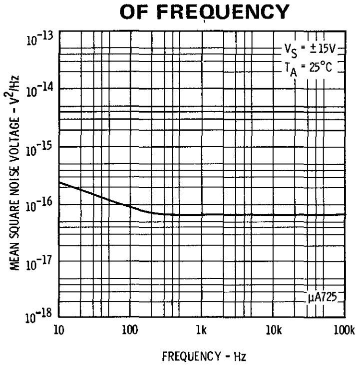
STABILIZATION TIME OF INPUT OFFSET VOLTAGE FROM POWER TURN-ON



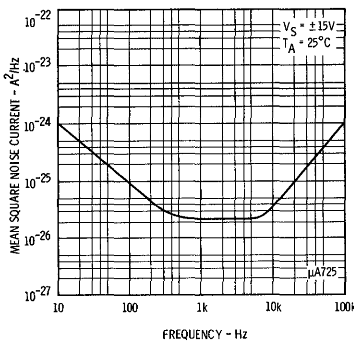
CHANGE IN INPUT OFFSET VOLTAGE DUE TO THERMAL SHOCK AS A FUNCTION OF TIME



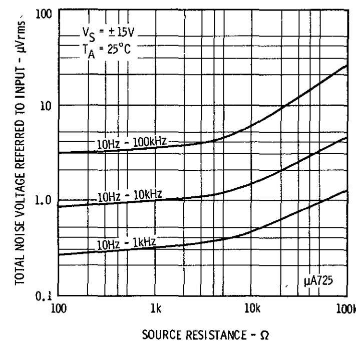
INPUT NOISE VOLTAGE AS A FUNCTION OF FREQUENCY



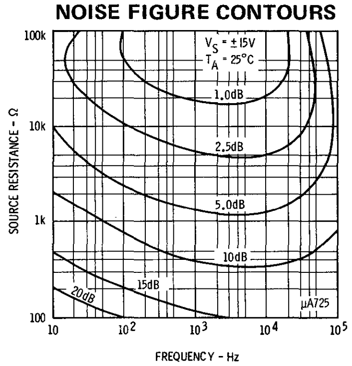
INPUT NOISE CURRENT AS A FUNCTION OF FREQUENCY



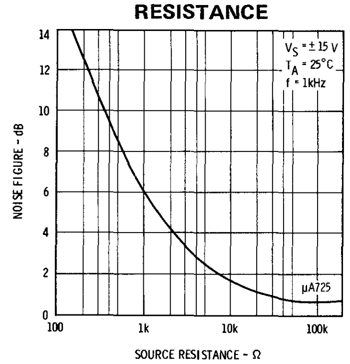
BROADBAND NOISE FOR VARIOUS BANDWIDTHS



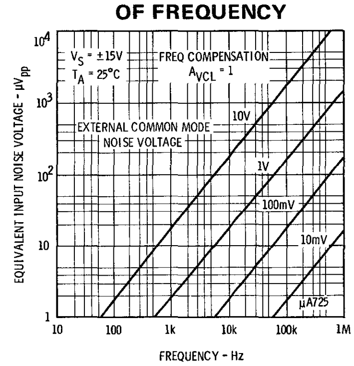
NARROW BAND SPOT NOISE FIGURE CONTOURS



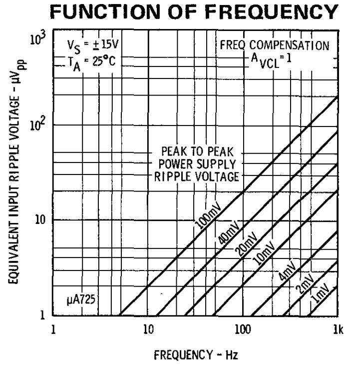
NOISE FIGURE AS A FUNCTION OF SOURCE RESISTANCE



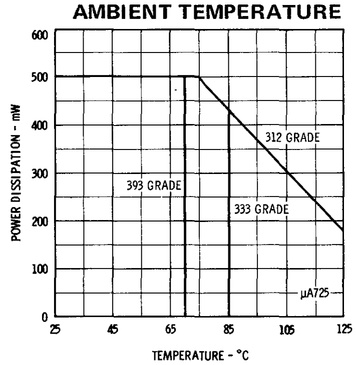
EQUIVALENT INPUT NOISE VOLTAGE DUE TO EXTERNAL COMMON MODE NOISE AS A FUNCTION OF FREQUENCY



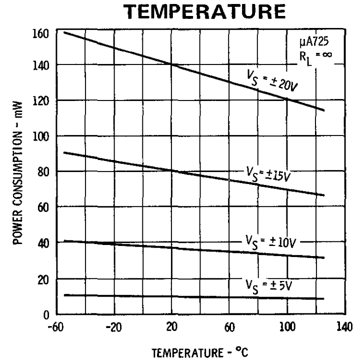
EQUIVALENT INPUT RIPPLE VOLTAGE DUE TO POWER SUPPLY RIPPLE AS A FUNCTION OF FREQUENCY



ABSOLUTE MAXIMUM POWER DISSIPATION AS A FUNCTION OF AMBIENT TEMPERATURE

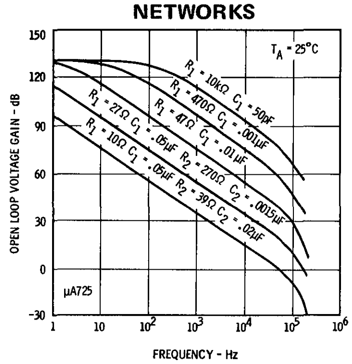


POWER CONSUMPTION AS A FUNCTION OF TEMPERATURE

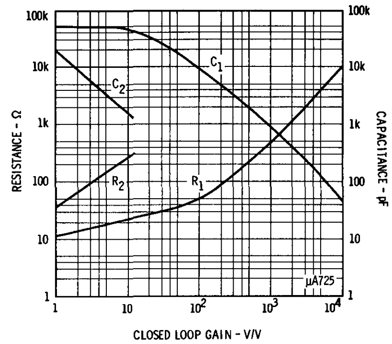


TYPICAL PERFORMANCE CURVES FOR ALL GRADES

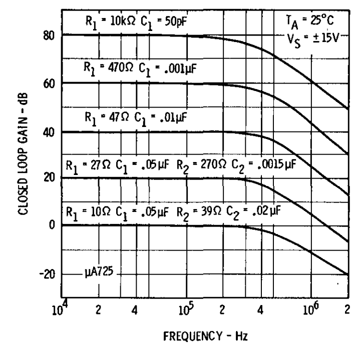
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY USING RECOMMENDED COMPENSATION NETWORKS



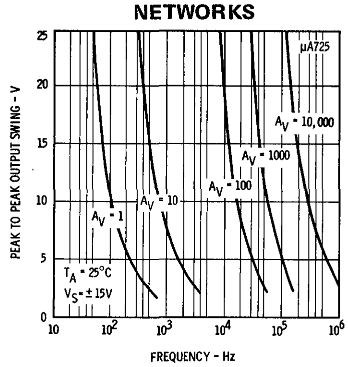
VALUES FOR SUGGESTED COMPENSATION NETWORKS FOR VARIOUS CLOSED LOOP VOLTAGE GAINS



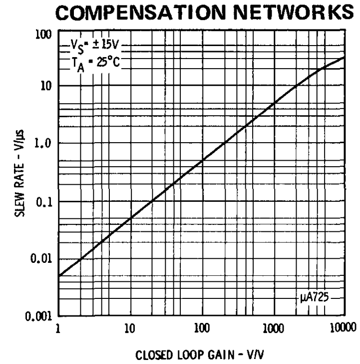
FREQUENCY RESPONSE FOR VARIOUS CLOSED-LOOP GAINS USING RECOMMENDED COMPENSATION NETWORKS



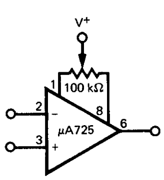
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY FOR RECOMMENDED COMPENSATION NETWORKS



SLEW RATE AS A FUNCTION OF CLOSED-LOOP GAIN USING RECOMMENDED COMPENSATION NETWORKS



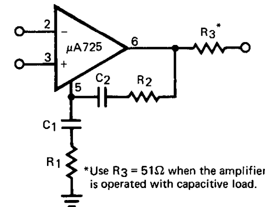
VOLTAGE OFFSET NULL CIRCUIT



COMPENSATION COMPONENT VALUES

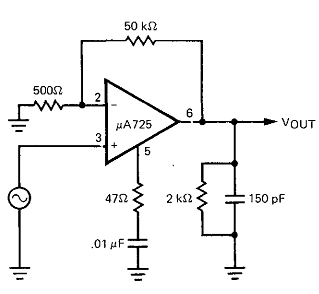
A_{VCL}	R_1 (Ω)	C_1 (μF)	R_2 (Ω)	C_2 (μF)
10,000	10 k	50 pF	–	–
1,000	470	.001	–	–
100	47	.01	–	–
10	27	.05	270	.0015
1	10	.05	39	.02

FREQUENCY COMPENSATION CIRCUIT



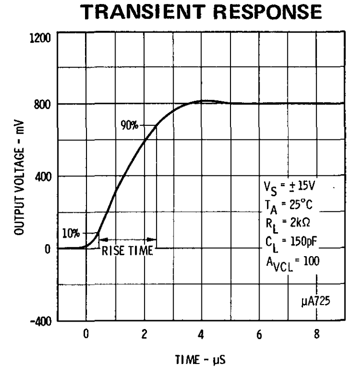
*Use $R_3 = 51\Omega$ when the amplifier is operated with capacitive load.

TRANSIENT RESPONSE TEST CIRCUIT



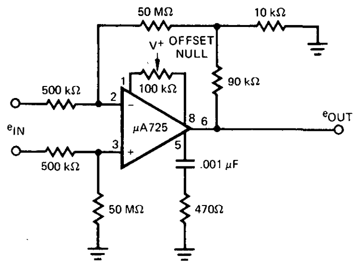
Pin numbers are shown for Metal Can only.

TRANSIENT RESPONSE



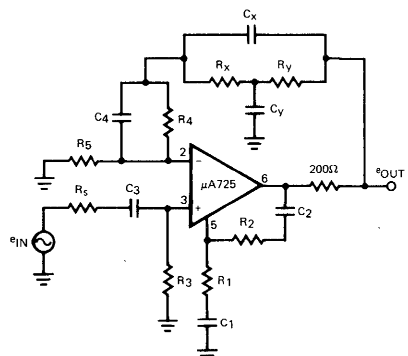
TYPICAL APPLICATIONS

PRECISION AMPLIFIER – A_{VCL} = 1000

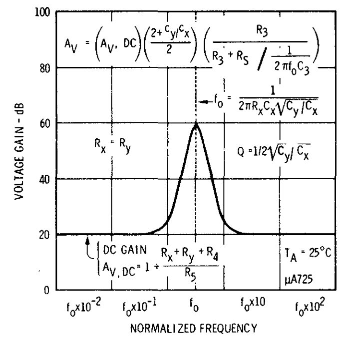


CHARACTERISTICS:
- A_{VCL} = 1000 = 60 dB
- DC Gain Error = 0.05%
- Bandwidth = 1 kHz for –0.05% error
- Diff. Input Res. = 1 MΩ
- Typical amplifying capability
- e_{IN} = 10 μV on V_{CMI} = 1.0 V
- Caution: Minimize Stray Capacitance

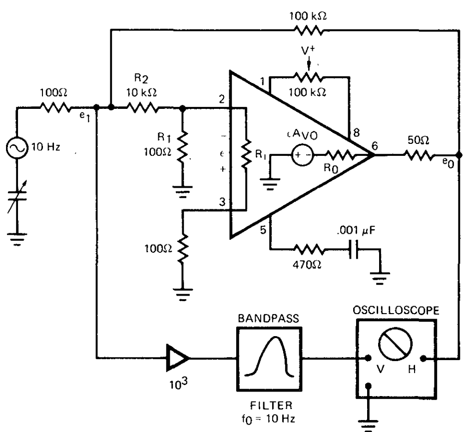
ACTIVE FILTER – BANDPASS WITH 60 dB GAIN



ACTIVE FILTER FREQUENCY RESPONSE

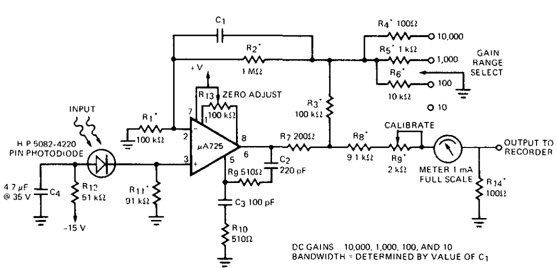


OPEN LOOP VOLTAGE GAIN TEST CIRCUIT



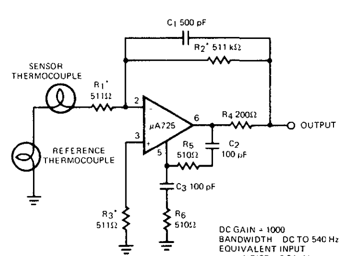
$$A_{VO} \simeq \frac{e_0}{e_1}\left(\frac{R_2 R_i + R_1 R_i + R_1 R_2}{R_1 R_i}\right) = \frac{e_0}{e_1}\,101$$

PIN PHOTODIODE AMPLIFIER



NOTE: * Indicates ±1% Metal film resistors recommended for temperature stability.

THERMOCOUPLE AMPLIFIER



NOTE: * Indicates ±1% metal film resistors recommended for temperature stability.

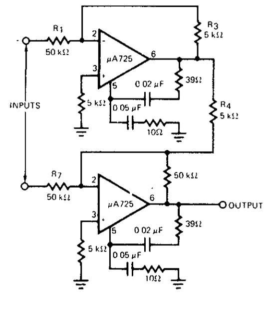
±100 V COMMON MODE RANGE INSTRUMENTATION AMPLIFIER

$$\frac{R_1}{R_7} = \frac{R_3}{R_4} \text{ for best CMRR}$$

$R_3 = R_4$

$R_1 = R_6 = 10R_3$

$$\text{Gain} = \frac{R_7}{R_6}$$



INSTRUMENTATION AMPLIFIER WITH HIGH COMMON MODE REJECTION

$$\frac{R_2}{R_5} = \frac{R_6}{R_7} \text{ for best CMR}$$

$R_1 = R_4$

$R_2 = R_5$

$$\text{Gain} = \frac{R_6}{R_2}\left(1 + \frac{2R_1}{R_3}\right)$$