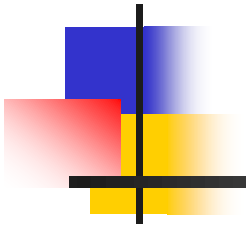

Electronic Circuits Design

Lecture – 3

- *Electrical Characteristics of Operational Amplifier*
- *uA741 Subcircuit into LTSpice*

Yeonbae Chung

School of Electronics Engineering

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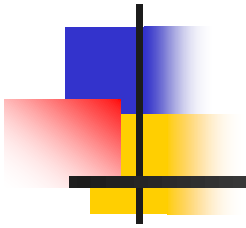


Electrical Characteristics of uA741 OP Amp

- **Short-Circuit Protection**
- **Offset-Voltage Null Capability**
- **Large Common-Mode and Differential Voltage Ranges**
- **No Frequency Compensation Required**
- **Low Power Consumption**
- **No Latch-Up**
- **Designed to Be Interchangeable With Fairchild μA741**

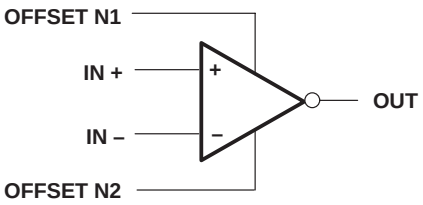
description

The μA741 is a general-purpose operational amplifier featuring offset-voltage null capability.

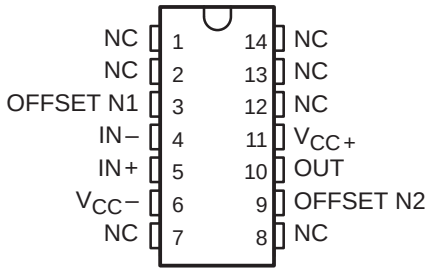
The high common-mode input voltage range and the absence of latch-up make the amplifier ideal for voltage-follower applications. The device is short-circuit protected and the internal frequency compensation ensures stability without external components. A low value potentiometer may be connected between the offset null inputs to null out the offset voltage as shown in Figure 2.

The μA741C is characterized for operation from 0°C to 70°C. The μA741I is characterized for operation from –40°C to 85°C.The μA741M is characterized for operation over the full military temperature range of –55°C to 125°C.

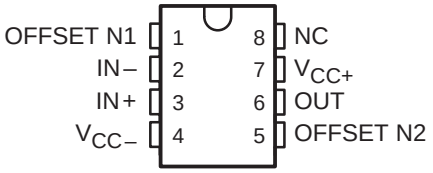
symbol



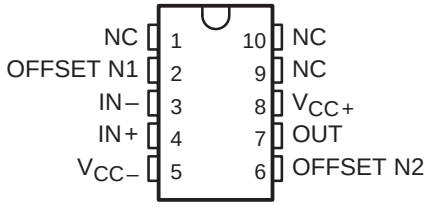
μA741M . . . J PACKAGE
(TOP VIEW)



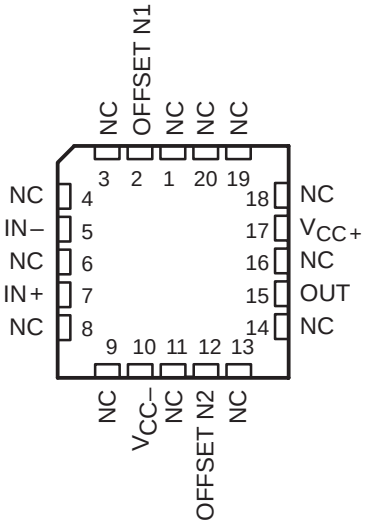
μA741M . . . JG PACKAGE
μA741C, μA741I . . . D, P, OR PW PACKAGE
(TOP VIEW)



μA741M . . . U PACKAGE
(TOP VIEW)



μA741M . . . FK PACKAGE
(TOP VIEW)



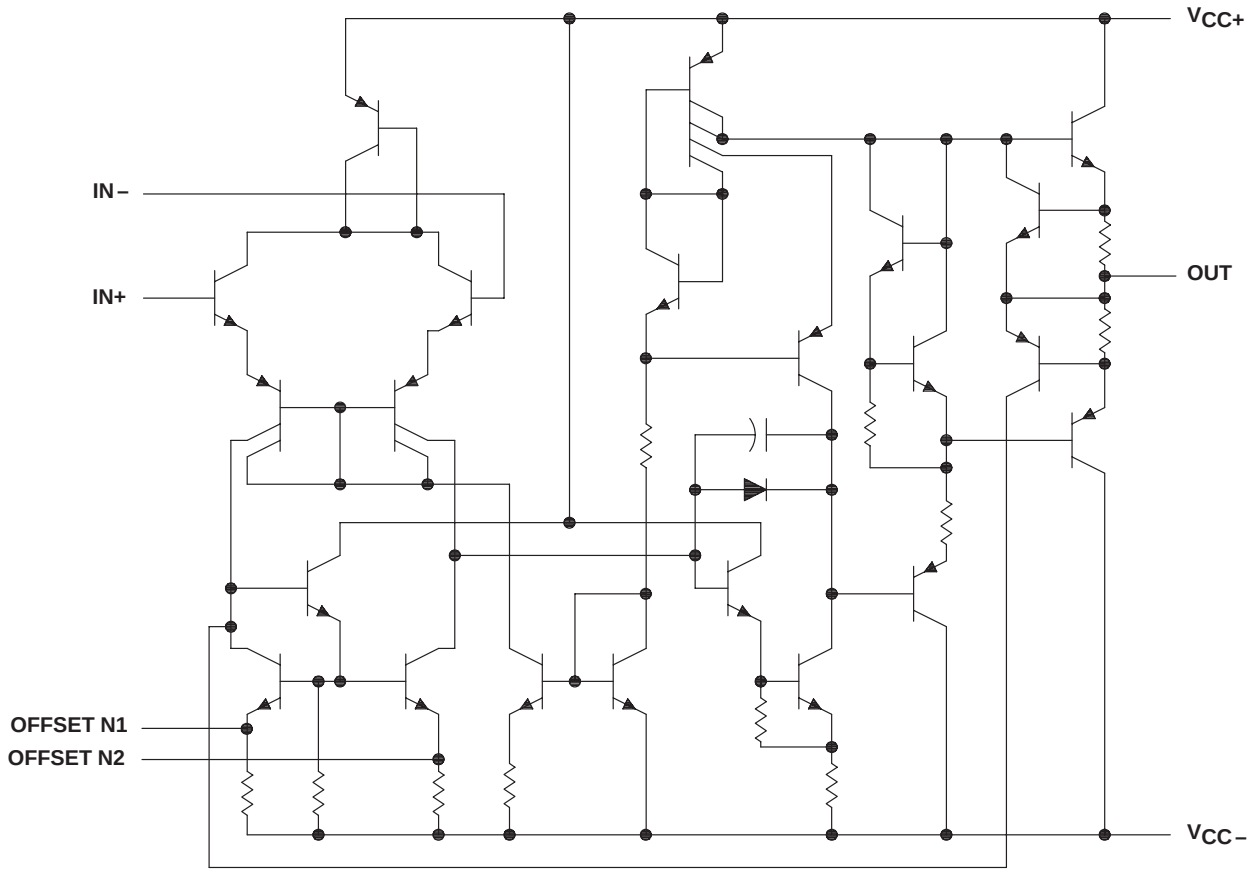
NC – No internal connection

AVAILABLE OPTIONS

T_A	PACKAGED DEVICES							CHIP FORM (Y)
	SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW)	FLAT PACK (U)	
0°C to 70°C	μA741CD				μA741CP	μA741CPW		μA741Y
–40°C to 85°C	μA741ID				μA741IP			
–55°C to 125°C		μA741MFK	μA741MJ	μA741MJG			μA741MU	

The D package is available taped and reeled. Add the suffix R (e.g., μA741CDR).

schematic

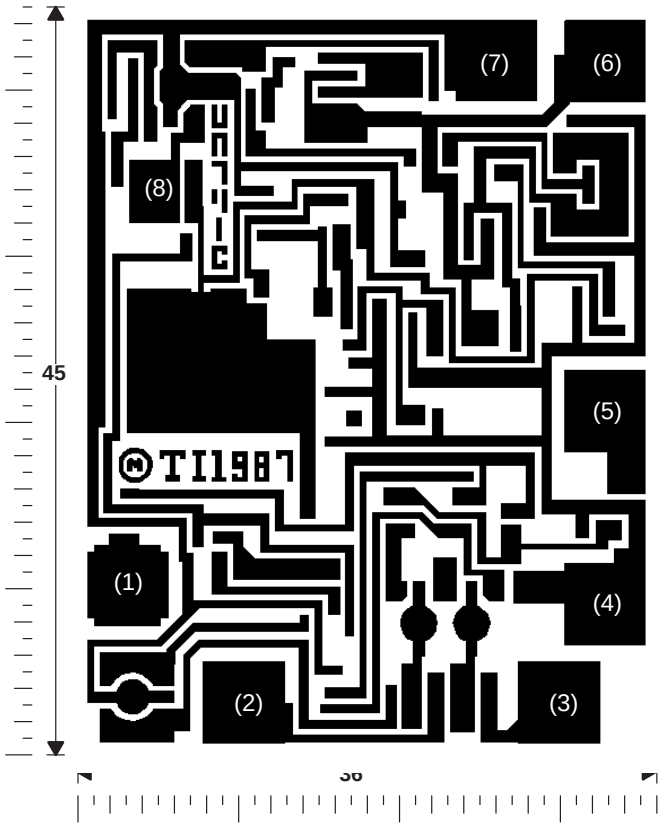


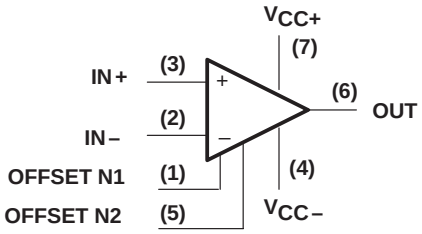
Component Count	
Transistors	22
Resistors	11
Diode	1
Capacitor	1

μA741Y chip information

This chip, when properly assembled, displays characteristics similar to the μA741C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.

BONDING PAD ASSIGNMENTS





CHIP THICKNESS: 15 TYPICAL

BONDING PADS: 4 × 4 MINIMUM

$T_J$max = 150°C.

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

		μA741C	μA741I	μA741M	UNIT
Supply voltage, V_{CC+} (see Note 1)		18	22	22	V
Supply voltage, V_{CC-} (see Note 1)		–18	–22	–22	V
Differential input voltage, V_{ID} (see Note 2)		±15	±30	±30	V
Input voltage, V_I any input (see Notes 1 and 3)		±15	±15	±15	V
Voltage between offset null (either OFFSET N1 or OFFSET N2) and V_{CC-}		±15	±0.5	±0.5	V
Duration of output short circuit (see Note 4)		unlimited	unlimited	unlimited	
Continuous total power dissipation		See Dissipation Rating Table			
Operating free-air temperature range, T_A		0 to 70	–40 to 85	–55 to 125	°C
Storage temperature range		–65 to 150	–65 to 150	–65 to 150	°C
Case temperature for 60 seconds	FK package			260	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	J, JG, or U package			300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	D, P, or PW package	260	260		°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values, unless otherwise noted, are with respect to the midpoint between V_{CC+} and V_{CC-}.
2. Differential voltages are at IN+ with respect to IN–.
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
4. The output may be shorted to ground or either power supply. For the μA741M only, the unlimited duration of the short circuit applies at (or below) 125°C case temperature or 75°C free-air temperature.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR	DERATE ABOVE T_A	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D	500 mW	5.8 mW/°C	64°C	464 mW	377 mW	N/A
FK	500 mW	11.0 mW/°C	105°C	500 mW	500 mW	275 mW
J	500 mW	11.0 mW/°C	105°C	500 mW	500 mW	275 mW
JG	500 mW	8.4 mW/°C	90°C	500 mW	500 mW	210 mW
P	500 mW	N/A	N/A	500 mW	500 mW	N/A
PW	525 mW	4.2 mW/°C	25°C	336 mW	N/A	N/A
U	500 mW	5.4 mW/°C	57°C	432 mW	351 mW	135 mW

electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	μA741C			μA741I, μA741M			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_O = 0	25°C		1	6		1	5	mV
			Full range			7.5			6	
$\Delta V_{IO(adj)}$	Offset voltage adjust range	V_O = 0	25°C		±15			±15		mV
I_{IO}	Input offset current	V_O = 0	25°C		20	200		20	200	nA
			Full range			300			500	
I_{IB}	Input bias current	V_O = 0	25°C		80	500		80	500	nA
			Full range			800			1500	
V_{ICR}	Common-mode input voltage range		25°C	±12	±13		±12	±13		V
			Full range	±12			±12			
V_{OM}	Maximum peak output voltage swing	R_L = 10 kΩ	25°C	±12	±14		±12	±14		V
		R_L ≥ 10 kΩ	Full range	±12			±12			
		R_L = 2 kΩ	25°C	±10	±13		±10	±13		
		R_L ≥ 2 kΩ	Full range	±10			±10			
A_{VD}	Large-signal differential voltage amplification	R_L ≥ 2 kΩ	25°C	20	200		50	200		V/mV
		V_O = ±10 V	Full range	15			25			
r_i	Input resistance		25°C	0.3	2		0.3	2		MΩ
r_o	Output resistance	V_O = 0, See Note 5	25°C		75			75		Ω
C_i	Input capacitance		25°C		1.4			1.4		pF
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR}min	25°C	70	90		70	90		dB
			Full range	70			70			
k_{SVS}	Supply voltage sensitivity ($\Delta V_{IO}/\Delta V_{CC}$)	V_{CC} = ±9 V to ±15 V	25°C		30	150		30	150	μV/V
			Full range			150			150	
I_{OS}	Short-circuit output current		25°C		±25	±40		±25	±40	mA
I_{CC}	Supply current	V_O = 0, No load	25°C		1.7	2.8		1.7	2.8	mA
			Full range			3.3			3.3	
P_D	Total power dissipation	V_O = 0, No load	25°C		50	85		50	85	mW
			Full range			100			100	

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. Full range for the μA741C is 0°C to 70°C, the μA741I is –40°C to 85°C, and the μA741M is –55°C to 125°C.

NOTE 5: This typical value applies only at frequencies above a few hundred hertz because of the effects of drift and thermal feedback.

operating characteristics, $V_{CC\pm}$ = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	μA741C			μA741I, μA741M			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
t_r	Rise time	V_I = 20 mV, R_L = 2 kΩ, C_L = 100 pF, See Figure 1		0.3			0.3		μs
	Overshoot factor			5%			5%		
SR	Slew rate at unity gain	V_I = 10 V, R_L = 2 kΩ, C_L = 100 pF, See Figure 1		0.5			0.5		V/μs

electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	μA741Y			UNIT
			MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_O = 0		1	6	mV
$\Delta V_{IO(adj)}$	Offset voltage adjust range	V_O = 0		±15		mV
I_{IO}	Input offset current	V_O = 0		20	200	nA
I_{IB}	Input bias current	V_O = 0		80	500	nA
V_{ICR}	Common-mode input voltage range		±12	±13		V
V_{OM}	Maximum peak output voltage swing	R_L = 10 kΩ	±12	±14		V
		R_L = 2 kΩ	±10	±13		
A_{VD}	Large-signal differential voltage amplification	$R_L \geq$ 2 kΩ	20	200		V/mV
r_i	Input resistance		0.3	2		MΩ
r_o	Output resistance	V_O = 0, See Note 5		75		Ω
C_i	Input capacitance			1.4		pF
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}$min	70	90		dB
k_{SVS}	Supply voltage sensitivity ($\Delta V_{IO}/\Delta V_{CC}$)	V_{CC} = ±9 V to ±15 V		30	150	μV/V
I_{OS}	Short-circuit output current			±25	±40	mA
I_{CC}	Supply current	V_O = 0, No load		1.7	2.8	mA
P_D	Total power dissipation	V_O = 0, No load		50	85	mW

† All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified.
NOTE 5: This typical value applies only at frequencies above a few hundred hertz because of the effects of drift and thermal feedback.

operating characteristics, $V_{CC\pm}$ = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	μA741Y			UNIT
			MIN	TYP	MAX	
t_r	Rise time	V_I = 20 mV, R_L = 2 kΩ, C_L = 100 pF, See Figure 1		0.3		μs
	Overshoot factor			5%		
SR	Slew rate at unity gain	V_I = 10 V, R_L = 2 kΩ, C_L = 100 pF, See Figure 1		0.5		V/μs

PARAMETER MEASUREMENT INFORMATION

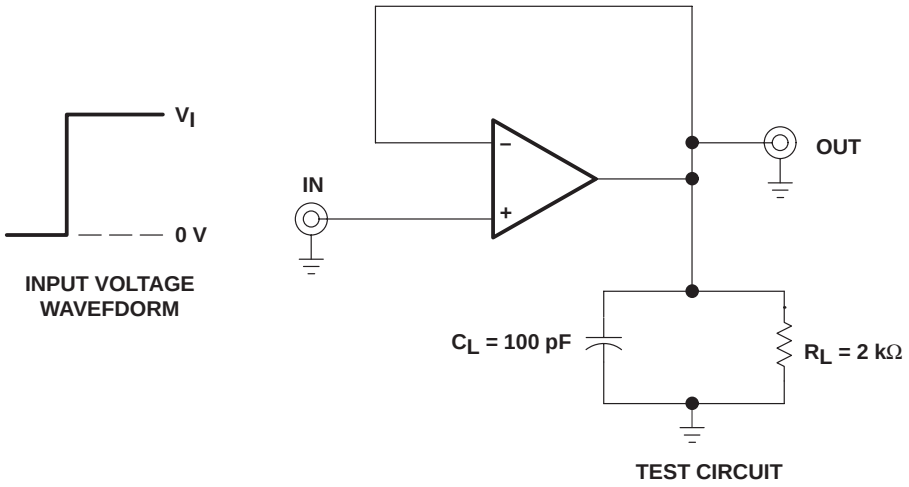


Figure 1. Rise Time, Overshoot, and Slew Rate

APPLICATION INFORMATION

Figure 2 shows a diagram for an input offset voltage null circuit.

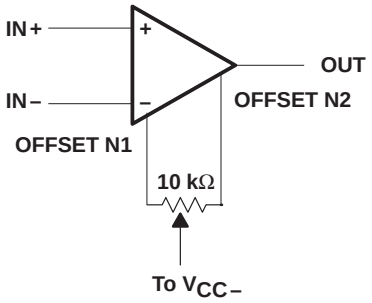


Figure 2. Input Offset Voltage Null Circuit

TYPICAL CHARACTERISTICS†

INPUT OFFSET CURRENT vs FREE-AIR TEMPERATURE

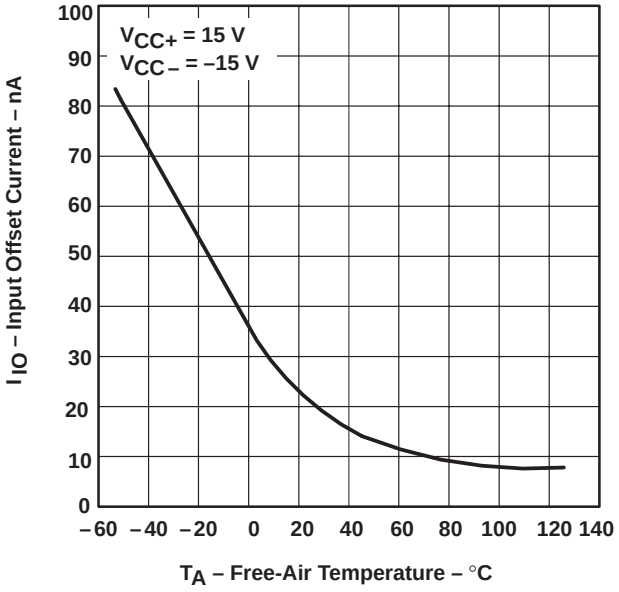


Figure 3

INPUT BIAS CURRENT vs FREE-AIR TEMPERATURE

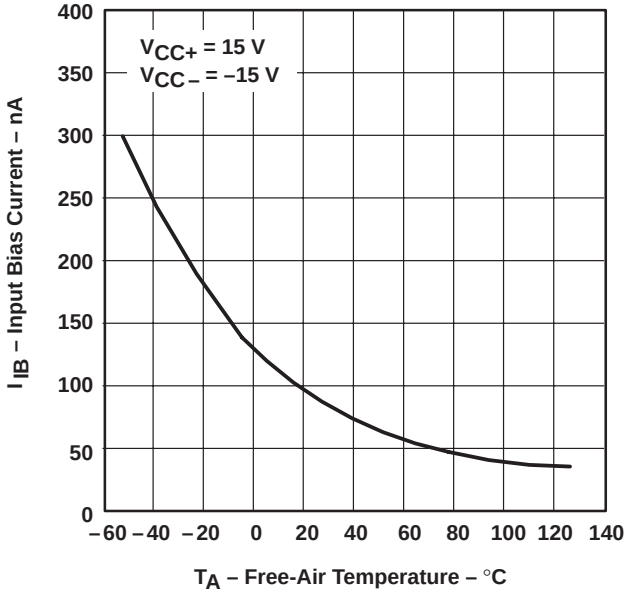


Figure 4

MAXIMUM PEAK OUTPUT VOLTAGE vs LOAD RESISTANCE

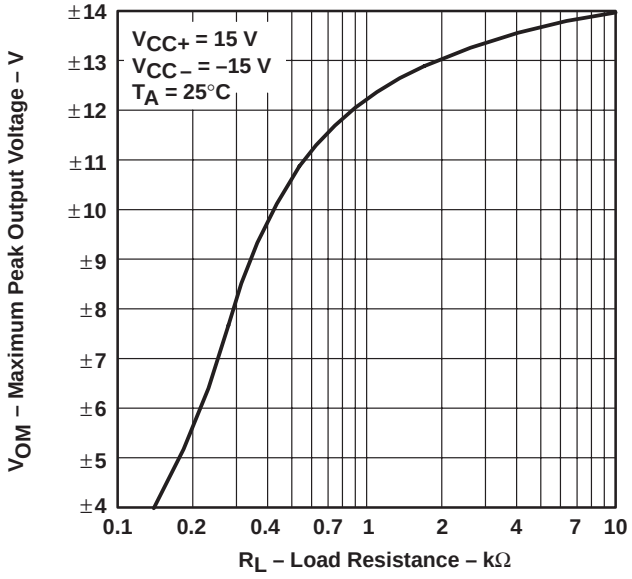


Figure 5

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

MAXIMUM PEAK OUTPUT VOLTAGE vs FREQUENCY

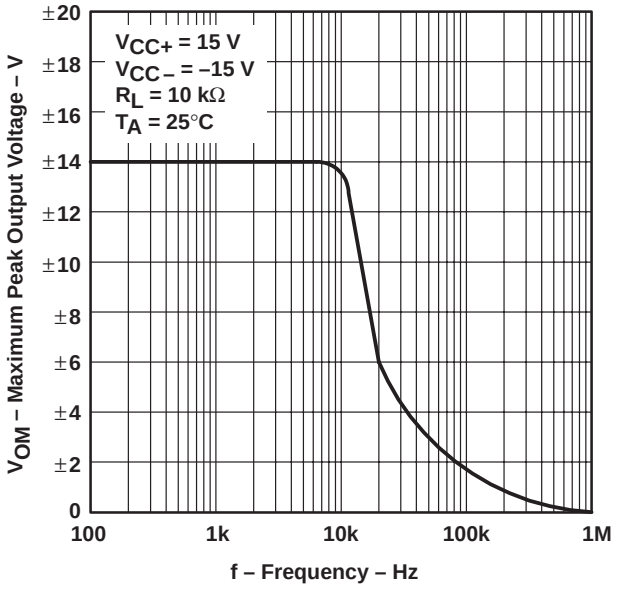


Figure 6

OPEN-LOOP SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs SUPPLY VOLTAGE

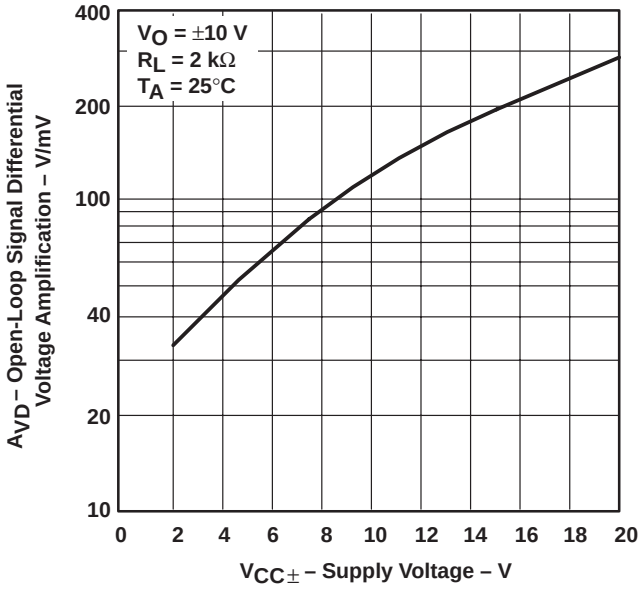
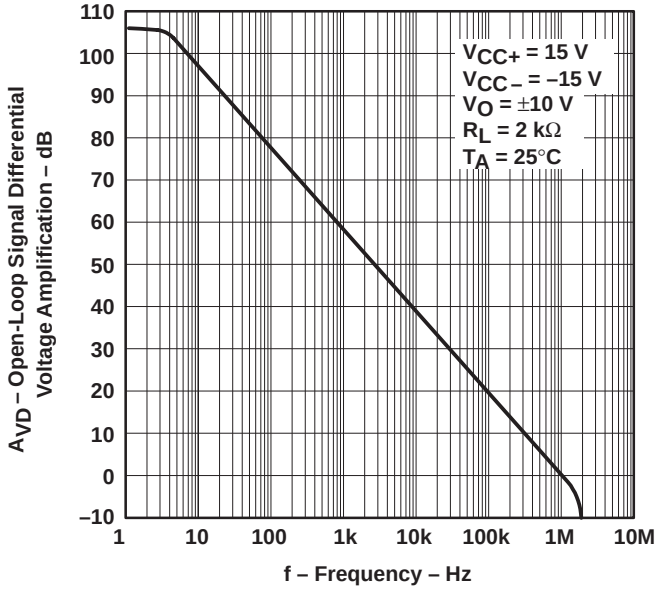


Figure 7

OPEN-LOOP LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREQUENCY



TYPICAL CHARACTERISTICS

COMMON-MODE REJECTION RATIO vs FREQUENCY

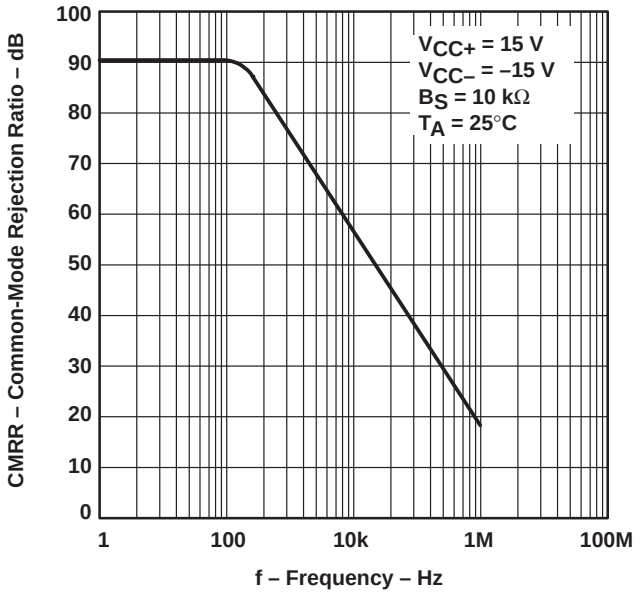


Figure 8

OUTPUT VOLTAGE vs ELAPSED TIME

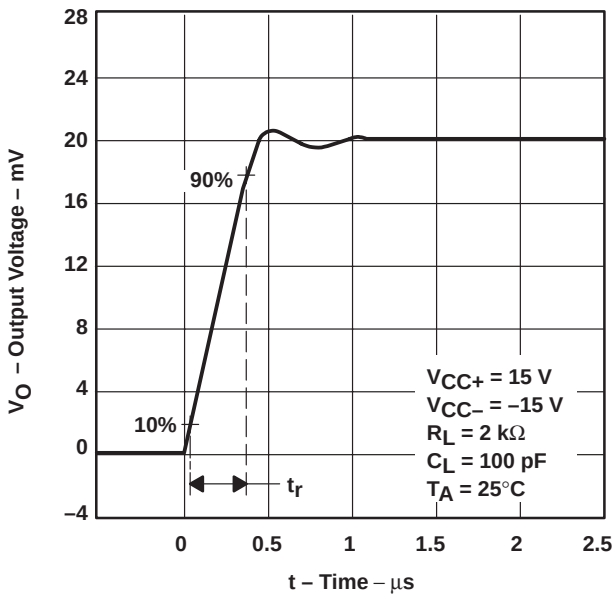


Figure 9

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

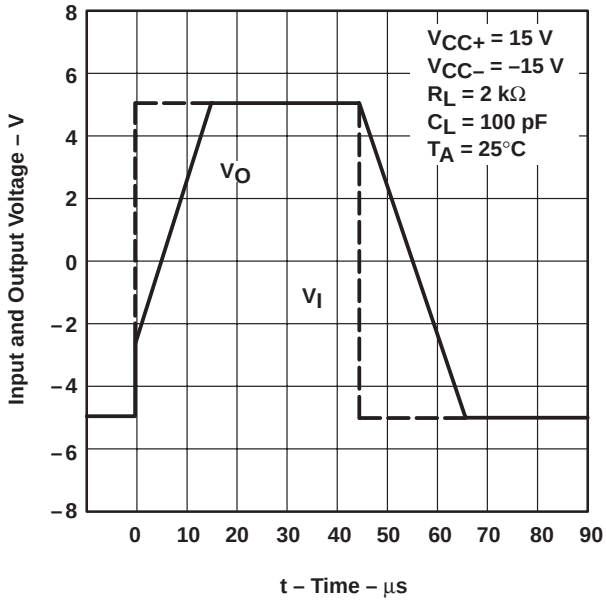


Figure 10

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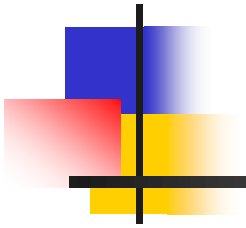

uA741 Subcircuit into LTSpice

How to Add uA741 Subcircuit ?

- Step 1: Copy the "UA741.sub" subcircuit file to LTSpice sub directory (C:₩Program Files₩LTC₩LTspiceIV₩lib₩sub).

- Step 2: In LTSpice schematic pannel, insert "opamp2" component. Right click on the opamp symbol and change the "value" to "UA741".

- Step 3: Add SPICE directive to the schematic. (Edit - text) For example, add ".lib UA741.sub".