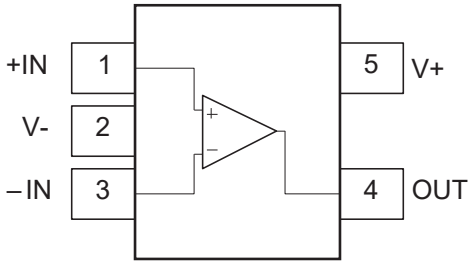
LM321E Operational Amplifiers

1 Introduction

The LM321E brings performance and economy to low power systems. With a high unity gain frequency and a guaranteed 0.4V/μs slew rate, the quiescent current is only 200μA/amplifier (5V). The input common mode range includes ground and therefore the device is able to operate in single supply applications as well as in dual supply applications. It is also capable of comfortably driving large capacitive loads. The LM321E is available in the SOT package. Overall the LM321E is a low power, wide supply range performance op amp that can be designed into a wide range of applications at an economical price without sacrificing valuable board space.

2 Applications

- Computer and motherboard
- Household electric appliances
- Inverter circuit
- Motor control
- Multi-functional printer
- Power supply and portable charger
- Uninterruptible power supply (UPS)



Pin Connections

3 Features

- Power Supply Range:

  Single supply: 3.0 to 36V

  Dual supplies: ±1.5 to ±18V

- Low supply current: 200μA
- Low Input Offset Voltage:
  0.5mV (Typ.) at 25°C
- Low Input Bias Current:
  15nA (Typ.) at 25°C
- Unity-gain Bandwidth: 1.0MHz (Typ.)
- Wide operating ambient temperature:
  -40 ~ 85°C
- Internally frequency compensated for unity gain
- Common-mode input voltage range includes ground

4 Available Packages

PART NUMBER	PACKAGE
LM321E-M5N	SOT-23-5L

6 Specifications

6.1 Absolute Maximum Ratings

(over operating ambient temperature range, unless otherwise specified)(1)

CHARACTERISTIC		SYMBOL	VALUE	UNIT
Maximum power supply	Single supply	V_S	40	V
	Dual supplies		±20	
Maximum differential input range(2)		V_{ID}	-32 ~ 32	V
Maximum input range (either input)		V_{IN}	-0.3 ~ 40	V
Duration of output short circuit (one amplifier) to ground (or below) at T_A = 25°C, V_S ≤ 15V		t_{SC}	Continuous(3)	s
Maximum junction temperature		$T_{J\ MAX}$	150	°C
Storage temperature		T_{stg}	-65 ~ 150	°C
Soldering temperature & time		T_{solder}	260°C, 10s	-

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum rated conditions for extended periods may affect device reliability.
(2) Differential voltages are at IN+, with respect to IN−.
(3) Short circuits from outputs to V_S can cause excessive heating and eventual destruction. A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

6.2 Recommend Operating Conditions

(over operating ambient temperature range, unless otherwise specified)

PARAMETER		SYMBOL	MIN.	NOM.	MAX.	UNIT
Power supply range	Single supply	V_S	3.0	-	36	V
	Dual supplies		±1.5	-	±18	
Common-mode voltage range		V_{CM}	V-	-	(V+) - 2.0	V
Operating ambient temperature	LM321E	T_A	-40	-	85	°C

6 Specifications

6.3 ESD Ratings

ESD RATINGS			SYMBOL	VALUE	UNIT
Electrostatic discharge(4)	Human body model	LM321E	$V_{ESD-HBM}$	1000	V

(4) ESD testing is conducted in accordance with the relevant specifications formulated by the Joint Electronic Equipment Engineering Commission (JEDEC). The human body model (HBM) electrostatic discharge test is based on the JESD22-A114D test standard, using a 100pF capacitor and discharging to each pin of the device through a resistance of 1.5kΩ.

6.4 Thermal Information

THERMAL METRIC(5)	SYMBOL	SOT-23-5L	UNIT
Junction-to-ambient thermal resistance	$R_{\Theta JA}$	250.3	°C/W
Junction-to-case thermal resistance	$R_{\Theta JC}$	65.4	°C/W
Reference maximum power dissipation (continuous)	$P_{D\ Ref}$	0.40	W

(5) T_A = 25°C, measured on evaluation board with 1oz. copper traces of minimum pad size, all device outputs were active.

6 Specifications

6.5 Electrical Characteristics

LM321E (V_S = (V+) - (V-) = 5.0V, T_A = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS[6]			MIN.	TYP.	MAX.	UNIT
Offset Voltage								
Input offset voltage	V_{OS}	V_S = 5.0 to 30V, V_{CM} = 0V, V_{OUT} = 1.4V		T_A = 25°C	-	0.5	3.0	mV
				Full range	-	-	5.0	
Input offset voltage vs power supply (ΔV_{IO} / ΔV_S)	PSRR	V_S = 5.0 to 30V			65	100	-	dB
Input offset voltage drift	dV_{OS} / dT	-		Full range	-	4.0	-	μV / °C
Channel separation	CS	f = 1k to 20kHz			-	120	-	dB
Input Voltage Range								
Common-mode voltage range	V_{CM}	V_S = 5.0 to 30V		T_A = 25°C	V-	-	(V+) - 1.5	V
				Full range	V-	-	(V+) - 2.0	
Common-mode rejection ratio	CMRR	V_S = 5.0 to 30V; V_{CM} = 0V			70	80	-	dB
Power Supply								
Quiescent current both amplifiers	I_Q	V_S = 5.0V, R_L = ∞			-	0.2	0.5	mA
		V_S = 30V, R_L = ∞			-	0.25	0.55	mA
Input Bias Current								
Input bias current	I_{IB}	V_{CM} = 0V, V_{OUT} = 1.4V		T_A = 25°C	-	±15	±150	nA
				Full range	-	-	±250	
Input offset current	I_{OS}	V_{CM} = 0V, V_{OUT} = 1.4V		T_A = 25°C	-	±3.0	±30	nA
				Full range	-	-	±150	
Frequency Response								
Gain bandwidth product	GBW	-			-	1.0	-	MHz
Slew rate	SR	G = +1			-	0.4	-	V / μs
Output								
Voltage output swing from rail	V_{OUT}	V_S = 30V, R_L ≥ 10kΩ	Positive rail	T_A = 25°C	-	2.0	3.0	V
				Full range	-	2.5	-	
		V_S = 30V, R_L = 2kΩ		T_A = 25°C	-	3.0	4.0	
				Full range	-	3.5	-	
		V_S = 5.0V, R_L = 10kΩ	Negative rail	Full range	-	5.0	20	mV
Output current	I_{OUT}	V_S = 15V, V_{OUT} = 0V, V_{ID} = 1V, Source			20	40	-	mA
		V_S = 15V, V_{OUT} =2V, V_{ID} = -1V, Sink			10	15	-	mA
		V_{OUT} =0.2V, V_{ID} = -2V			12	50	-	μA
Short-circuit current	I_{SC}	V_S = 15V			-	±40	±60	mA
Open-loop Gain								
Open-loop voltage gain	A_{OL}	V_S = 15V, V_{OUT} = 1.0 to 11V, R_L ≥ 2kΩ			25	100	-	V / mV

6 Specifications

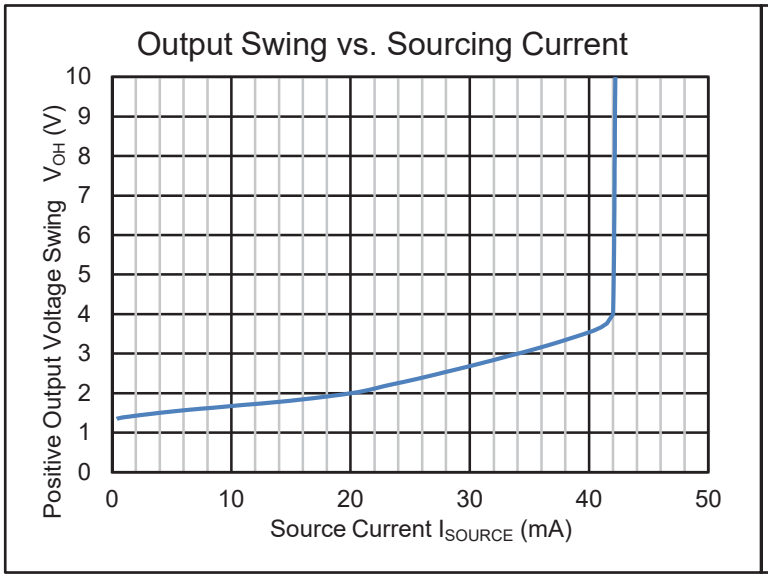
6.5 Electrical Characteristics (continued)

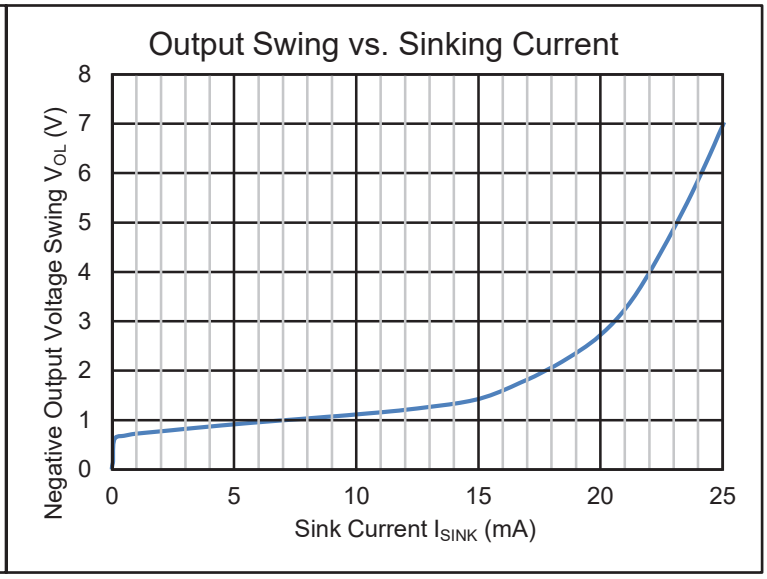
Note:

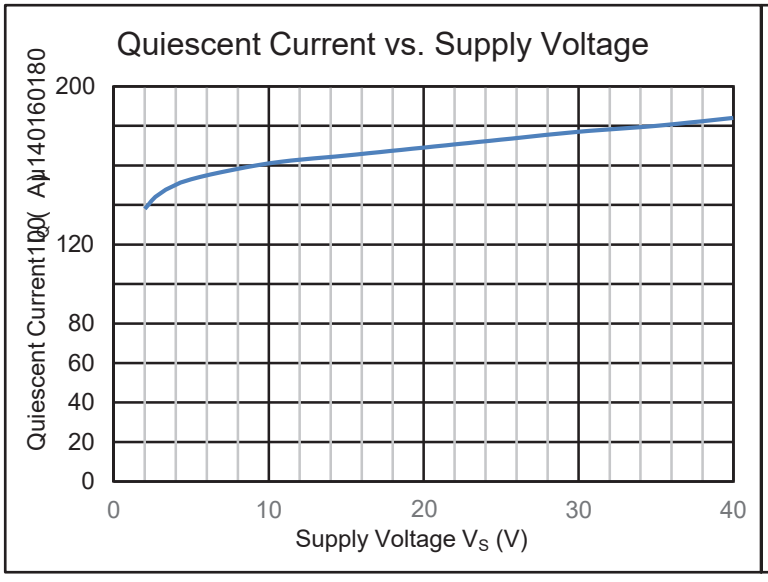
(6) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. All typical values are T_A = 25°C. For the LM321E, "Full range" refers to T_A ranging from -40 to 85°C.

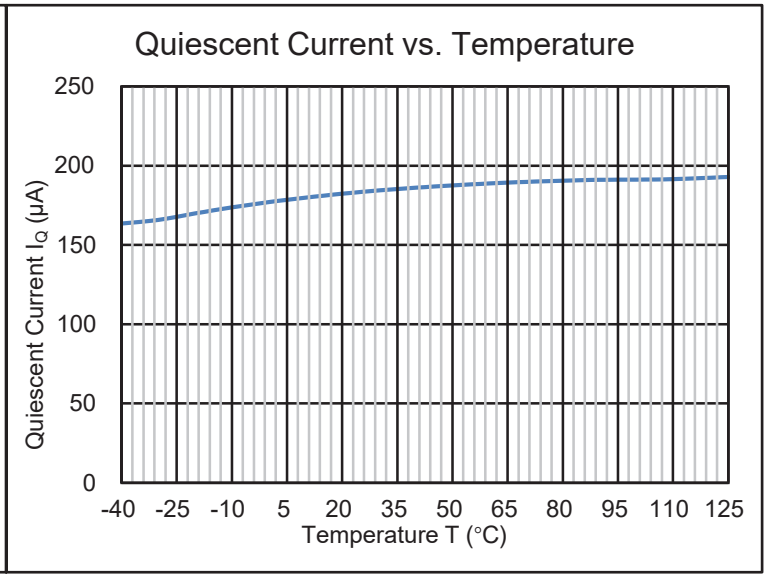
6.6 Typical Characteristics

LM321E (V_S = (V+) - (V-) = 5.0V, V_{CM} = 0V, R_L = ∞, T_A = 25°C, unless otherwise specified)





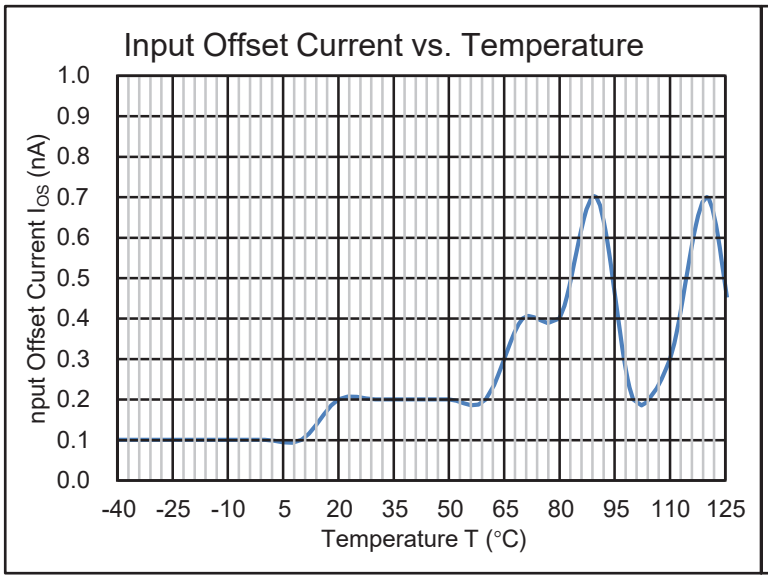


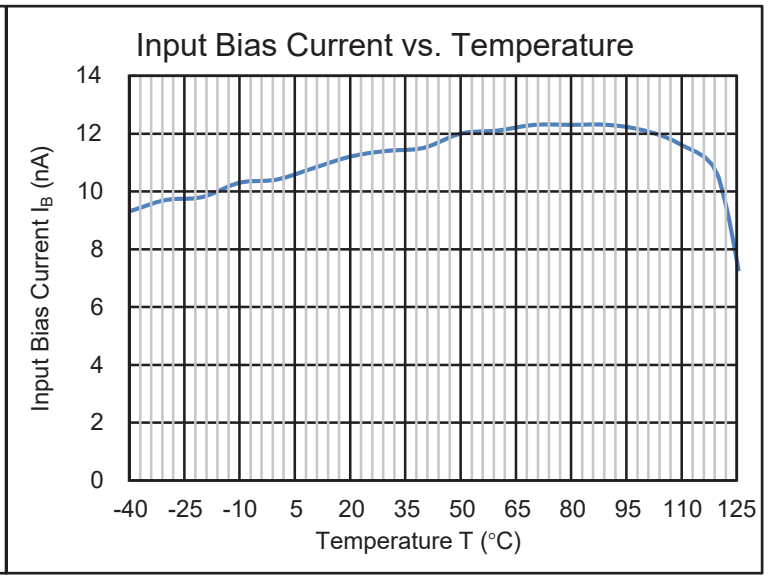


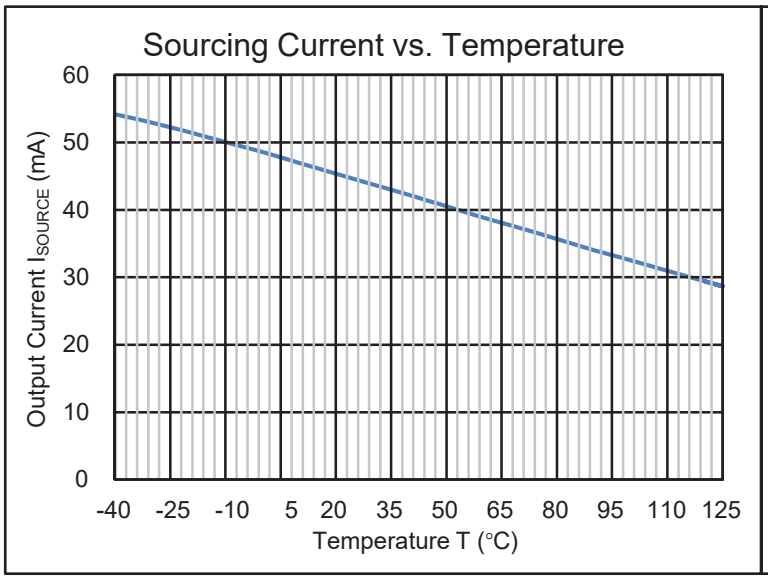
6 Specifications

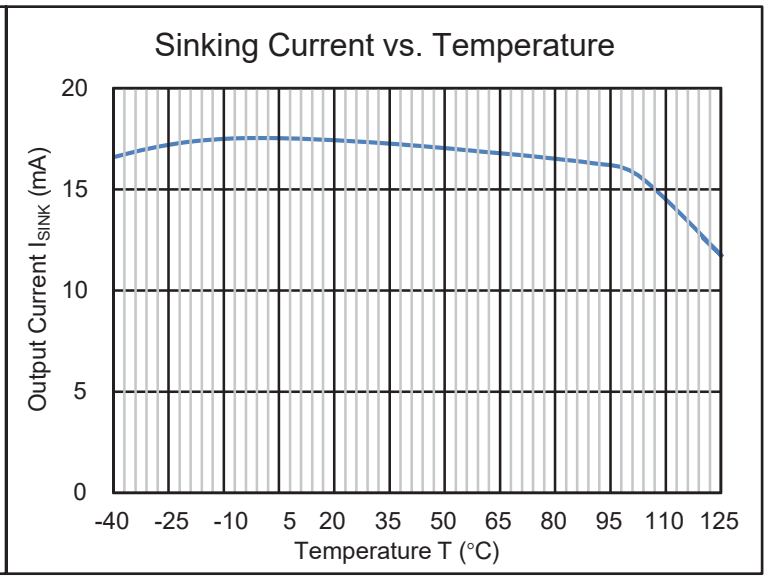
6.6 Typical Characteristics (continued)

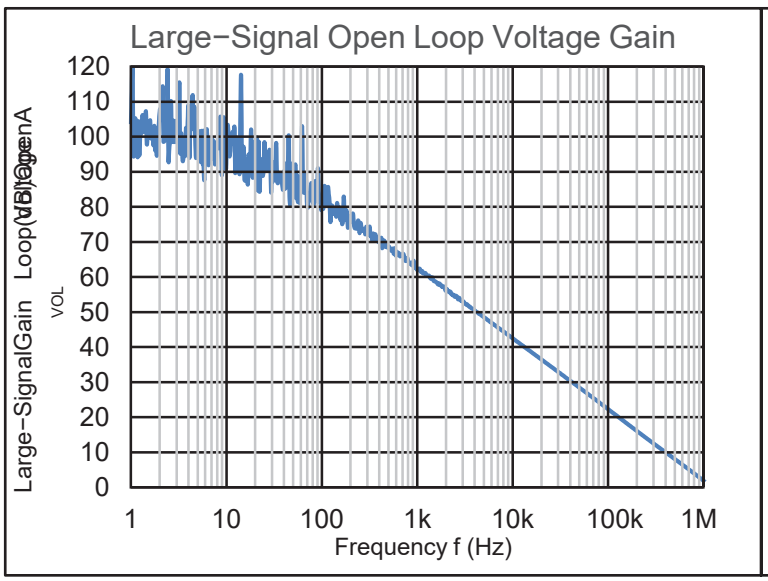
LM321E (V_S = (V+) - (V-) = 5.0V, V_{CM} = 0V, R_L = ∞, T_A = 25°C, unless otherwise specified)

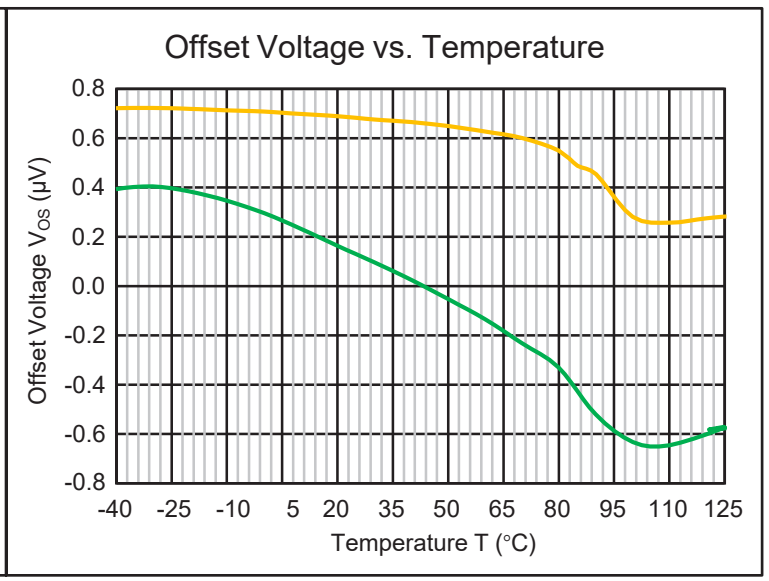








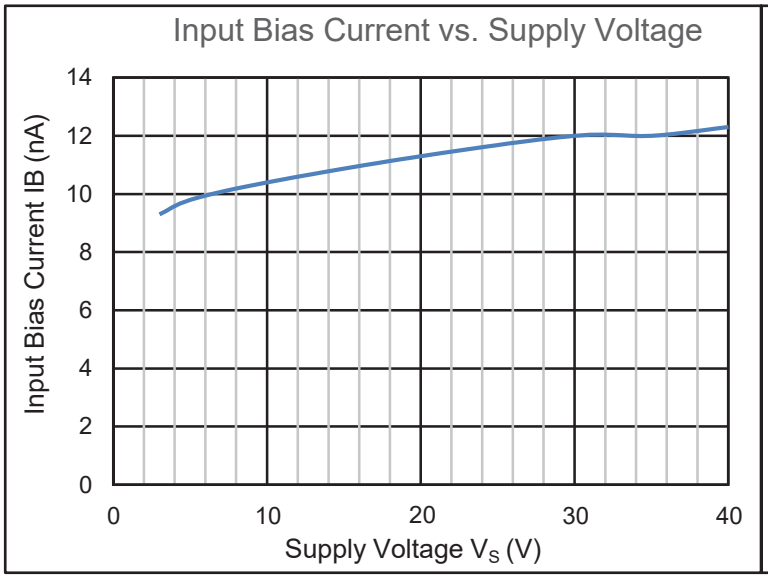


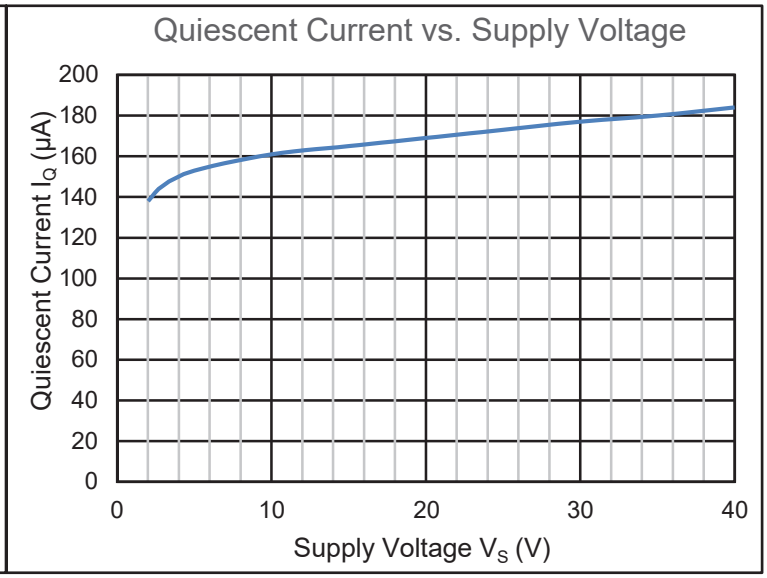


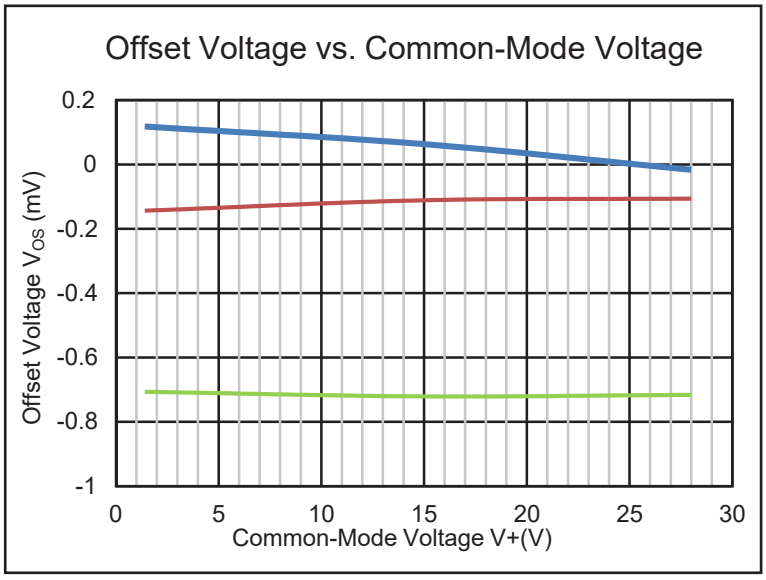
6 Specifications

6.6 Typical Characteristics (continued)

LM321E (V_S = (V+) - (V-) = 5.0V, V_{CM} = 0V, R_L = ∞, T_A = 25°C, unless otherwise specified)

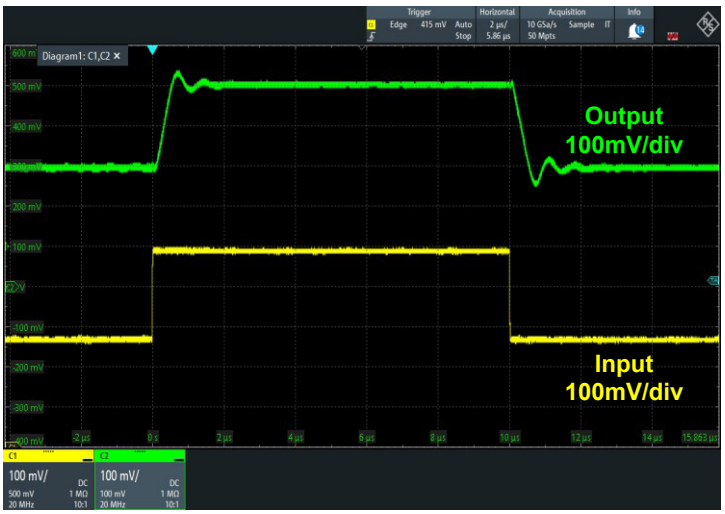






Large-Signal Step Response
(V_S = 15V)

Small-Signal Step Response
(V_S = 15V)

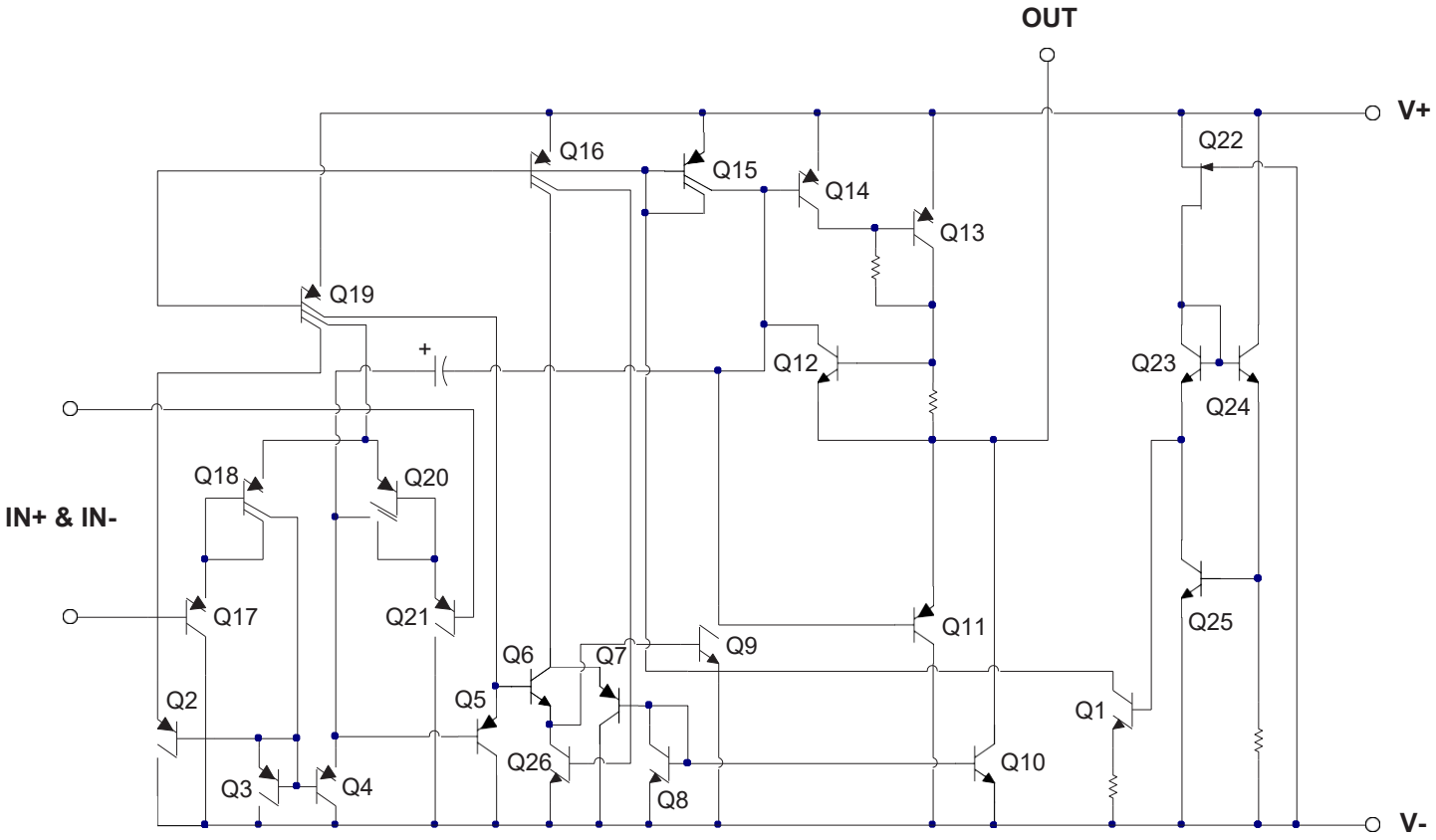


7 Detail Description

7.1 Description

The LM321E consists of one high gain, low-power consumption operational amplifiers, which can be powered by a single power supply. The V_S should be at least 1.5V higher than the input common mode voltage. The low power supply current is independent of the power supply voltage. The LM321E can be directly powered from a standard 5V power supply used in digital systems without the need for an additional ±5V power supply.

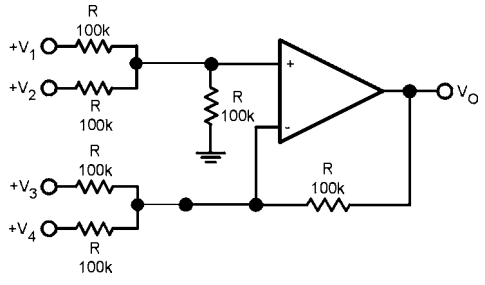
7.2 Representative Schematic Diagram



8 Application and Implementation

8.1 Typical Application Circuits

The LM321E operational amplifer can operate with a single or dual power supply voltage, has true-differential inputs, and remains in the linear mode with an input common-mode voltage of 0VDC. This amplifier operates over a wide range of power supply voltages, with little change in performance characteristics. At 25°C amplifier operation is possible down to a minimum supply voltage of 3V. Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than V+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than −0.3VDC (at 25°C). An input clamp diode with a resistor to the IC input terminal can be used.



Where: $V_0 = V_1 + V_2 - V_3 - V_4$, $(V_1 + V_2) \geq (V_3 + V_4)$ to keep $V_O > 0\ V_{DC}$

Figure 8-1. DC Summing Amplifier ($V_{IN's} \geq 0\ V_{DC}$ and $V_O \geq V_{DC}$)

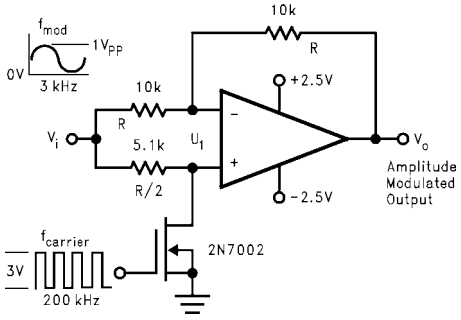
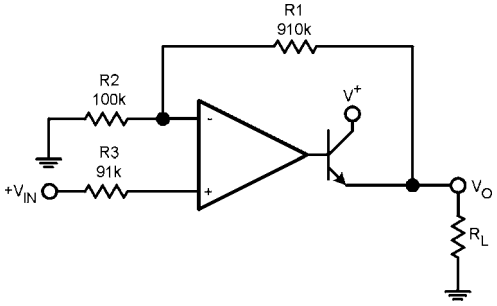


Figure 8-2. Amplitude Modulator Circuit



$V_0 = 0\ V_{DC}$ for $V_{IN} = 0\ V_{DC}$, $A_V = 10$

Figure 8-3. Power Amplifier

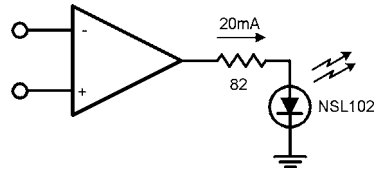


Figure 8-4. LED Driver

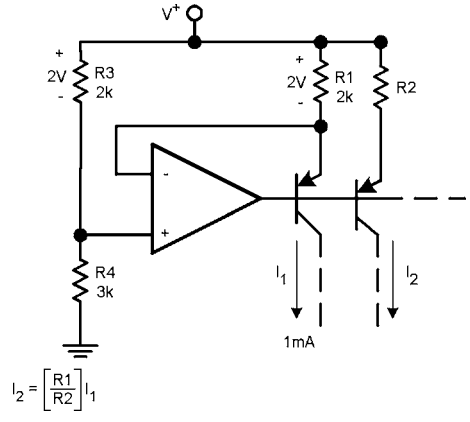


Figure 8-5. Fixed Current Sources

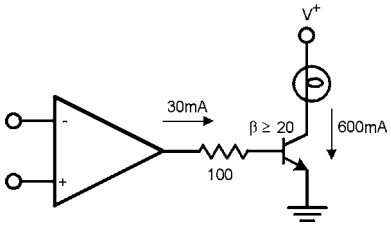


Figure 8-6. Lamp Driver