

# AN6500, AN6500S, AN6501

## Built-in Reference Voltage Operational Amplifiers

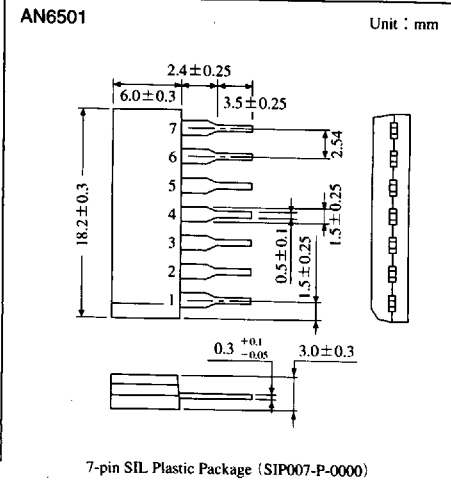
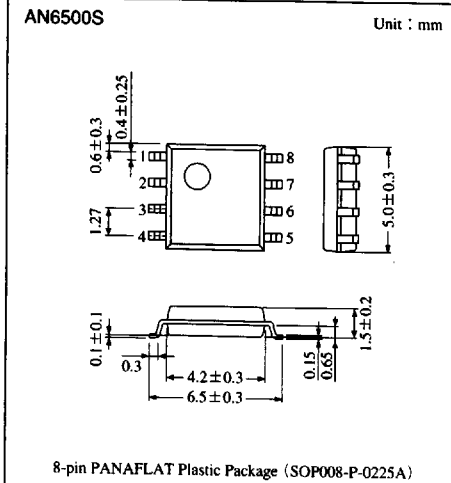
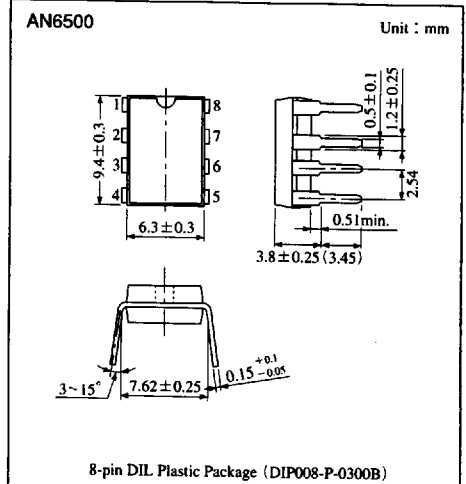
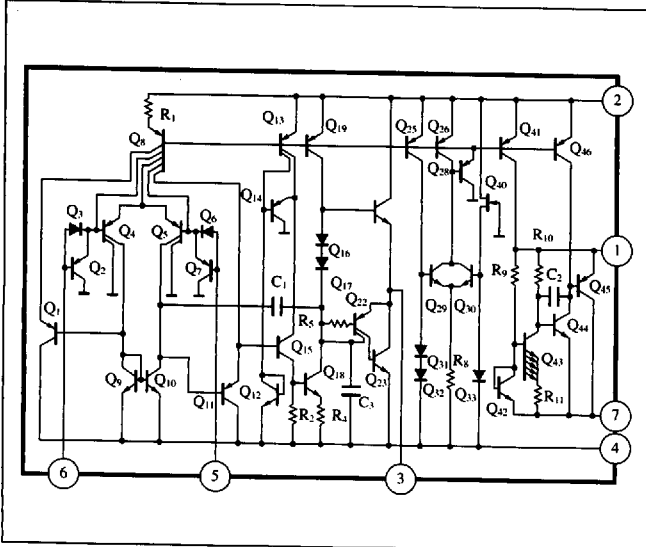
### Overview

The AN6500, the AN6500S, and the AN6501 are high-performance operational amplifiers with reference voltage built-in, allowing single power supply voltage operation and wide application with reference voltage.

### Features

- Wide range of operating voltage : 3 to 24V
- Single power supply voltage operation
- Large output current :  $I_{O} = +120\text{mA typ.}$   
 $-110\text{mA typ.}$
- Low reference voltage :  $V_{REF} = 1.33\text{V typ.}$
- Easy to compose variable regulator with reference voltage
- 3 types of packages are available
- Little cross-over distortion in operational amplifier circuit

### Schematic Diagram



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### ■ Pin Descriptions

Pin No.	Pin name
1	Ref. voltage (+)
2	Supply voltage
3	OP. amp. output
4	GND
5	OP. amp. input (+)
6	OP. amp. input (-)
7	Ref. voltage (-)
8	NC

### ■ Absolute Maximum Ratings (Ta = 25°C)

Parameter		Symbol	Rating	Unit
Supply voltage		V <sub>CC</sub>	24	V
Supply current		I <sub>CC</sub>	160	mA
Reference voltage outflow current		(V <sub>REF</sub> ) - I <sup>*1</sup>	-100	μA
Reference voltage inflow current		(V <sub>REF</sub> ) + I <sup>*2</sup>	500	μA
Common-mode input voltage range		V <sub>ICM</sub>	-0.3 to +24	V
Differential input voltage		V <sub>ID</sub>	24	V
Output sink current		V <sub>SINK</sub>	150	mA
Power dissipation	AN6500	P <sub>D</sub> <sup>*3</sup>	750	mW
	AN6500S		360	mW
	AN6501		925	mW
Operating ambient temperature		T <sub>opr</sub>	-20 to +75	°C
Storage temperature	AN6500, AN6501	T <sub>stg</sub>	-55 to +150	°C
	AN6500S		-40 to +125	°C

\*1 Current flowed out from Pin①. \*2 Current flowed into Pin①. \*3 When enlarging output current, watch power consumption.

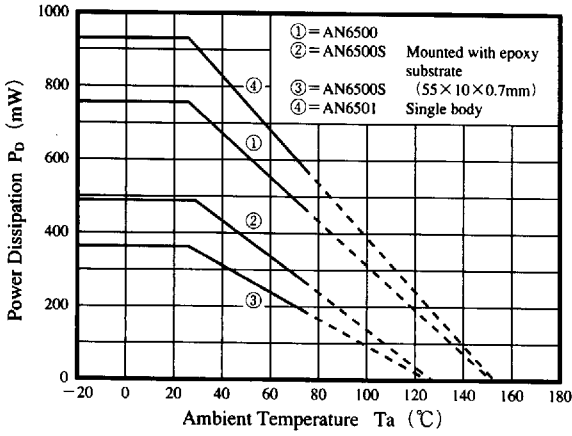
### ■ Electrical Characteristics (V<sub>CC</sub> = 5V, Ta = 25°C ± 2°C)

Parameter	Symbol	Condition	min	typ	max	Unit
Reference voltage	V <sub>REF</sub>		1.25	1.33	1.45	V
Reference voltage temperature variation characteristics	ΔV <sub>REF</sub> /Ta	Ta = 0 to 50°C	—	-30	—	ppm/°C
Input offset voltage	V <sub>I(offset)</sub>	R <sub>S</sub> = 50Ω	—	2	7	mV
Input bias current	I <sub>Bias</sub>		—	100	500	nA
Input offset current	I <sub>IO</sub>		—	5	300	nA
Common-mode input voltage range	V <sub>CM</sub>		—	—	3.5	V
Supply current	I <sub>CC</sub>	R <sub>L</sub> = ∞	—	2.5	3.5	mA
Voltage gain	G <sub>V</sub>	R <sub>L</sub> ≥ 2kΩ	80	108	—	dB
Maximum output voltage (1)	V <sub>O(max)1</sub>	R <sub>L</sub> ≥ 2kΩ	3.5	—	—	V
Maximum output voltage (2)	V <sub>O(max)2</sub>	V <sub>CC</sub> = 5V, I <sub>O</sub> = 70mA	3	4.1	—	V
Common-mode rejection ratio	CMR		—	85	—	dB
Supply voltage rejection ratio	SVR		—	90	—	dB
Output source current	I <sub>O(source)</sub>	V <sub>IN</sub> <sup>+</sup> = 1V, V <sub>IN</sub> <sup>-</sup> = 0V	70	110	—	mA
Output sink current	I <sub>SINK</sub>	V <sub>IN</sub> <sup>+</sup> = 0V, V <sub>IN</sub> <sup>-</sup> = 1V	70	120	—	mA
Zero-cross frequency	f <sub>(T)</sub>		—	1	—	MHz

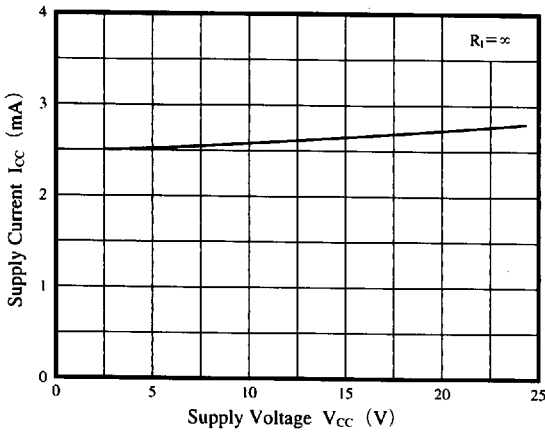
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■ Characteristics Curve

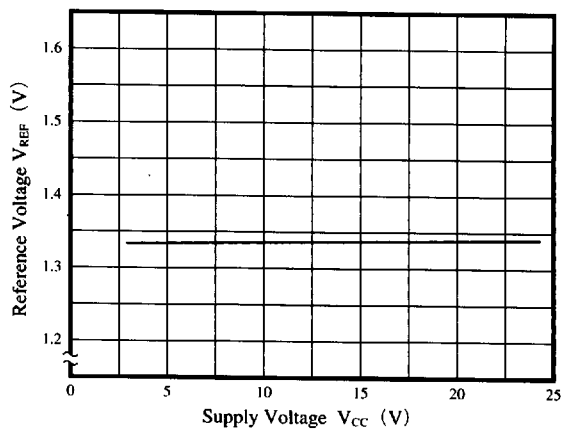
$P_D - T_a$



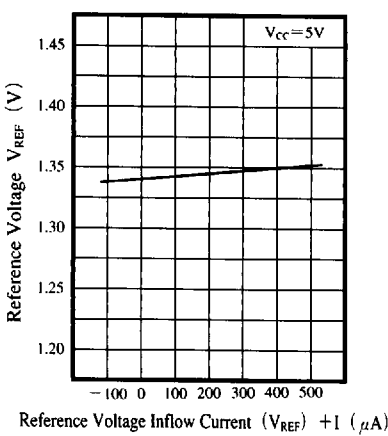
$I_{CC} - V_{CC}$



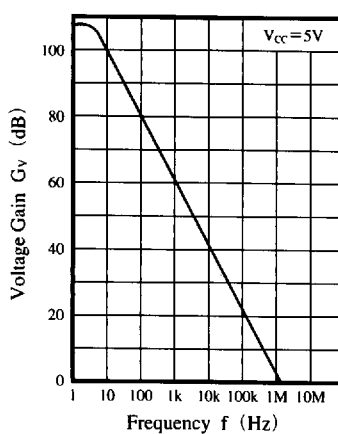
$V_{REF} - V_{CC}$



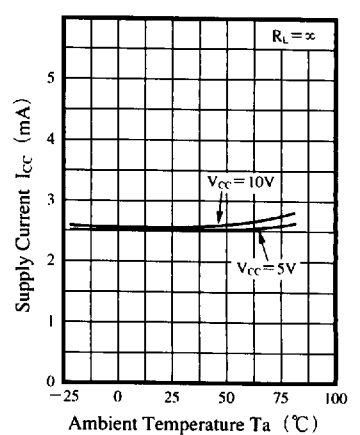
$V_{REF} - (V_{REF}) + I$



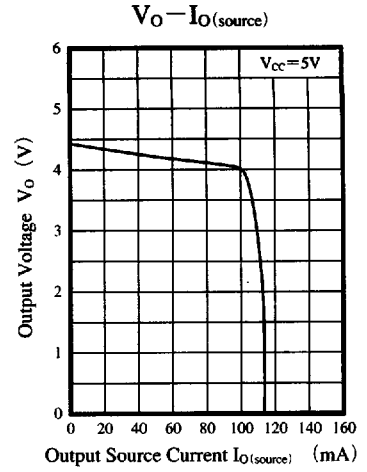
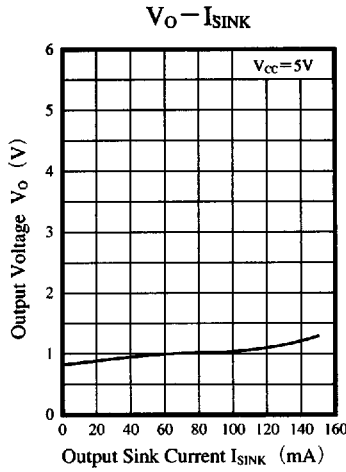
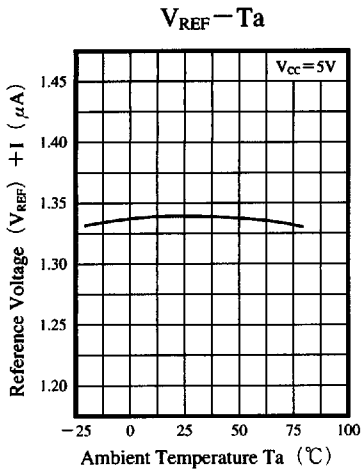
$G_V - f$



$I_{CC} - T_a$



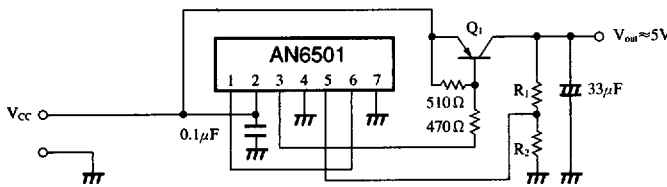
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**Application Circuits**

**1. Voltage Regulator Circuit**

High efficiency circuit with small I/O voltage difference



• Output voltage ( $V_{out}$ ) is calculated by the following formula.

$$V_{out} = \frac{R_1 + R_2}{R_2} V_{REF}$$

$$\approx \frac{R_1 + R_2}{R_2} \times 1.33 \text{ (V)}$$

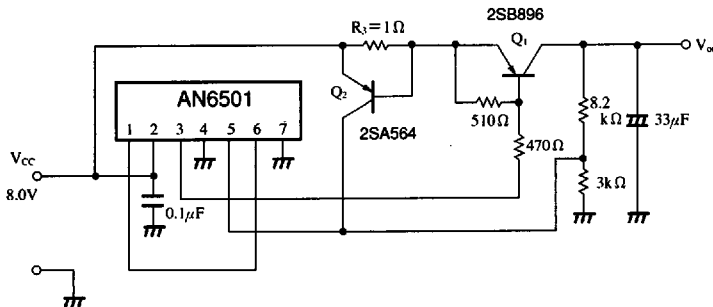
• I/O Voltage difference

2SB896 is applied for  $Q_1$  when output current is 330mA. The minimum I/O voltage difference is 0.2V.

Parameter	Symbol	Condition	typ	Unit
Line regulation	REG <sub>IN</sub>	$V_{CC}=6 \text{ to } 20\text{V}, I_O=1\text{A}$	16	mV
Load regulation	REG <sub>L</sub>	$V_{CC}=10\text{V}, I_O=5\text{mA to } 1\text{A}$	9	mV
Ripple rejection ratio	RR	$V_{CC}=8 \text{ to } 18\text{V}, I_O=100\text{mA}, f=120\text{Hz}$	57.4	dB

**2. Voltage Regulator Circuit**

With output current limiter



• Limit Current  $I_{O(Lim)}$  is calculated by the following formula

$$I_{O(Lim)} = \frac{V_{BE}(Q_2)}{R_3}$$

When  $V_{BE}(Q_2) = 0.7\text{V}$ , and  $R_3 = 1\Omega$ ,

$$I_{O(Lim)} = \frac{0.7}{1} = 0.7\text{A}$$

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