

## 550MHz Differential Twisted-Pair Driver

**élantec**

The EL5177 is a high bandwidth amplifier with an output in differential form. It is primarily targeted for

applications such as driving twisted-pair lines or any application where common mode injection is likely to occur. The input signal can be in either single-ended or differential form but the output is always in differential form.

On the EL5177, two feedback inputs provide the user with the ability to set the device gain (stable at minimum gain of one.)

The output common mode level is set by the reference pin (REF), which has a -3dB bandwidth of 110MHz. Generally, this pin is grounded but it can be tied to any voltage reference.

Both outputs (OUT+, OUT-) are short circuit protected to withstand temporary overload condition.

The EL5177 is available in the 10-pin MSOP package and is specified for operation over the full -40°C to +85°C temperature range.

See also EL5174 (EL5177 in 8-pin MSOP.)

## Ordering Information

PART NUMBER	PACKAGE	TAPE & REEL	PKG. DWG. #
EL5177IY	10-Pin MSOP	-	MDP0043
EL5177IY-T7	10-Pin MSOP	7"	MDP0043
EL5177IY-T13	10-Pin MSOP	13"	MDP0043
EL5177IYZ (See Note)	10-Pin MSOP (Pb-free)	-	MDP0043
EL5177IYZ-T7 (See Note)	10-Pin MSOP (Pb-free)	7"	MDP0043
EL5177IYZ-T13 (See Note)	10-Pin MSOP (Pb-free)	13"	MDP0043

NOTE: Intersil Pb-free products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which is compatible with both SnPb and Pb-free soldering operations. Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J Std-020B.

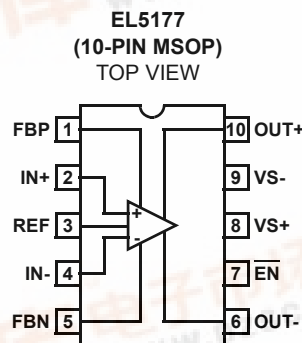
## Features

- Pb-free available
- Fully differential inputs, outputs, and feedback
- Differential input range  $\pm 2.3V$
- 550MHz 3dB bandwidth
- 1100V/ $\mu s$  slew rate
- Low distortion at 20MHz
- Single 5V or dual  $\pm 5V$  supplies
- 40mA maximum output current
- Low power - 12.5mA typical supply current

## Applications

- Twisted-pair drivers
- Differential line drivers
- VGA over twisted-pair
- ADSL/HDSL drivers
- Single ended to differential amplification
- Transmission of analog signals in a noisy environment

## Pinout



# EL5177

## Absolute Maximum Ratings (T<sub>A</sub> = 25°C)

Supply Voltage (V<sub>S+</sub> to V<sub>S-</sub>) ..... 12V  
 Maximum Output Current ..... ±60mA  
 Storage Temperature Range ..... -65°C to +150°C  
 Operating Junction Temperature ..... +135°C

Recommended Operating Temperature ..... -40°C to +85°C  
 V<sub>IN</sub>, V<sub>INB</sub>, V<sub>REF</sub> ..... V<sub>S-</sub> + 0.8V (min) to V<sub>S+</sub> - 0.8V (max)  
 V<sub>IN</sub> - V<sub>INB</sub> ..... ±5V

**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

**IMPORTANT NOTE:** All parameters having Min/Max specifications are guaranteed. Typ values are for information purposes only. Unless otherwise noted, all tests are at the specified temperature and are pulsed tests, therefore: T<sub>J</sub> = T<sub>C</sub> = T<sub>A</sub>

**Electrical Specifications** V<sub>S+</sub> = +5V, V<sub>S-</sub> = -5V, T<sub>A</sub> = 25°C, V<sub>IN</sub> = 0V, R<sub>LD</sub> = 1kΩ, R<sub>F</sub> = 0, R<sub>G</sub> = OPEN, C<sub>LD</sub> = 2.7pF, Unless Otherwise Specified

PARAMETER	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNIT
<b>AC PERFORMANCE</b>						
BW	-3dB Bandwidth	A <sub>V</sub> = 1, C <sub>LD</sub> = 2.7pF		550		MHz
		A <sub>V</sub> = 2, R <sub>F</sub> = 500, C <sub>LD</sub> = 2.7pF		130		MHz
		A <sub>V</sub> = 10, R <sub>F</sub> = 500, C <sub>LD</sub> = 2.7pF		20		MHz
BW	±0.1dB Bandwidth	A <sub>V</sub> = 1, C <sub>LD</sub> = 2.7pF		120		MHz
SR	Slew Rate	V <sub>OUT</sub> = 3V <sub>P-P</sub> , 20% to 80%	800	1100		V/μs
T <sub>STL</sub>	Settling Time to 0.1%	V <sub>OUT</sub> = 2V <sub>P-P</sub>		10		ns
T <sub>OVR</sub>	Output Overdrive Recovery Time			20		ns
GBWP	Gain Bandwidth Product			200		MHz
V <sub>REFBW</sub> (-3dB)	V <sub>REF</sub> -3dB Bandwidth	A <sub>V</sub> = 1, C <sub>LD</sub> = 2.7pF		110		MHz
V <sub>REFSR+</sub>	V <sub>REF</sub> Slew Rate - Rise	V <sub>OUT</sub> = 2V <sub>P-P</sub> , 20% to 80%		134		V/μs
V <sub>REFSR-</sub>	V <sub>REF</sub> Slew Rate - Fall	V <sub>OUT</sub> = 2V <sub>P-P</sub> , 20% to 80%		70		V/μs
V <sub>N</sub>	Input Voltage Noise	at 10kHz		21		nV/√Hz
I <sub>N</sub>	Input Current Noise	at 10kHz		2.7		pA/√Hz
HD2	Second Harmonic Distortion	V <sub>OUT</sub> = 2V <sub>P-P</sub> , 5MHz		-95		dBc
		V <sub>OUT</sub> = 2V <sub>P-P</sub> , 20MHz		-94		dBc
HD3	Third Harmonic Distortion	V <sub>OUT</sub> = 2V <sub>P-P</sub> , 5MHz		-88		dBc
		V <sub>OUT</sub> = 2V <sub>P-P</sub> , 20MHz		-87		dBc
dG	Differential Gain at 3.58MHz	R <sub>LD</sub> = 300Ω, A <sub>V</sub> = 2		0.06		%
dθ	Differential Phase at 3.58MHz	R <sub>LD</sub> = 300Ω, A <sub>V</sub> = 2		0.13		°
<b>INPUT CHARACTERISTICS</b>						
V <sub>OS</sub>	Input Referred Offset Voltage			±1.4	±25	mV
I <sub>IN</sub>	Input Bias Current (V <sub>IN+</sub> , V <sub>IN-</sub> )		-20	-14	-7	μA
I <sub>REF</sub>	Input Bias Current (V <sub>REF</sub> )		0.5	2.3	4	μA
R <sub>IN</sub>	Differential Input Resistance			150		kΩ
C <sub>IN</sub>	Differential Input Capacitance			1		pF
DMIR	Differential Mode Input Range		±2.1	±2.3	±2.5	V
CMIR+	Common Mode Positive Input Range at V <sub>IN+</sub> , V <sub>IN-</sub>			3.4		V
CMIR-	Common Mode Negative Input Range at V <sub>IN+</sub> , V <sub>IN-</sub>			-4.3		V
V <sub>REFIN+</sub>	Positive Reference Input Voltage Range	V <sub>IN+</sub> = V <sub>IN-</sub> = 0V	3.4	3.7		V
V <sub>REFIN-</sub>	Negative Reference Input Voltage Range	V <sub>IN+</sub> = V <sub>IN-</sub> = 0V		-3.3	-3	V

## EL5177

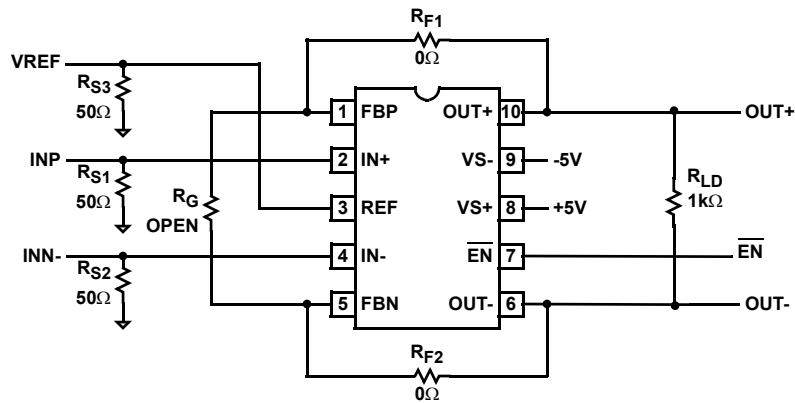
**Electrical Specifications**  $V_{S+} = +5V$ ,  $V_{S-} = -5V$ ,  $T_A = 25^\circ C$ ,  $V_{IN} = 0V$ ,  $R_{LD} = 1k\Omega$ ,  $R_F = 0$ ,  $R_G = OPEN$ ,  $C_{LD} = 2.7pF$ , Unless Otherwise Specified **(Continued)**

PARAMETER	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNIT
V <sub>REFOS</sub>	Output Offset Relative to V <sub>REF</sub>			±50	±100	mV
CMRR	Input Common Mode Rejection Ratio	V <sub>IN</sub> = ±2.5V	65	78		dB
Gain	Gain Accuracy	V <sub>IN</sub> = 1V	0.980	0.995	1.010	V
<b>OUTPUT CHARACTERISTICS</b>						
V <sub>OUT</sub>	Output Voltage Swing	R <sub>L</sub> = 500Ω to GND	±3.6	±3.8		V
I <sub>OUT+(Max)</sub>	Maximum Source Output Current	R <sub>L</sub> = 10Ω, V <sub>IN+</sub> = 1.1V, V <sub>IN-</sub> = -1.1V, V <sub>REF</sub> = 0	35	50		mA
I <sub>OUT-(Max)</sub>	Maximum Sink Output Current			-40	-30	mA
R <sub>OUT</sub>	Output Impedance			130		mΩ
<b>SUPPLY</b>						
V <sub>SUPPLY</sub>	Supply Operating Range	V <sub>S+</sub> to V <sub>S-</sub>	4.75		11	V
I <sub>S(ON)</sub>	Power Supply Current - Per Channel		10	12.5	14	mA
I <sub>S(OFF)+</sub>	Positive Power Supply Current - Disabled	$\overline{EN}$ pin tied to 4.8V		76	120	μA
I <sub>S(OFF)-</sub>	Negative Power Supply Current - Disabled		-200	-120	μA	
PSRR	Power Supply Rejection Ratio	V <sub>S</sub> from ±4.5V to ±5.5V	60	75		dB
<b>ENABLE</b>						
t <sub>EN</sub>	Enable Time			130		ns
t <sub>DS</sub>	Disable Time			1.2		μs
V <sub>IH</sub>	$\overline{EN}$ Pin Voltage for Power-Up				V <sub>S+</sub> - 1.5	V
V <sub>IL</sub>	$\overline{EN}$ Pin Voltage for Shut-Down		V <sub>S+</sub> - 0.5			V
I <sub>IH-EN</sub>	$\overline{EN}$ Pin Input Current High	At V <sub>EN</sub> = 5V		40	50	μA
I <sub>IL-EN</sub>	$\overline{EN}$ Pin Input Current Low	At V <sub>EN</sub> = 0V	-6	-2.5		μA

### Pin Descriptions

PIN NUMBER	PIN NAME	PIN DESCRIPTION
1	FBP	Non-inverting feedback input; resistor R <sub>F1</sub> must be connected from this pin to V <sub>OUT</sub>
2	IN+	Non-inverting input
3	REF	Output common-mode control; the common-mode voltage of V <sub>OUT</sub> will follow the voltage on this pin
4	IN-	Inverting input
5	FBN	Inverting feedback input; resistor R <sub>F2</sub> must be connected from this pin to V <sub>OUT</sub>
6	OUT-	Inverting output
7	$\overline{EN}$	Enabled when this pin is floating or the applied voltage ≤ V <sub>S+</sub> - 1.5
8	VS+	Positive supply
9	VS-	Negative supply
10	OUT+	Non-inverting output

Connection Diagram



Typical Performance Curves

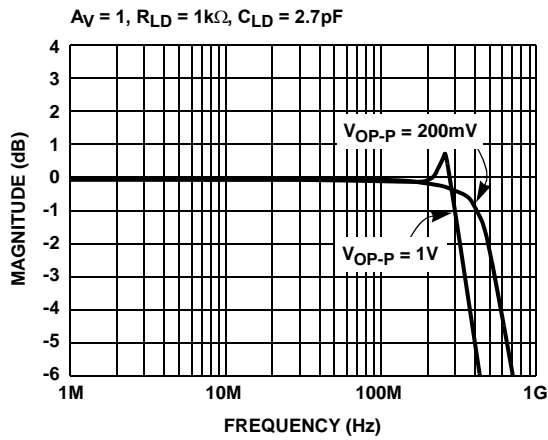


FIGURE 1. FREQUENCY RESPONSE

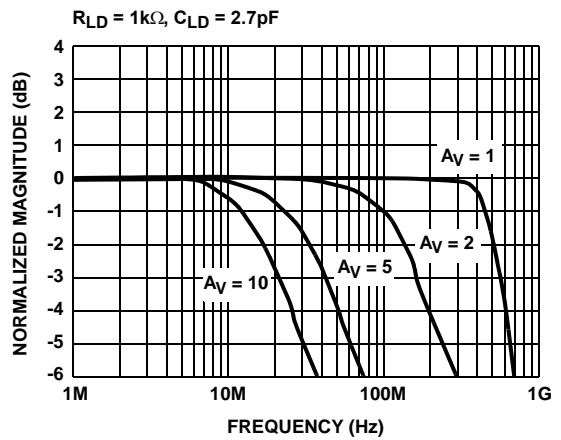


FIGURE 2. FREQUENCY RESPONSE FOR VARIOUS GAIN

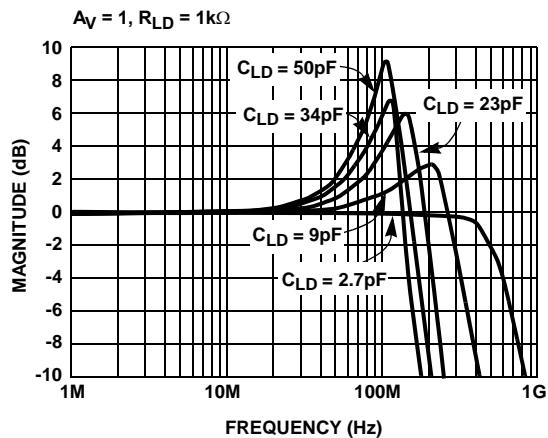


FIGURE 3. FREQUENCY RESPONSE vs  $C_{LD}$

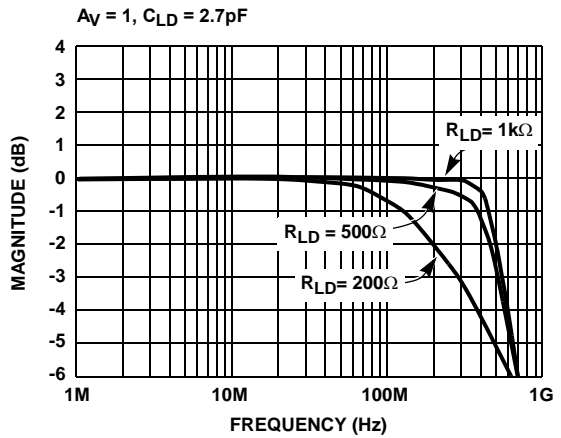


FIGURE 4. FREQUENCY RESPONSE vs  $R_{LD}$

Typical Performance Curves (Continued)

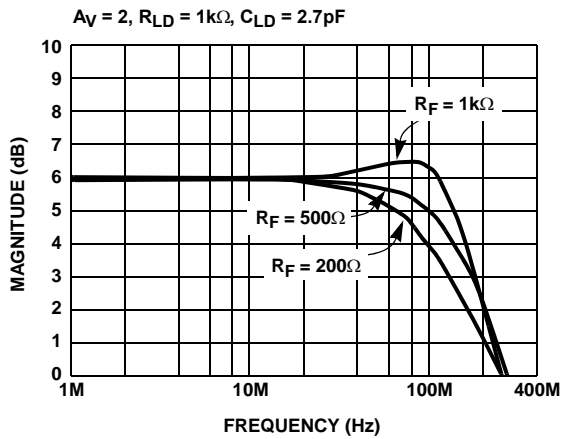


FIGURE 5. FREQUENCY RESPONSE

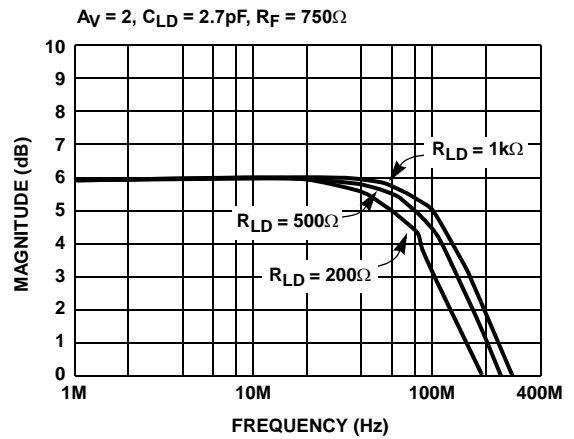


FIGURE 6. FREQUENCY RESPONSE vs  $R_{LD}$

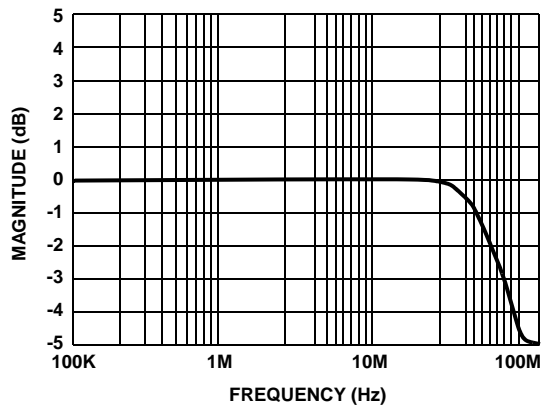


FIGURE 7. FREQUENCY RESPONSE -  $V_{REF}$

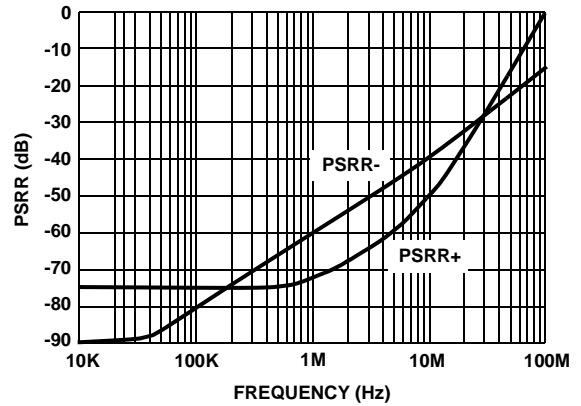


FIGURE 8. PSRR vs FREQUENCY

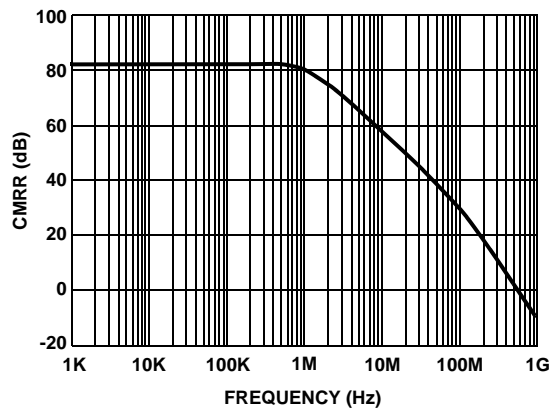


FIGURE 9. CMRR vs FREQUENCY

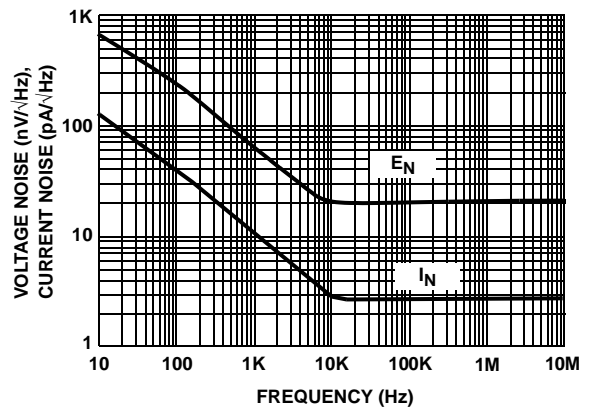


FIGURE 10. VOLTAGE AND CURRENT NOISE vs FREQUENCY

Typical Performance Curves (Continued)

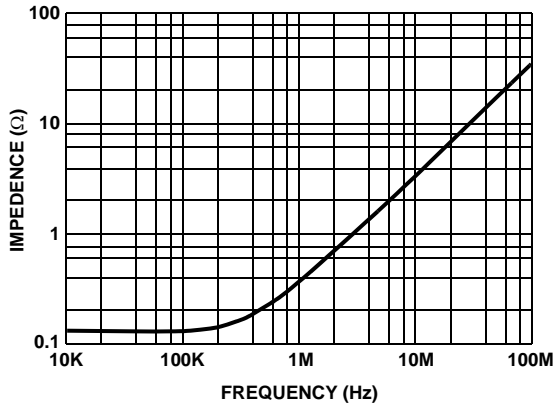


FIGURE 11. OUTPUT IMPEDANCE vs FREQUENCY

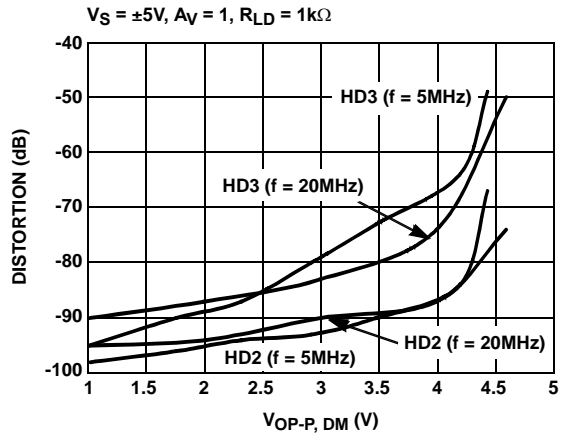


FIGURE 12. HARMONIC DISTORTION vs DIFFERENTIAL OUTPUT VOLTAGE

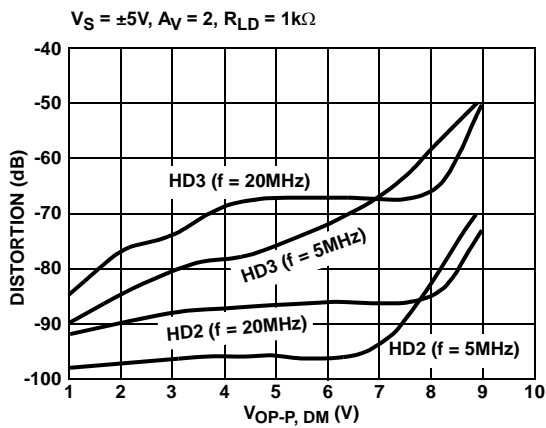


FIGURE 13. HARMONIC DISTORTION vs DIFFERENTIAL OUTPUT VOLTAGE

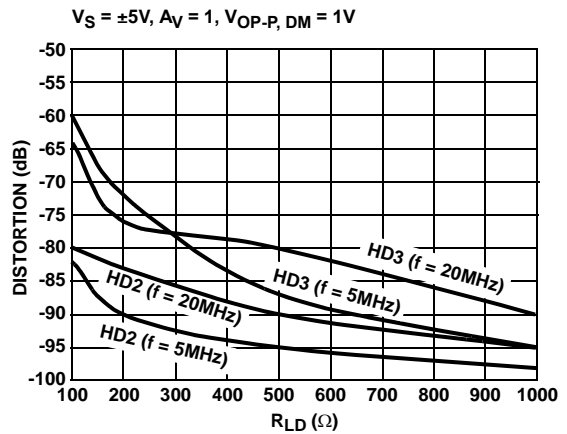


FIGURE 14. HARMONIC DISTORTION vs  $R_{LD}$

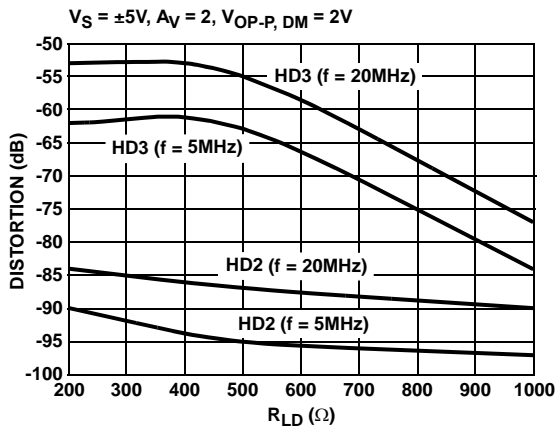


FIGURE 15. HARMONIC DISTORTION vs  $R_{LD}$

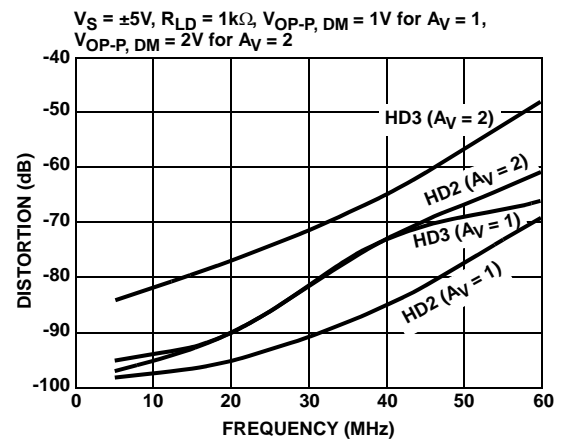


FIGURE 16. HARMONIC DISTORTION vs FREQUENCY

Typical Performance Curves (Continued)

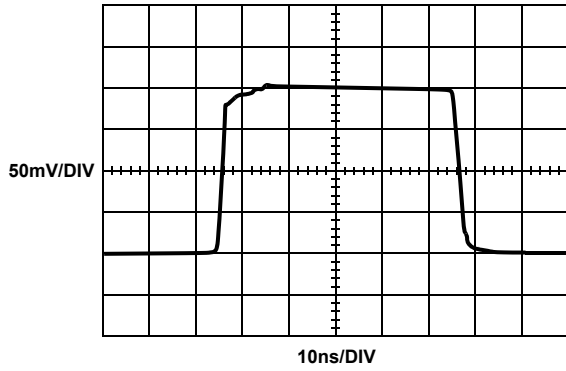


FIGURE 17. SMALL SIGNAL TRANSIENT RESPONSE

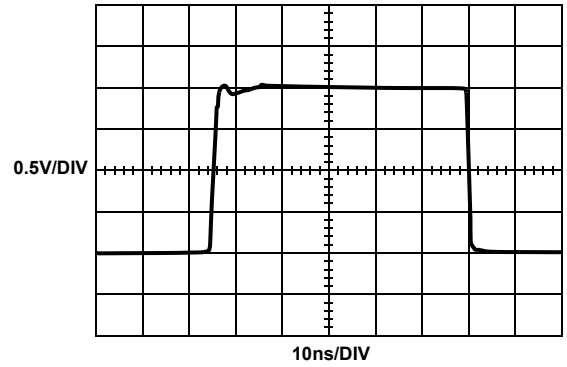


FIGURE 18. LARGE SIGNAL TRANSIENT RESPONSE

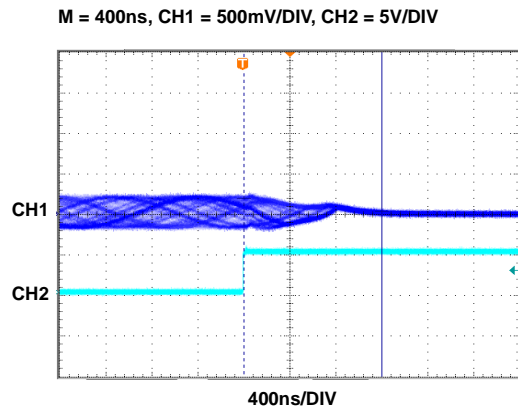


FIGURE 19. ENABLED RESPONSE

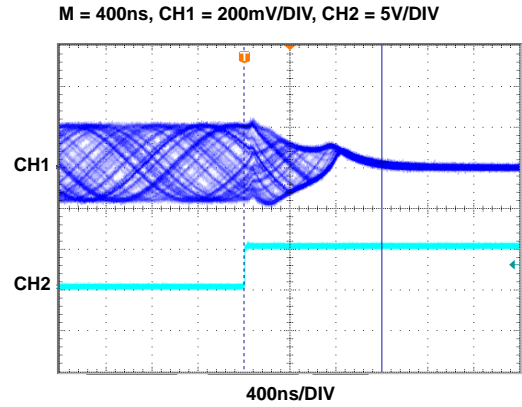


FIGURE 20. DISABLED RESPONSE

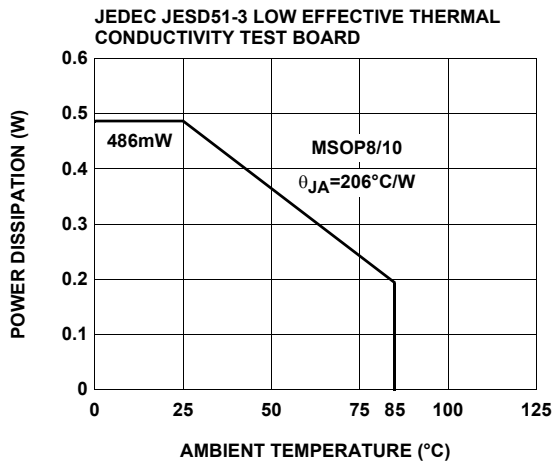


FIGURE 21. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

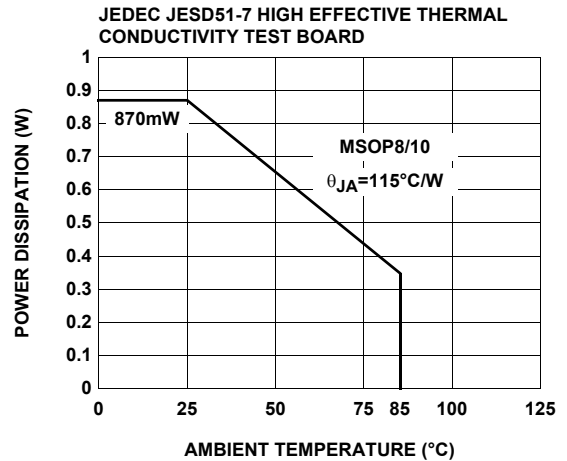
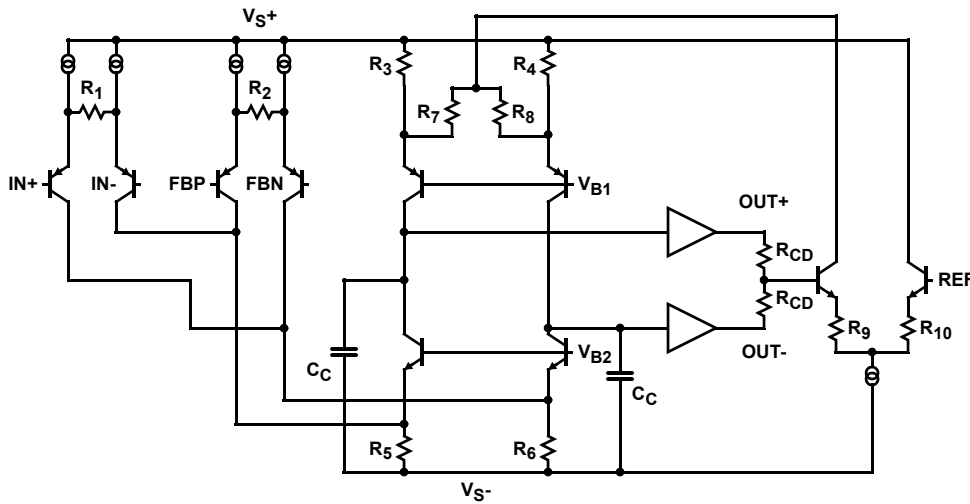


FIGURE 22. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

**Simplified Schematic**



**Description of Operation and Application Information**

**Product Description**

The EL5177 is a wide bandwidth, low power and single/differential ended to differential output amplifier. It can be used as single/differential ended to differential converter. The EL5177 is internally compensated for closed loop gain of +1 or greater. Connected in gain of 1 and driving a 1kΩ differential load, the EL5177 has a -3dB bandwidth of 550MHz. Driving a 200Ω differential load at gain of 2, the bandwidth is about 130MHz. The EL5177 is available with a power down feature to reduce the power while the amplifier is disabled.

**Input, Output, and Supply Voltage Range**

The EL5177 has been designed to operate with a single supply voltage of 5V to 10V or a split supplies with its total voltage from 5V to 10V. The amplifiers have an input common mode voltage range from -4.3V to 3.4V for ±5V supply. The differential mode input range (DMIR) between the two inputs is from -2.3V to +2.3V. The input voltage range at the REF pin is from -3.3V to 3.7V. If the input common mode or differential mode signal is outside the above-specified ranges, it will cause the output signal distorted.

The output of the EL5177 can swing from -3.8V to +3.8V at 1kΩ differential load at ±5V supply. As the load resistance becomes lower, the output swing is reduced.

**Differential and Common Mode Gain Settings**

The voltage applied at REF pin can set the output common mode voltage and the gain is one. The differential gain is set by the R<sub>F</sub> and R<sub>G</sub> network.

The gain setting for EL5177 is:

$$V_{ODM} = (V_{IN+} - V_{IN-}) \times \left( 1 + \frac{R_{F1} + R_{F2}}{R_G} \right)$$

$$V_{ODM} = (V_{IN+} - V_{IN-}) \times \left( 1 + \frac{2R_F}{R_G} \right)$$

$$V_{OCM} = V_{REF}$$

Where:

- R<sub>F1</sub> = R<sub>F2</sub> = R<sub>F</sub>

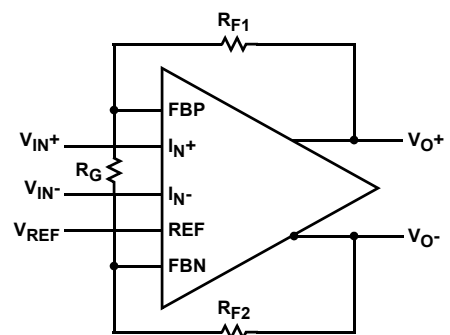


FIGURE 23.

**Choice of Feedback Resistor and Gain Bandwidth Product**

For applications that require a gain of +1, no feedback resistor is required. Just short the OUT+ pin to FBP pin and OUT- pin to FBN pin. For gains greater than +1, the feedback resistor forms a pole with the parasitic capacitance at the inverting input. As this pole becomes smaller, the amplifier's phase margin is reduced. This causes ringing in the time domain and peaking in the frequency domain. Therefore, R<sub>F</sub> has some maximum value that should not be



exceeded for optimum performance. If a large value of  $R_F$  must be used, a small capacitor in the few Pico farad range in parallel with  $R_F$  can help to reduce the ringing and peaking at the expense of reducing the bandwidth.

The bandwidth of the EL5177 depends on the load and the feedback network.  $R_F$  and  $R_G$  appear in parallel with the load for gains other than +1. As this combination gets smaller, the bandwidth falls off. Consequently,  $R_F$  also has a minimum value that should not be exceeded for optimum bandwidth performance. For gain of +1,  $R_F = 0$  is optimum. For the gains other than +1, optimum response is obtained with  $R_F$  between  $500\Omega$  to  $1k\Omega$ .

The EL5177 has a gain bandwidth product of 200MHz for  $R_{LD} = 1k\Omega$ . For gains  $\geq 5$ , its bandwidth can be predicted by the following equation:

$$\text{Gain} \times \text{BW} = 200\text{MHz}$$

### Driving Capacitive Loads and Cables

The EL5177 can drive 23pF differential capacitor in parallel with  $1k\Omega$  differential load with less than 5dB of peaking at gain of +1. If less peaking is desired in applications, a small series resistor (usually between  $5\Omega$  to  $50\Omega$ ) can be placed in series with each output to eliminate most peaking. However, this will reduce the gain slightly. If the gain setting is greater than 1, the gain resistor  $R_G$  can then be chosen to make up for any gain loss which may be created by the additional series resistor at the output.

When used as a cable driver, double termination is always recommended for reflection-free performance. For those applications, a back-termination series resistor at the amplifier's output will isolate the amplifier from the cable and allow extensive capacitive drive. However, other applications may have high capacitive loads without a back-termination resistor. Again, a small series resistor at the output can help to reduce peaking.

### Disable/Power-Down

The EL5177 can be disabled and placed its outputs in a high impedance state. The turn off time is about  $1.2\mu\text{s}$  and the turn on time is about 130ns. When disabled, the amplifier's supply current is reduced to  $1.7\mu\text{A}$  for  $I_{S+}$  and  $120\mu\text{A}$  for  $I_{S-}$  typically, thereby effectively eliminating the power consumption. The amplifier's power down can be controlled by standard CMOS signal levels at the EN pin. The applied logic signal is relative to  $V_{S+}$  pin. Letting the  $\overline{\text{EN}}$  pin float or applying a signal that is less than 1.5V below  $V_{S+}$  will enable the amplifier. The amplifier will be disabled when the signal at  $\overline{\text{EN}}$  pin is above  $V_{S+} - 0.5\text{V}$ .

### Output Drive Capability

The EL5177 has internal short circuit protection. Its typical short circuit current is  $\pm 40\text{mA}$ . If the output is shorted indefinitely, the power dissipation could easily increase such that the part will be destroyed. Maximum reliability is

maintained if the output current never exceeds  $\pm 40\text{mA}$ . This limit is set by the design of the internal metal interconnect.

### Power Dissipation

With the high output drive capability of the EL5177. It is possible to exceed the  $135^\circ\text{C}$  absolute maximum junction temperature under certain load current conditions. Therefore, it is important to calculate the maximum junction temperature for the application to determine if the load conditions or package types need to be modified for the amplifier to remain in the safe operating area.

The maximum power dissipation allowed in a package is determined according to:

$$PD_{\text{MAX}} = \frac{T_{\text{JMAX}} - T_{\text{AMAX}}}{\theta_{\text{JA}}}$$

Where:

- $T_{\text{JMAX}}$  = Maximum junction temperature
- $T_{\text{AMAX}}$  = Maximum ambient temperature
- $\theta_{\text{JA}}$  = Thermal resistance of the package

The maximum power dissipation actually produced by an IC is the total quiescent supply current times the total power supply voltage, plus the power in the IC due to the load, or:

$$PD = V_S \times I_{\text{SMAX}} + V_S \times \frac{\Delta V_O}{R_{\text{LD}}}$$

Where:

- $V_S$  = Total supply voltage
- $I_{\text{SMAX}}$  = Maximum quiescent supply current per channel
- $\Delta V_O$  = Maximum differential output voltage of the application
- $R_{\text{LD}}$  = Differential load resistance
- $I_{\text{LOAD}}$  = Load current

By setting the two  $PD_{\text{MAX}}$  equations equal to each other, we can solve the output current and  $R_{\text{LD}}$  to avoid the device overheat.

### Power Supply Bypassing and Printed Circuit Board Layout

As with any high frequency device, a good printed circuit board layout is necessary for optimum performance. Lead lengths should be as short as possible. The power supply pin must be well bypassed to reduce the risk of oscillation. For normal single supply operation, where the  $V_{S-}$  pin is connected to the ground plane, a single  $4.7\mu\text{F}$  tantalum capacitor in parallel with a  $0.1\mu\text{F}$  ceramic capacitor from  $V_{S+}$  to GND will suffice. This same capacitor combination should be placed at each supply pin to ground if split supplies are to be used. In this case, the  $V_{S-}$  pin becomes the negative supply rail.

## EL5177

For good AC performance, parasitic capacitance should be kept to minimum. Use of wire wound resistors should be avoided because of their additional series inductance. Use of sockets should also be avoided if possible. Sockets add parasitic inductance and capacitance that can result in

compromised performance. Minimizing parasitic capacitance at the amplifier's inverting input pin is very important. The feedback resistor should be placed very close to the inverting input pin. Strip line design techniques are recommended for the signal traces.

### Typical Applications

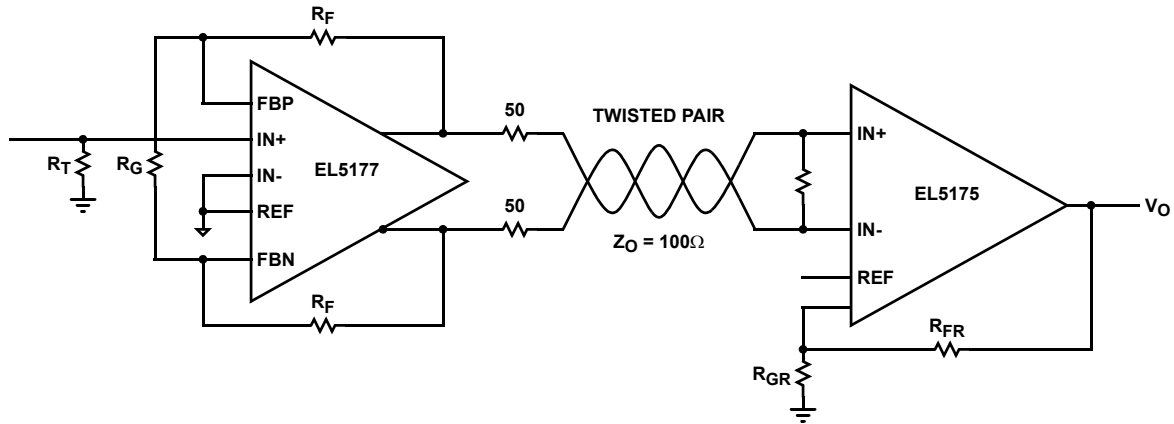
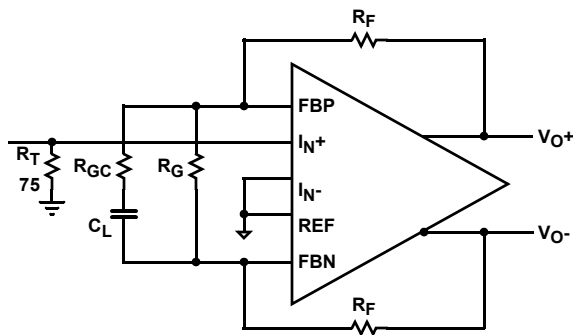


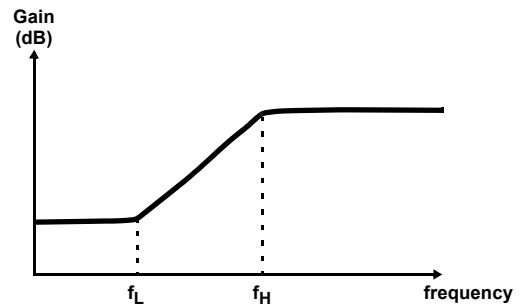
FIGURE 24. TWISTED PAIR CABLE RECEIVER

As the signal is transmitted through a cable, the high frequency signal will be attenuated. One way to compensate this loss is to boost the high frequency gain at the receiver side.



$$\text{DC Gain} = 1 + \frac{2R_F}{R_G}$$

$$\text{(HF)Gain} = 1 + \frac{2R_F}{R_G \parallel R_{GC}}$$

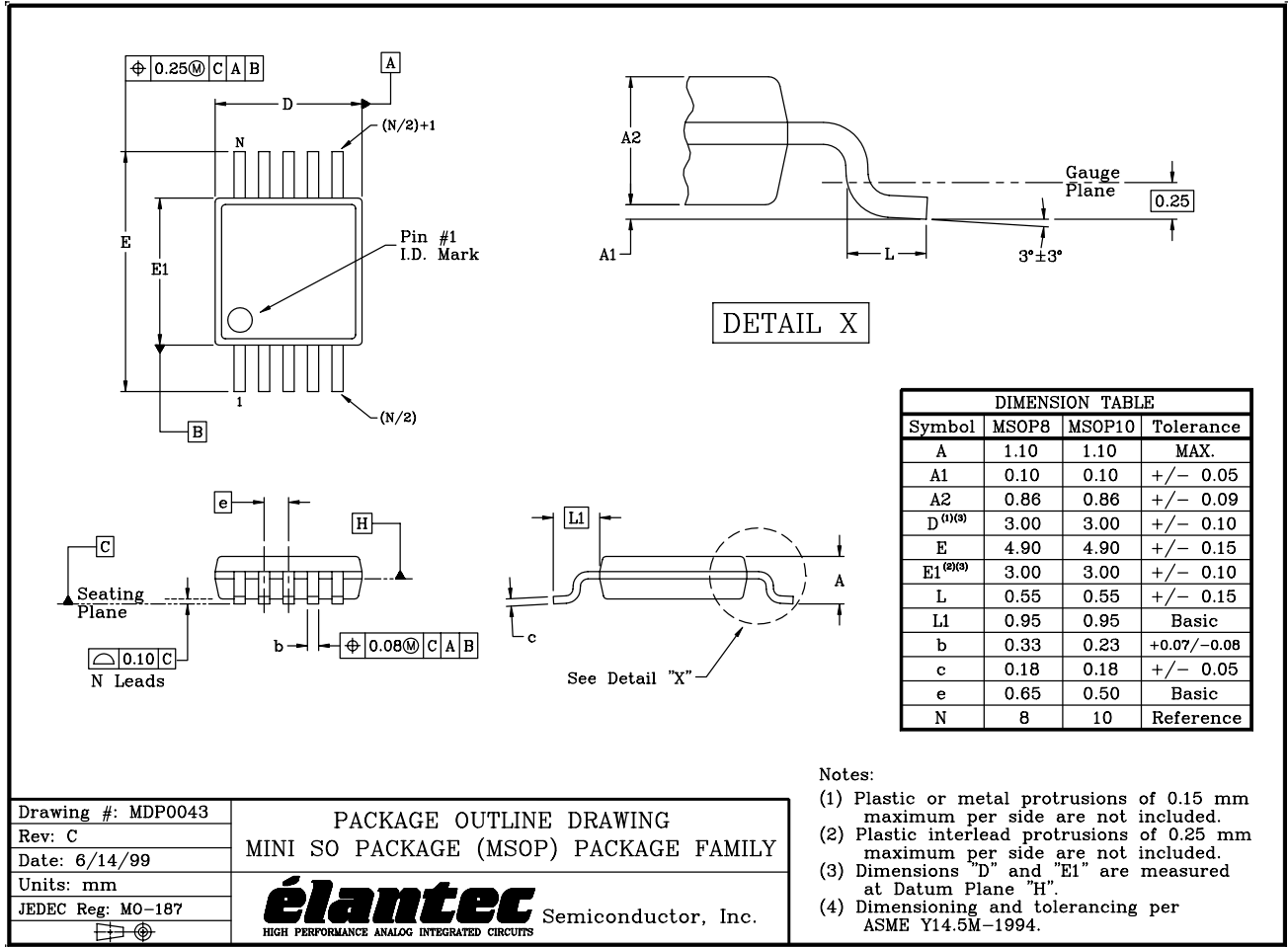


$$f_L \cong \frac{1}{2\pi R_G C_C}$$

$$f_H \cong \frac{1}{2\pi R_{GC} C_C}$$

FIGURE 25. TRANSMIT EQUALIZER

MSOP Package Outline Drawing



Notes:

- (1) Plastic or metal protrusions of 0.15 mm maximum per side are not included.
- (2) Plastic interlead protrusions of 0.25 mm maximum per side are not included.
- (3) Dimensions "D" and "E1" are measured at Datum Plane "H".
- (4) Dimensioning and tolerancing per ASME Y14.5M-1994.

Drawing #: MDP0043	PACKAGE OUTLINE DRAWING MINI SO PACKAGE (MSOP) PACKAGE FAMILY  Semiconductor, Inc. <small>HIGH PERFORMANCE ANALOG INTEGRATED CIRCUITS</small>
Rev: C	
Date: 6/14/99	
Units: mm	
JEDEC Reg: MO-187	

NOTE: The package drawing shown here may not be the latest version. To check the latest revision, please refer to the Intersil website at <http://www.intersil.com/design/packages/index.asp>

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