MIC863

Dual Ultra-Low Power Op Amp in SOT-23-8

Features

- 8-Pin SOT-23 Package
- 450 kHz Gain-Bandwidth Product
- 800 kHz, –3 dB Bandwidth
- 4.2 µA Supply Current/Channel
- Rail-to-Rail Output
- Ground Sensing at Input (Common-Mode-to-GND)
- Drives Large Capacitive Loads (0.02 µF)
- Unity Gain Stable

Applications

- Portable Equipment
- Medical Instrument
- PDAs
- Pagers
- Cordless Phones
- Consumer Electronics

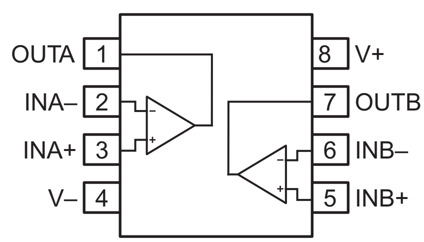
General Description

The MIC863 is a dual low-power operational amplifier in a SOT-23-8 package. It is designed to operate in the 2V to 5V range, rail-to-rail output, with input common-mode to ground. The MIC863 provides 450 kHz gain-bandwidth product while consuming only a 4.2 µA supply current

With low supply voltage and 8-pin SOT-23 packaging, MIC863 provides two channels as general-purpose amplifiers for portable and battery-powered applications. Its package provides the maximum performance available while maintaining an extremely slim form factor. The minimal power consumption of this IC maximizes the battery life potential.

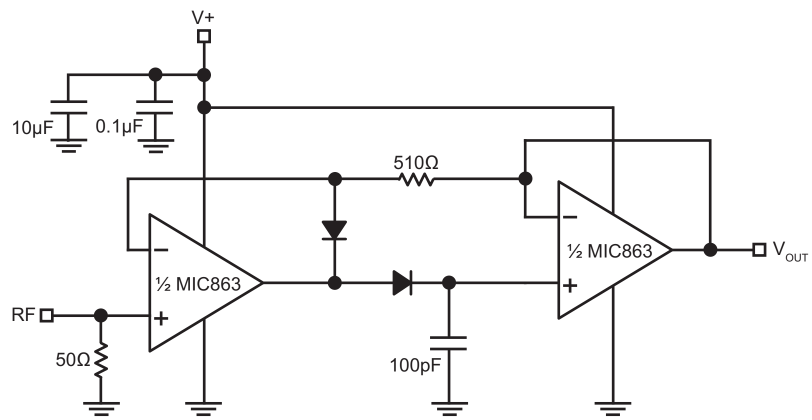
Package Type

MIC863
8-Lead SOT-23 (M8)



Typical Application Schematic

Peak Detector Circuit



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{V+} – V_{V-}) .... +6.0V
Differential Input Voltage (|V_{IN+} – V_{IN-}|) (Note 1) .... +6.0V
Input Voltage (V_{IN+} – V_{IN-}) .... V_{V+} + 0.3V, V_{V-} – 0.3V
Output Short-Circuit Current Duration .... Indefinite
ESD Rating (Note 2) .... ESD Sensitive

Operating Ratings ‡

Supply Voltage .... +2.0V to +5.25V

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ Notice: The device is not guaranteed to function outside the operating ratings.

Note 1: Exceeding the maximum differential input voltage will damage the input stage and degrade performance (in particular, input bias current is likely to increase).

2: Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS (2.0V)

Electrical Characteristics: V+ = +2V, V– = 0V, V_{CM} = V+/2; R_L = 500 kΩ to V+/2; T_A = 25°C, unless otherwise noted.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	V_{OS}	–5	0.1	5	mV	—
		–6	0.1	6		–40°C ≤ T_A ≤ +85°C
Differential Offset Voltage		—	0.5	—	mV	—
Input Offset Voltage Temperature Coefficient	$\Delta V_{OS}/\Delta T_A$	—	6	—	µV/°C	—
Input Bias Current	I_B	—	10	—	pA	—
Input Offset Current	I_{OS}	—	5	—	pA	—
Input Voltage Range	V_{CM}	0.5	1	—	V	CMRR > 50 dB, –40°C ≤ T_A ≤ +85°C
Common-Mode Rejection Ratio	CMRR	45	75	—	dB	0V < V_{CM} < 1V, –40°C ≤ T_A ≤ +85°C
Power Supply Rejection Ratio	PSRR	50	85	—	dB	Supply voltage change of 2V to 2.7V, –40°C ≤ T_A ≤ +85°C
Large-Signal Voltage Gain	A_{VOL}	66	81	—	dB	R_L = 100 kΩ, V_{OUT} = 1.4 V_{PP}, –40°C ≤ T_A ≤ +85°C
		73	90	—		R_L = 500 kΩ, V_{OUT} = 1.4 V_{PP}, –40°C ≤ T_A ≤ +85°C
Maximum Output Voltage Swing	V_{OUT}	V+ – 3 mV	V+ – 1.4 mV	—	V	R_L = 500 kΩ, –40°C ≤ T_A ≤ +85°C
Minimum Output Voltage Swing		—	V– + 0.5 mV	V– + 3 mV		
Gain-Bandwidth Product	GBWP	—	320	—	kHz	R_L = 200 kΩ, C_L = 2 pF, A_V = 11
Phase Margin	PM	—	69	—	°	R_L = 200 kΩ, C_L = 2 pF, A_V = 11
–3 dB Bandwidth	BW	—	600	—	kHz	A_V = 1, C_L = 2 pF, R_L = 1 MΩ
Slew Rate	SR	—	0.33	—	V/µs	A_V = 1, C_L = 2 pF, R_L = 1 MΩ, Positive Slew Rate = 0.17 V/µs
Short-Circuit Output Current	I_{SC}	1.8	2.6	—	mA	Source, –40°C ≤ T_A ≤ +85°C
		1.5	2.2	—		Sink, –40°C ≤ T_A ≤ +85°C
Supply Current (per Op Amp)	I_S	—	3.5	7	µA	No Load, –40°C ≤ T_A ≤ +85°C
Channel-to-Channel Crosstalk	—	—	–100	—	dB	Note 1

Note 1: DC signal referenced to input. Refer to the AC Performance Characteristics section.

ELECTRICAL CHARACTERISTICS (2.7V)

Electrical Characteristics: V+ = +2.7V, V– = 0V, V_{CM} = V+/2; R_L = 500 kΩ to V+/2; T_A = 25°C, unless otherwise noted.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	V_{OS}	–5	0.1	5	mV	—
		–6	0.1	6		–40°C ≤ T_A ≤ +85°C
Differential Offset Voltage		—	0.5	—	mV	—
Input Offset Voltage Temperature Coefficient	$\Delta V_{OS}/\Delta T_A$	—	6	—	µV/°C	—
Input Bias Current	I_B	—	10	—	pA	—
Input Offset Current	I_{OS}	—	5	—	pA	—
Input Voltage Range	V_{CM}	1	1.8	—	V	CMRR > 60 dB, –40°C ≤ T_A ≤ +85°C
Common-Mode Rejection Ratio	CMRR	60	83	—	dB	0V < V_{CM} < 1.35V, –40°C ≤ T_A ≤ +85°C
Power Supply Rejection Ratio	PSRR	55	85	—	dB	Supply voltage change of 2.7V to 3V, –40°C ≤ T_A ≤ +85°C
Large-Signal Voltage Gain	A_{VOL}	70	83	—	dB	R_L = 100 kΩ, V_{OUT} = 2 V_{PP}, –40°C ≤ T_A ≤ +85°C
		78	91	—		R_L = 500 kΩ, V_{OUT} = 2 V_{PP}, –40°C ≤ T_A ≤ +85°C
Gain-Bandwidth Product	GBWP	—	350	—	kHz	R_L = 200 kΩ, C_L = 2 pF, A_V = 11
Phase Margin	PM	—	65	—	°	R_L = 200 kΩ, C_L = 2 pF, A_V = 11
–3 dB Bandwidth	BW	—	600	—	kHz	A_V = 1, C_L = 2 pF, R_L = 1 MΩ
Slew Rate	SR	—	0.35	—	V/µs	A_V = 1, C_L = 2 pF, R_L = 1 MΩ, Positive Slew Rate = 0.17 V/µs
Short-Circuit Output Current	I_{SC}	4.5	6.3	—	mA	Source, –40°C ≤ T_A ≤ +85°C
		4.5	6.2	—		Sink, –40°C ≤ T_A ≤ +85°C
Supply Current (per Op Amp)	I_S	—	3.6	7	µA	No Load, –40°C ≤ T_A ≤ +85°C
Channel-to-Channel Crosstalk	—	—	–120	—	dB	Note 1

Note 1: DC signal referenced to input. Refer to the AC Performance Characteristics section.

ELECTRICAL CHARACTERISTICS (5.0V)

Electrical Characteristics: V+ = +5V, V– = 0V, V_{CM} = V+/2; R_L = 500 kΩ to V+/2; T_A = 25°C, unless otherwise noted.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	V_{OS}	–5	0.1	5	mV	—
		–6	0.1	6		–40°C ≤ T_A ≤ +85°C
Differential Offset Voltage		—	0.5	—	mV	—
Input Offset Voltage Temperature Coefficient	$\Delta V_{OS}/\Delta T_A$	—	6	—	µV/°C	—
Input Bias Current	I_B	—	10	—	pA	—
Input Offset Current	I_{OS}	—	5	—	pA	—
Input Voltage Range	V_{CM}	3.5	4.1	—	V	CMRR > 60 dB, –40°C ≤ T_A ≤ +85°C
Common-Mode Rejection Ratio	CMRR	60	85	—	dB	0V < V_{CM} < 3.5V, –40°C ≤ T_A ≤ +85°C
Power Supply Rejection Ratio	PSRR	60	86	—	dB	Supply voltage change of 3V to 5V, –40°C ≤ T_A ≤ +85°C
Large-Signal Voltage Range	A_{VOL}	73	81	—	dB	R_L = 100 kΩ, V_{OUT} = 4.0 V_{PP}, –40°C ≤ T_A ≤ +85°C
		78	88	—		R_L = 500 kΩ, V_{OUT} = 4.0 V_{PP}, –40°C ≤ T_A ≤ +85°C
Maximum Output Voltage Swing	V_{OUT}	V+ – 3 mV	V+ – 1.3 mV	—	V	R_L = 500 kΩ, –40°C ≤ T_A ≤ +85°C
Minimum Output Voltage Swing		—	V– + 0.7 mV	V– + 3 mV		
Gain-Bandwidth Product	GBWP	—	450	—	kHz	R_L = 200 kΩ, C_L = 2 pF, A_V = 11
Phase Margin	PM	—	63	—	°	—
–3 dB Bandwidth	BW	—	800	—	kHz	A_V = 1, C_L = 2 pF, R_L = 1 MΩ
Slew Rate	SR	—	0.35	—	V/µs	A_V = 1, C_L = 2 pF, R_L = 1 MΩ, Positive Slew Rate = 0.2 V/µs
Short-Circuit Output Current	I_{SC}	17	23	—	mA	Source, –40°C ≤ T_A ≤ +85°C
		18	27	—		Sink, –40°C ≤ T_A ≤ +85°C
Supply Current (per Op Amp)	I_S	—	4.2	8	µA	No Load, –40°C ≤ T_A ≤ +85°C
Channel-to-Channel Crosstalk	—	—	–120	—	dB	Note 1

Note 1: DC signal referenced to input. Refer to the AC Performance Characteristics section.

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Ambient Temperature Range	T_A	–40	—	+85	°C	—
Storage Temperature Range	T_S	—	—	+150	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 10s
Package Thermal Resistance						
Thermal Resistance SOT-23-8	θ_{JA}	—	100	—	°C/W	Using 4-Layer PCB
	θ_{CA}	—	70	—	°C/W	Using 4-Layer PCB

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +85°C rating. Sustained junction temperatures above +85°C can impact the device reliability.

2.0 TYPICAL PERFORMANCE CURVES

Note:	The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

2.1 DC Performance Characteristics

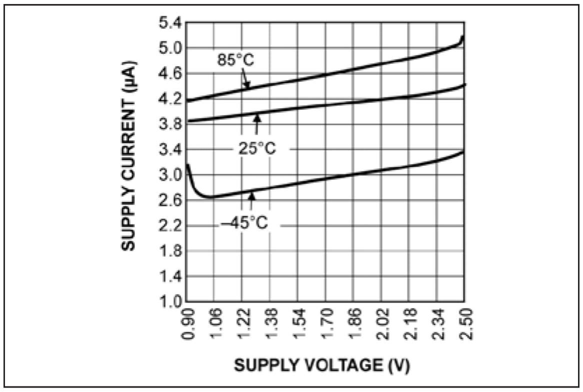


FIGURE 2-1: Supply Current vs. Supply Voltage.

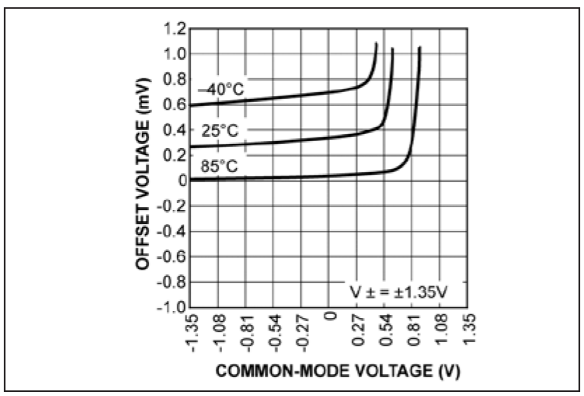


FIGURE 2-2: Offset Voltage vs. Common-Mode Voltage.

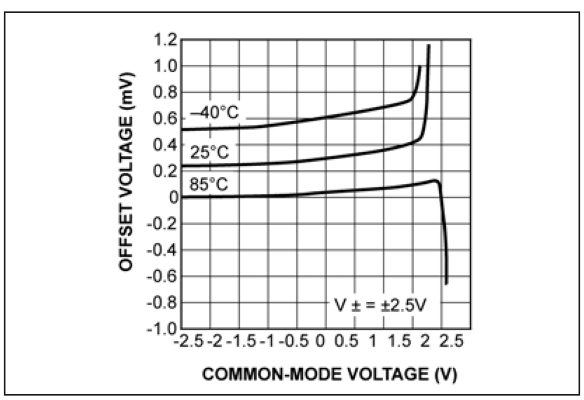


FIGURE 2-3: Offset Voltage vs. Common-Mode Voltage.

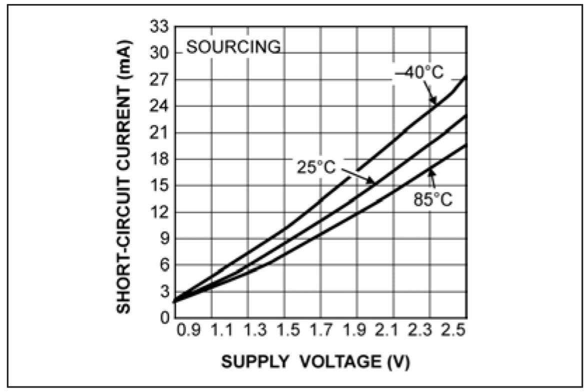


FIGURE 2-4: Short-Circuit Current vs. Supply Voltage.

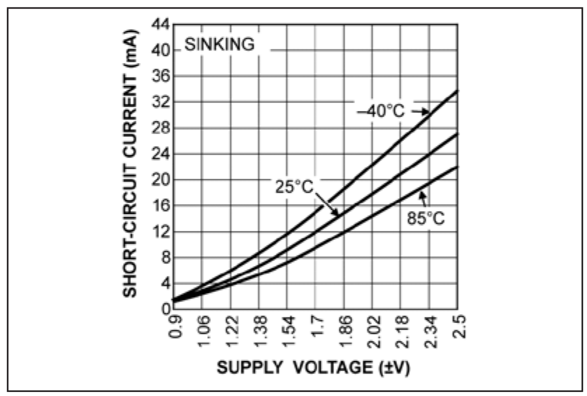


FIGURE 2-5: Short-Circuit Current vs. Supply Voltage.

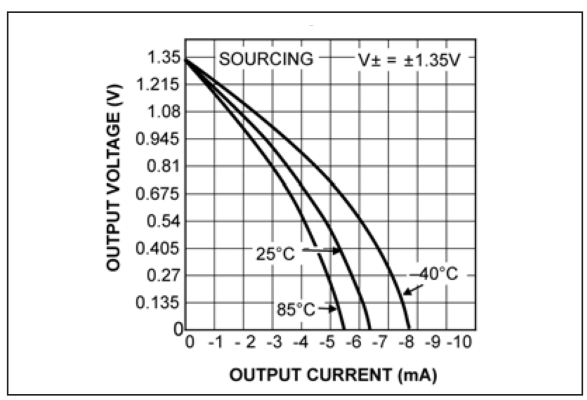


FIGURE 2-6: Output Voltage vs. Output Current.

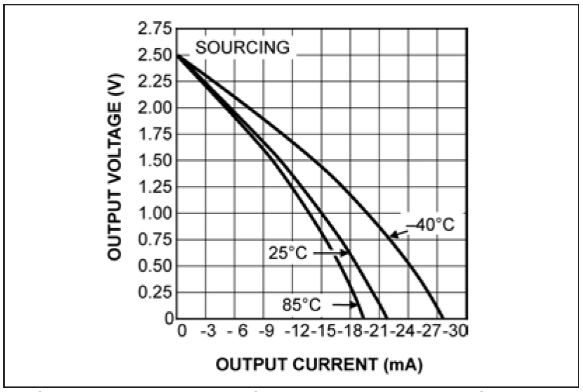


FIGURE 2-7: *Output Voltage vs. Output Current.*

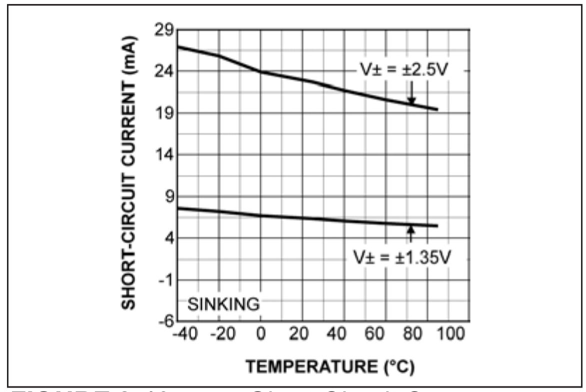


FIGURE 2-10: *Short-Circuit Current vs. Temperature.*

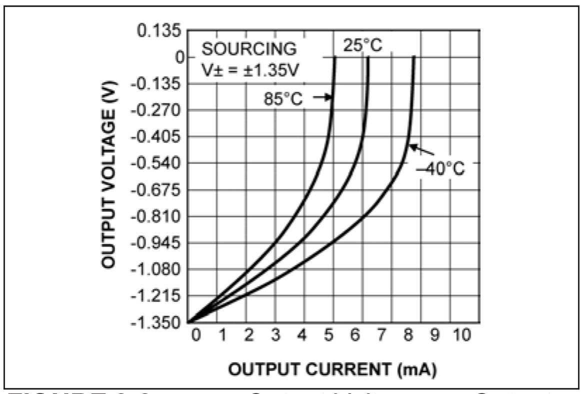


FIGURE 2-8: *Output Voltage vs. Output Current.*

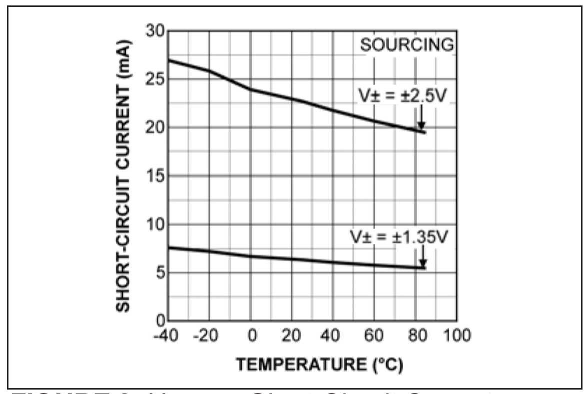


FIGURE 2-11: *Short-Circuit Current. vs. Temperature.*

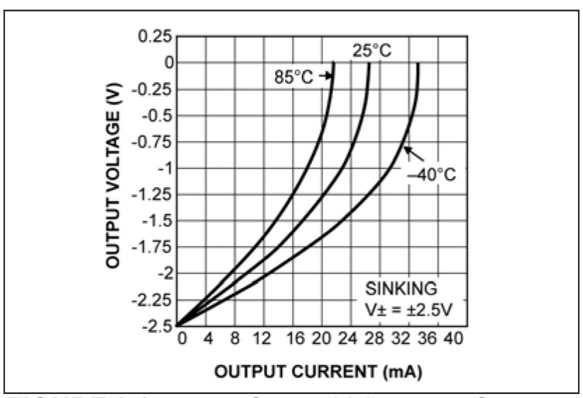


FIGURE 2-9: *Output Voltage vs. Output Current.*

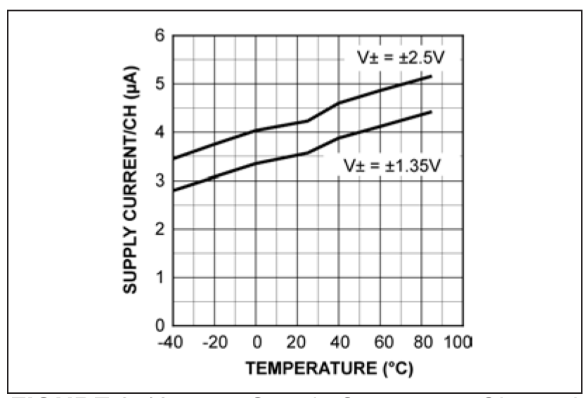


FIGURE 2-12: *Supply Current per Channel vs. Temperature.*

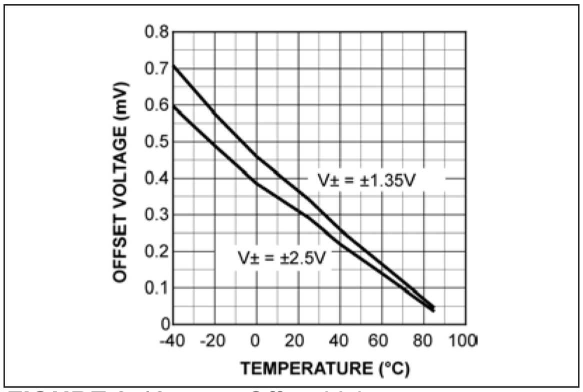


FIGURE 2-13: *Offset Voltage vs. Temperature.*

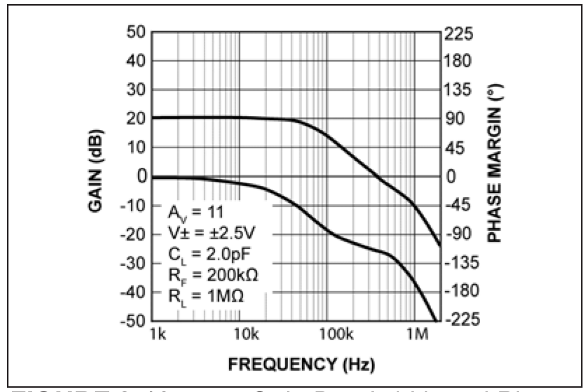


FIGURE 2-16: *Gain Bandwidth and Phase Margin.*

2.2 AC Performance Characteristics

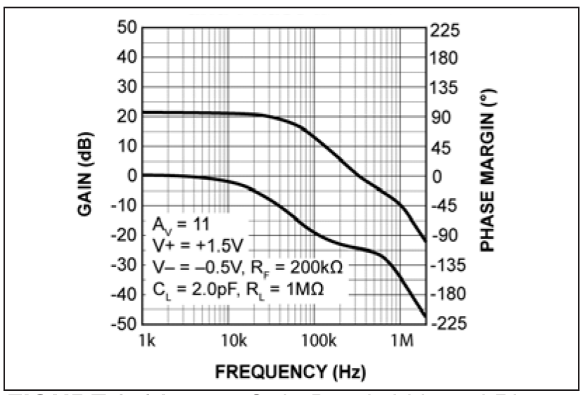


FIGURE 2-14: *Gain Bandwidth and Phase Margin.*

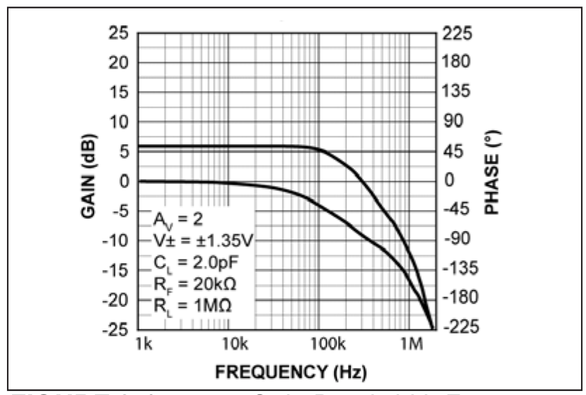


FIGURE 2-17: *Gain Bandwidth Frequency Response.*

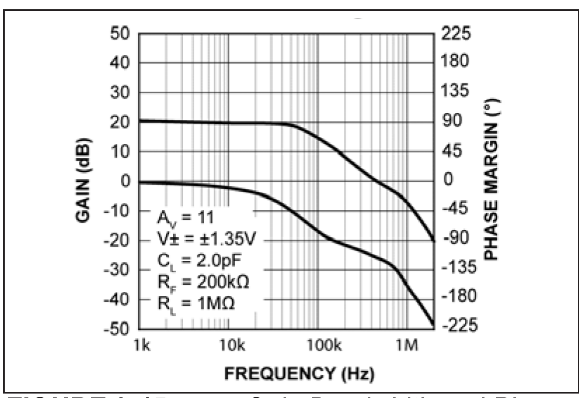


FIGURE 2-15: *Gain Bandwidth and Phase Margin.*

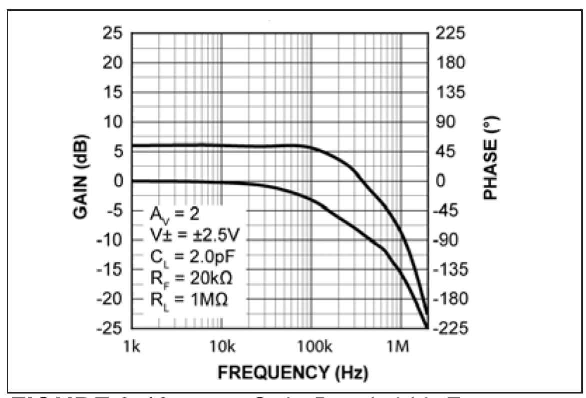


FIGURE 2-18: *Gain Bandwidth Frequency Response.*

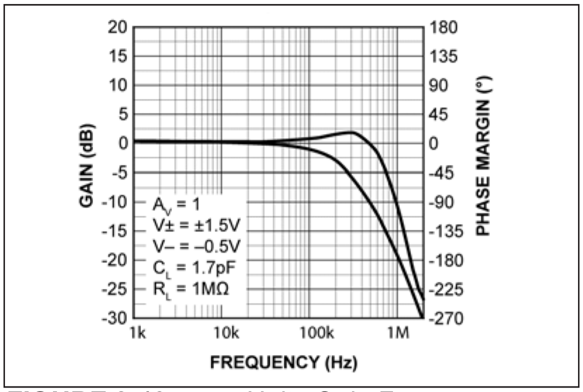


FIGURE 2-19: *Unity Gain Frequency Response.*

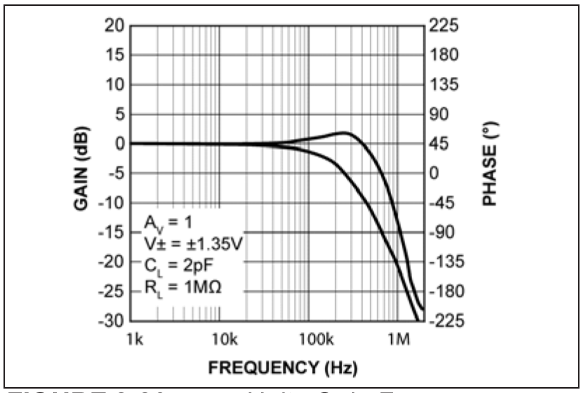


FIGURE 2-20: *Unity Gain Frequency Response.*

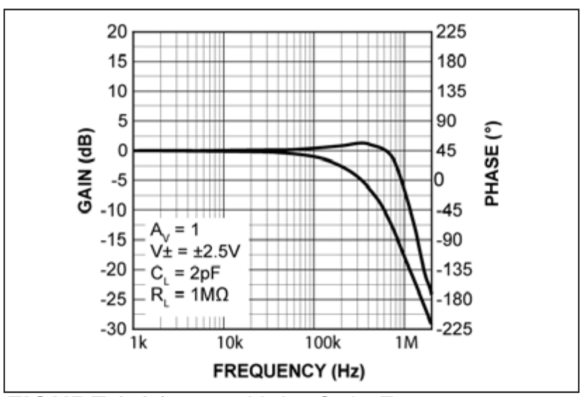


FIGURE 2-21: *Unity Gain Frequency Response.*

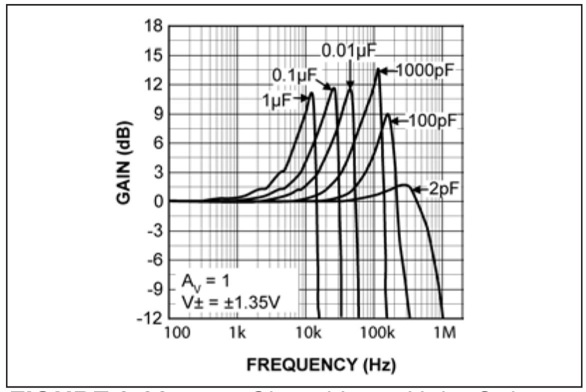


FIGURE 2-22: *Closed Loop Unity Gain Frequency Response.*

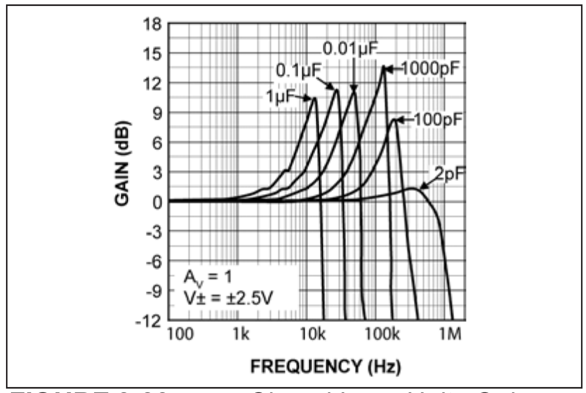


FIGURE 2-23: *Closed Loop Unity Gain Frequency Response.*

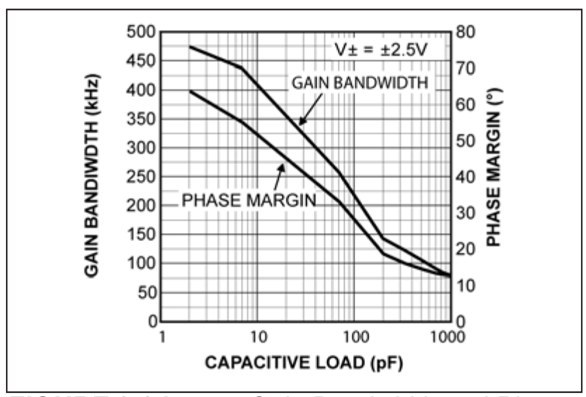


FIGURE 2-24: *Gain Bandwidth and Phase Margin vs. Capacitive Load.*

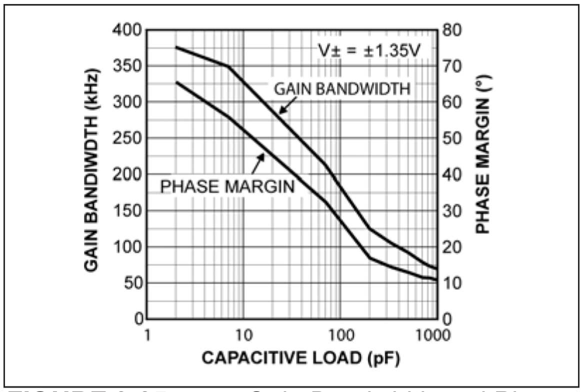


FIGURE 2-25: Gain Bandwidth and Phase Margin vs. Capacitive Load.

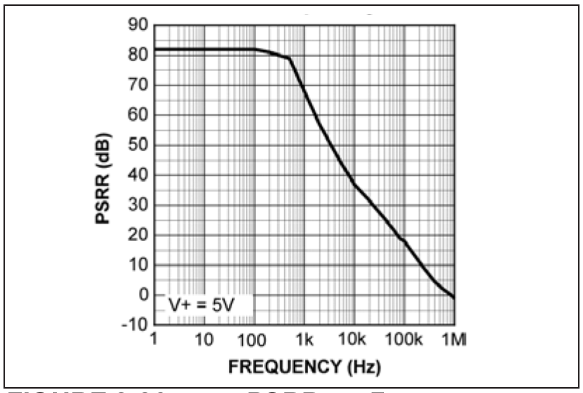


FIGURE 2-26: PSRR vs. Frequency.

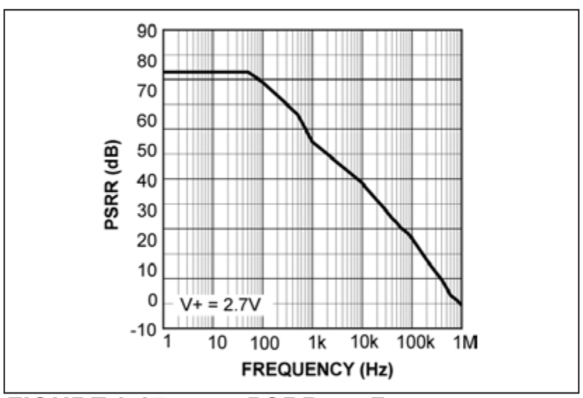


FIGURE 2-27: PSRR vs. Frequency.

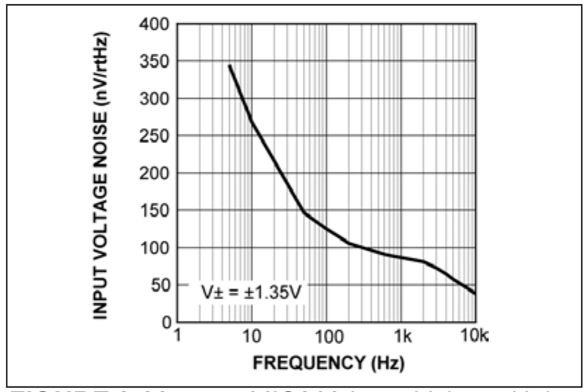


FIGURE 2-28: MIC863 Input Voltage Noise vs. Frequency.

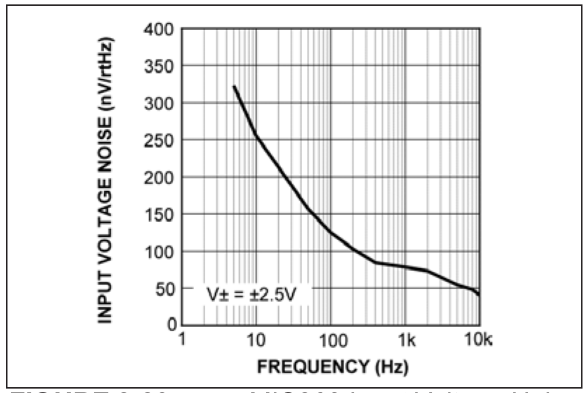


FIGURE 2-29: MIC863 Input Voltage Noise vs. Frequency.

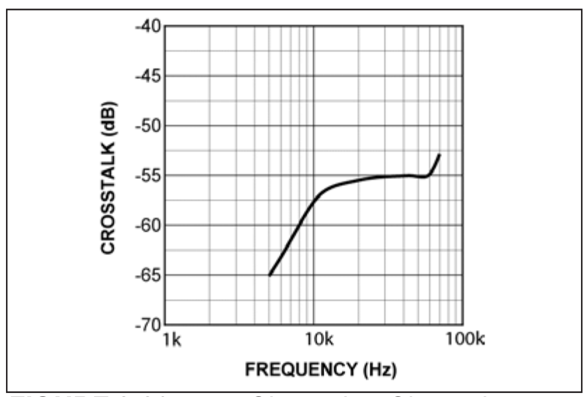


FIGURE 2-30: Channel-to-Channel Crosstalk.

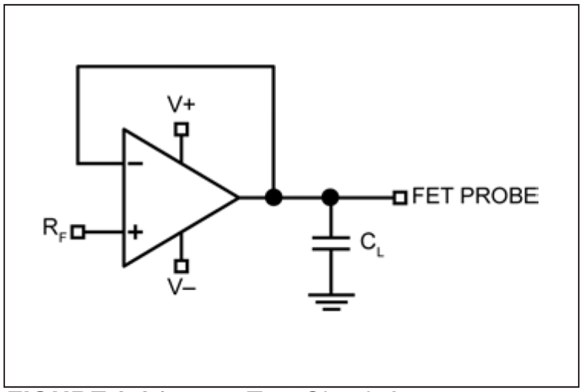


FIGURE 2-31: *Test Circuit A.*

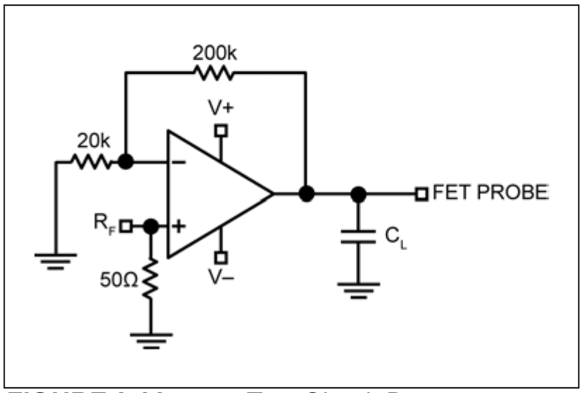


FIGURE 2-32: *Test Circuit B.*

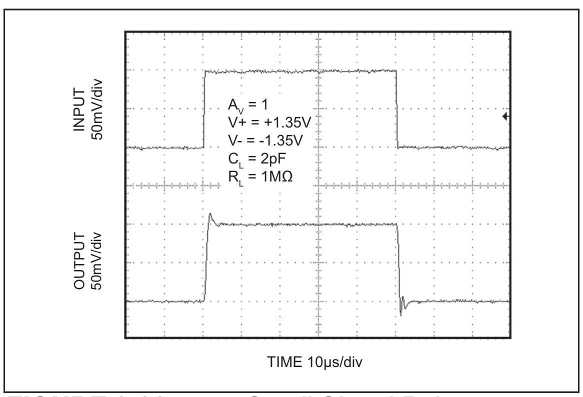


FIGURE 2-33: *Small Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 2 pF).*

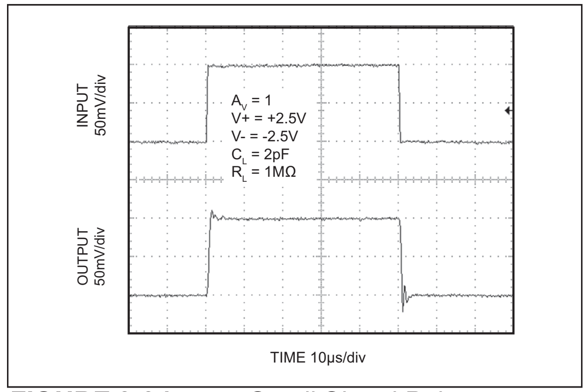


FIGURE 2-34: *Small Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 2 pF).*

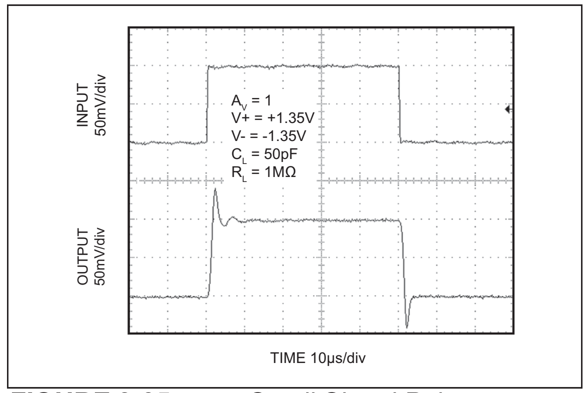


FIGURE 2-35: *Small Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 50 pF).*

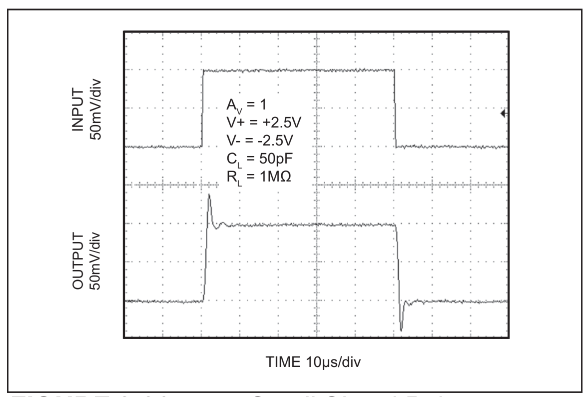


FIGURE 2-36: *Small Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 50 pF).*

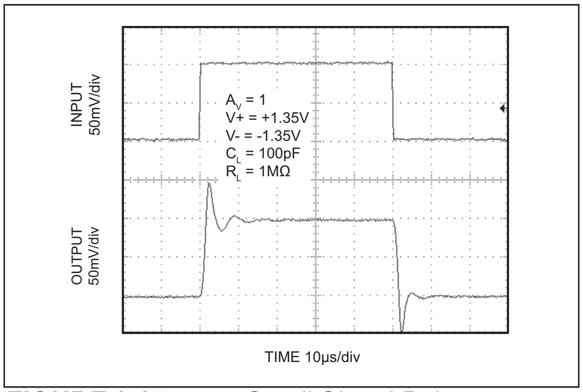


FIGURE 2-37: *Small Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 100 pF).*

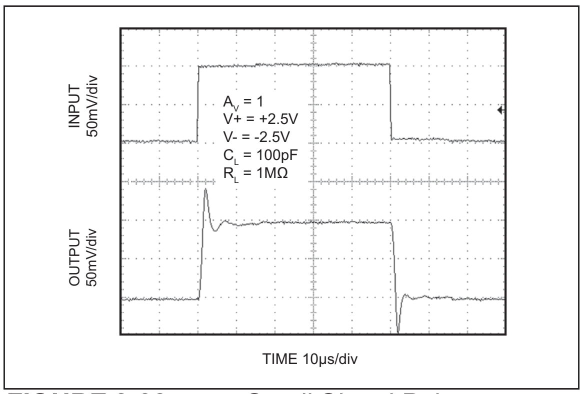


FIGURE 2-38: *Small Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 100 pF).*

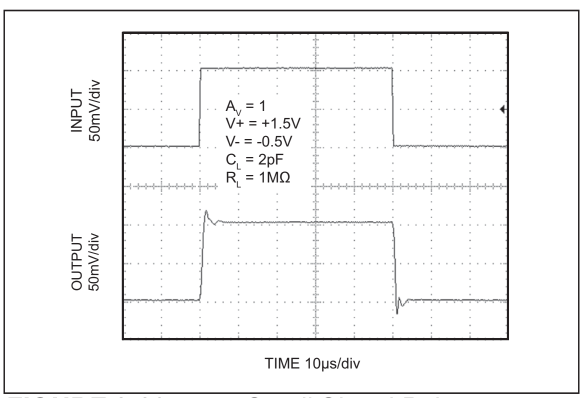


FIGURE 2-39: *Small Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 2 pF).*

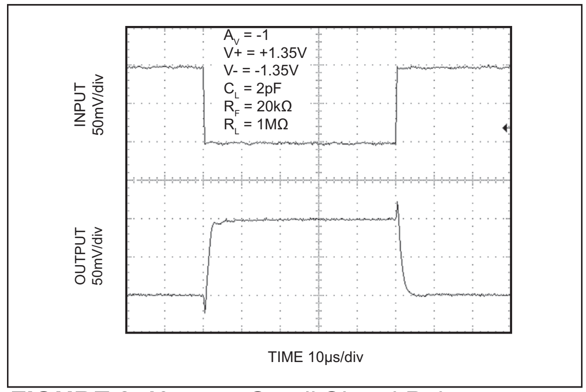


FIGURE 2-40: *Small Signal Pulse Response (Test Circuit B: A_V = –1, C_L = 2 pF).*

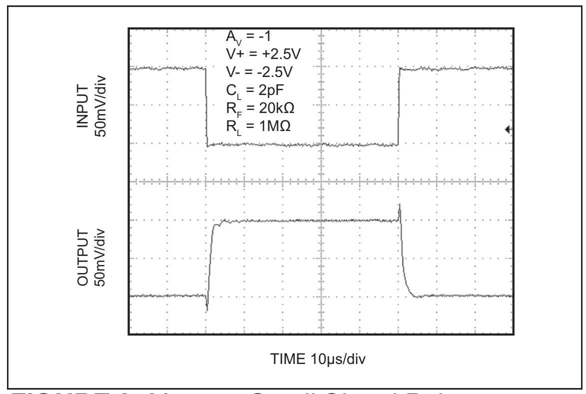


FIGURE 2-41: *Small Signal Pulse Response (Test Circuit B: A_V = –1, C_L = 2 pF).*

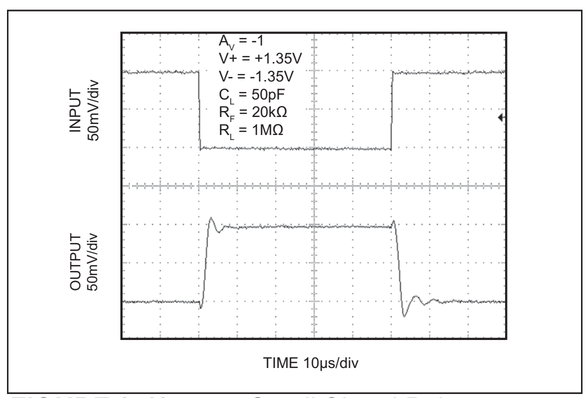


FIGURE 2-42: *Small Signal Pulse Response (Test Circuit B: A_V = –1, C_L = 50 pF).*

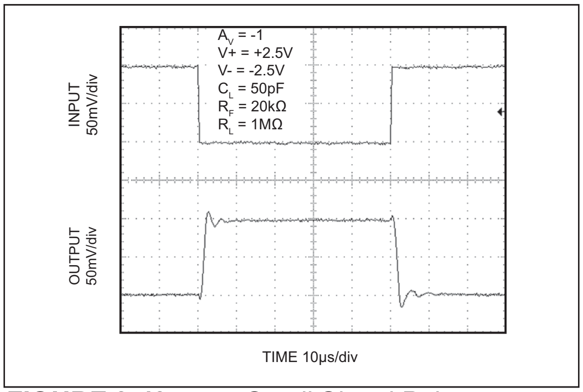


FIGURE 2-43: *Small Signal Pulse Response (Test Circuit B: A_V = –1, C_L = 50 pF).*

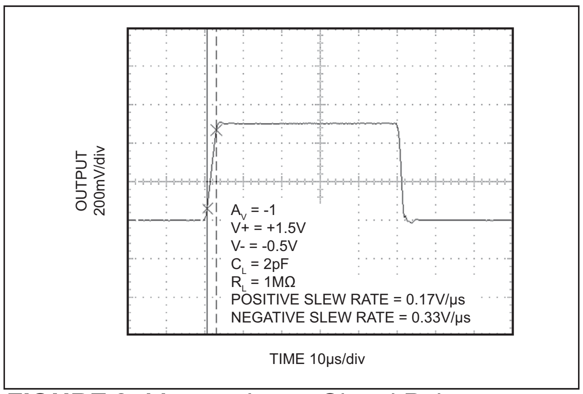


FIGURE 2-44: *Large Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 2 pF).*

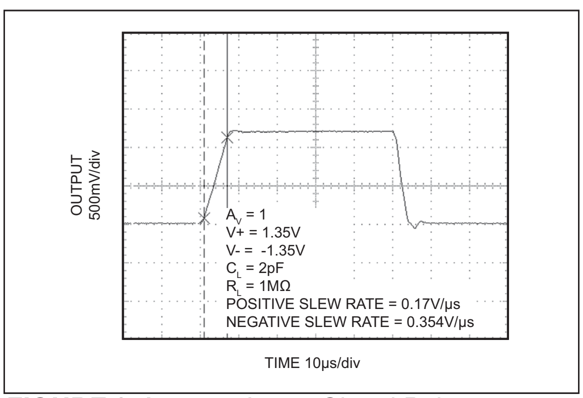


FIGURE 2-45: *Large Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 2 pF).*

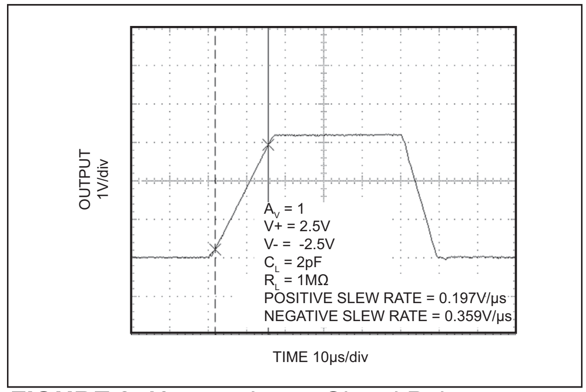


FIGURE 2-46: *Large Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 2 pF).*

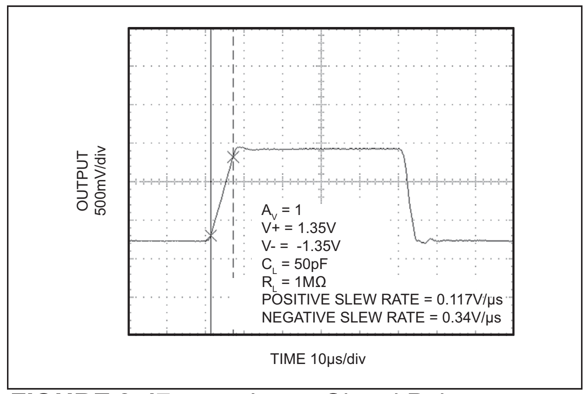


FIGURE 2-47: *Large Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 50 pF).*

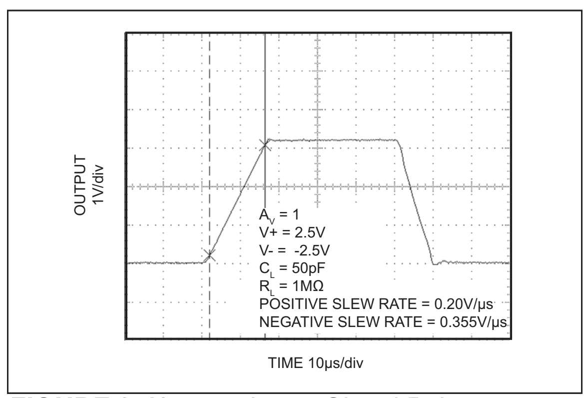


FIGURE 2-48: *Large Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 50 pF).*

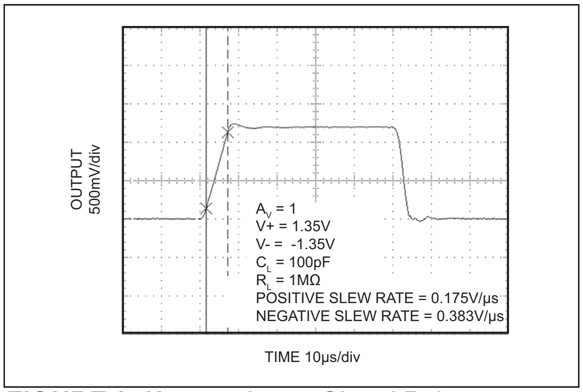


FIGURE 2-49: *Large Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 100 pF).*

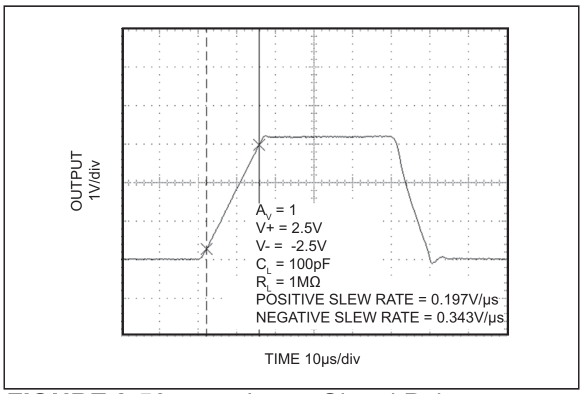


FIGURE 2-50: *Large Signal Pulse Response (Test Circuit A: A_V = 1, C_L = 100 pF).*

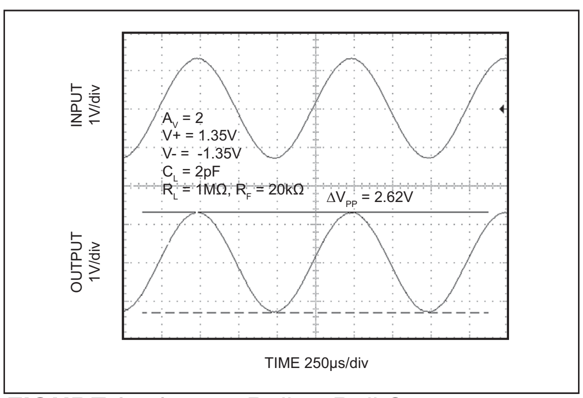


FIGURE 2-51: *Rail-to-Rail Output Operation.*

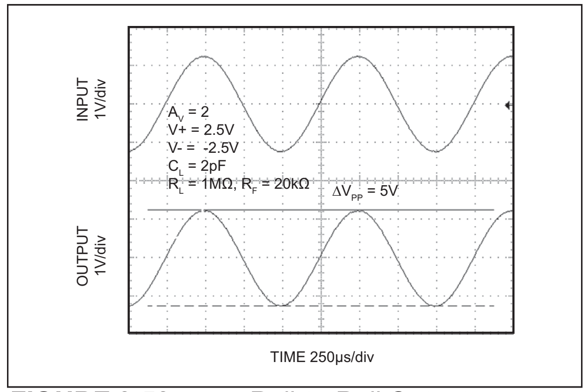


FIGURE 2-52: *Rail-to-Rail Output Operation.*

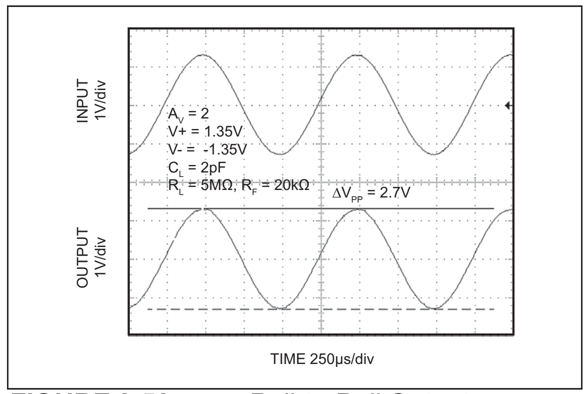


FIGURE 2-53: *Rail-to-Rail Output Operation.*

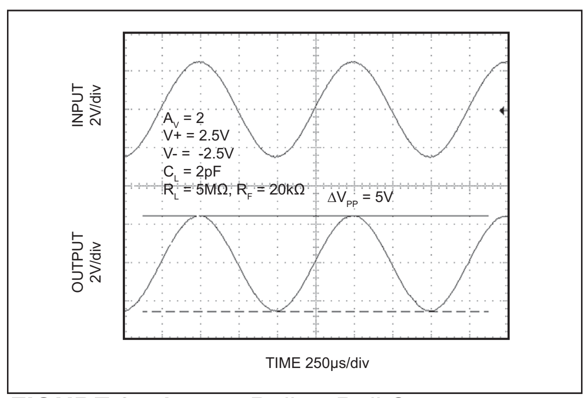


FIGURE 2-54: *Rail-to-Rail Output Operation.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Symbol	Description
1	OUTA	Amplifier A Output.
2	INA–	Amplifier A Inverting Input.
3	INA+	Amplifier A Non-Inverting Input
4	V–	Negative Supply.
5	INB+	Amplifier B Non-Inverting Input.
6	INB–	Amplifier B Inverting Input.
7	OUTB	Amplifier B Output.
8	V+	Positive Supply.

4.0 APPLICATION INFORMATION

Regular supply bypassing techniques are recommended. A 10 µF capacitor in parallel with a 0.1 µF capacitor on both the positive and negative supplies are ideal. For best performance all bypassing capacitors should be located as close to the op amp as possible and all capacitors should be low equivalent series inductance (ESL), equivalent series resistance (ESR). Surface-mount ceramic capacitors are ideal.

The MIC863 is intended for single-supply applications configured with a grounded load. It is not advisable to operate the MIC863 under either of the following conditions when the load is less than 20 kΩ and the output swing is greater than 1V (peak-to-peak):

- A grounded load and split supplies (±V)
- A single supply where the load is terminated above ground.

Under the conditions listed above, there may be some instability when the output is sinking current.

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

8-Lead SOT-23* (Front)	Example
XXX	A35

8-Lead SOT-23* (Back)	Example
NNN	831

Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

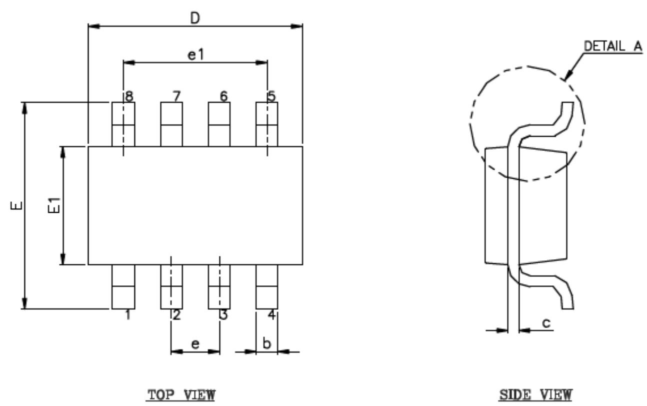
Underbar (_) and/or Overbar (‾) symbol may not be to scale.

8-Lead SOT-23 Package Outline and Recommended Land Pattern

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

TITLE
8 LEAD SOT23 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

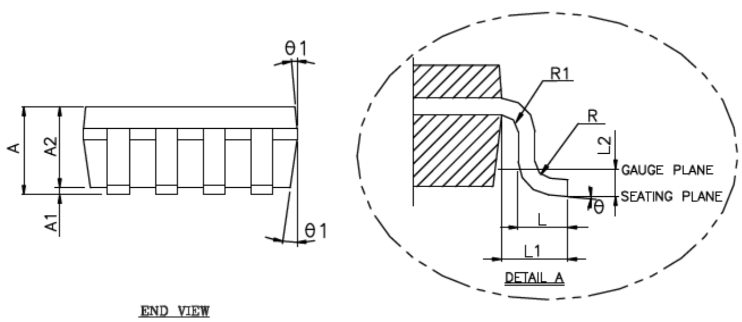
DRAWING #	SOT23-8LD-PL-1	**UNIT**	MM
Lead Frame	Copper Alloy	**Lead Finish**	Matte Tin

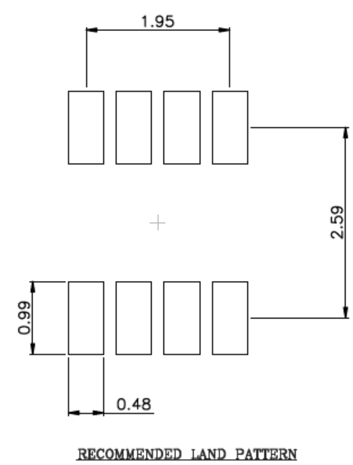


VARIATION(ALL DIMENSIONS SHOWN IN MM)

SYMBOL	MIN.	NOM.	MAX.
A	–	–	1.45
A1	0.00	–	0.15
A2	0.90	1.15	1.30
b	0.22	–	0.38
c	0.08	–	0.22
D		2.90 BSC.	
E		2.80 BSC.	
E1		1.60 BSC.	
e		0.65 BSC.	
e1		1.95 BSC.	
L	0.30	0.45	0.60
L1		0.60 REF.	
L2		0.25 BSC.	
R	0.10	–	–
R1	0.10	–	0.25
θ	0°	4°	8°
θ1	5°	10°	15°

NOTE :
1. JEDEC OUTLINE : MO-178 BA.





APPENDIX A: REVISION HISTORY

Revision A (March 2020)

- Converted Micrel document MIC863 to Microchip data sheet template DS20006308A.
- Minor text changes throughout.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	X	XX	-XX
Device	Temperature	Package	Media Type

Device:	MIC863:		Dual Ultra-Low Power Op Amp
Temperature:	Y	=	–40°C to +85°C
Package:	M8	=	8-Lead SOT-23
Media Type:	TR	=	3,000/Reel

Examples:

a) MIC863YM8-TR: Dual Ultra-Low Power Op Amp –40°C to +85°C Junction Temperature Range, 8-Lead SOT-23 Package, 3,000/Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Trademarks

ISBN: 978-1-5224-5719-0

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880- 3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-72400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820

05/14/19