Data Sheet June 3, 2009 FN6637.0

1A Rail-to-Rail Input-Output Operational Amplifier

The ISL24021 is a high output current, high voltage, rail-to-rail voltage feedback amplifier. The ISL24021 is capable of ±1A peak output short circuit current. The amplifier exhibits beyond the rail input capability, rail-to-rail output capability and is unity gain stable.

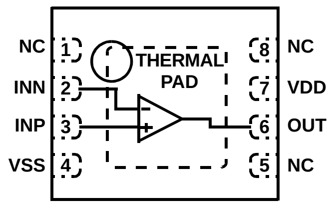
The operating supply voltage range is from 4.5V to 19V maximum and the ISL24021 can be configured for single or dual supply operation. The ISL24021 has the ability to quickly source and sink large peak currents up to ±1A and to drive large continuous currents of ±300mA.

The ISL24021 features fast slewing and settling times. Also, the device provides common mode input capability beyond the supply rails, and rail-to-rail output capability. This enables the amplifier to offer maximum dynamic range at any supply voltage. These features make the ISL24021 an ideal solution as a V_{COM} driver in TFT-LCD panel applications. Other applications may include battery power and portable devices, and especially where low power consumption is important.

The ISL24021 is available in a 8 Ld 3mmx3mm TDFN package featuring a standard operational amplifier pinout with a lead pitch of 0.65mm. The device utilizes a thermally enhanced package and has a built-in thermal protection circuit. It is specified for operation over an ambient temperature range of -40°C to +85°C.

Pinout

ISL24021
(8 LD TDFN)
TOP VIEW



THERMAL PAD IS ELECTRICALLY ISOLATED, OR CONNECTED TO VSS

Features

- ±1A Output Short Circuit Current
- 4.5V to 19V Maximum Supply Voltage Range
- 2.0mA Supply Current
- 18V/µs Slew Rate
- 25MHz -3dB Bandwidth
- ±300mA Continuous Output Current
- Unity-Gain Stable
- Beyond the Rails Input Capability
- Rail-to-Rail Output Swing
- Built-in Thermal Protection
- -40°C to +85°C Ambient Temperature Range
- Pb-Free (RoHS Compliant)

Applications

- TFT-LCD Panels
- V_{COM} Driver
- Video Processing
- Audio Processing
- Active Filters
- Test Equipment
- Battery-Powered Applications
- Portable Equipment

Ordering Information

PART NUMBER (Note)	LEAD PITCH (mm)	PART MARKING	PACKAGE (Pb-Free)	PKG. DWG. #
ISL24021IRT065Z	0.65	P021	8 Ld TDFN	L8.3x3A
ISL24021IRT065Z-T13*	0.65	P021	8 Ld TDFN	L8.3x3A

*Please refer to TB347 for details on reel specifications

NOTE: These Intersil Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is RoHS compliant and 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-020.

Absolute Maximum Ratings (T_A = +25°C)

Supply Voltage Range (V_{DD} -V_{SS}) 19.8V
Input Voltage Range (INN, INP). . . . . V_{SS} - 0.5V, V_{DD} + 0.5V
Input Differential Voltage (INP - INN) . . . (V_{DD} + 0.5V) - (V_{SS} - 0.5V)
ESD Rating
Human Body Model 3000V

Thermal Information

Thermal Resistance (Typical, Note 1) θ_{JA} (°C/W)
8 Ld TDFN 50
Maximum Junction Temperature . . . . +150°C
Storage Temperature . . . .-65°C to +150°C
Ambient Operating Temperature . . . . -40°C to +85°C
Power Dissipation . . . . see Figure 28
Pb-free Reflow Profile . . . . .see link below
http://www.intersil.com/pbfree/Pb-FreeReflow.asp

CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

NOTE:

1. θ_{JA} is measured in free air with the component mounted on a high effective thermal conductivity test board with “direct attach” features. See Tech Brief TB379.

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: $T_J = T_C = T_A$

Electrical Specifications

V_{DD} = 5V, V_{SS} = -5V, R_L = 1kΩ to 0V, T_A = +25°C, Unless Otherwise Specified.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 4)	TYP	MAX (Note 4)	UNIT
POWER SUPPLY PERFORMANCE						
V_{DD} - V_{SS}	Supply Voltage Range		4.5		19	V
I_S	Supply Current	No load		2.1	2.8	mA
PSRR	Power Supply Rejection Ratio	V_S is moved from ±2.25V to ±9.5V	60	80		dB
INPUT CHARACTERISTICS						
V_{OS}	Input Offset Voltage	V_{CM} = 0V		1.4	15	mV
TCV_{OS}	Average Offset Voltage Drift (Note 2)			1		µV/°C
I_{LEAK}	Input Leakage Current	V_{CM} = 0V		2	10	nA
R_{IN}	Input Resistance			1		GΩ
C_{IN}	Input Capacitance			2		pF
CMIR	Common-Mode Input Range		V_{SS}- 0.5		V_{DD}+ 0.5	V
CMRR	Common-Mode Rejection Ratio	For V_{IN} from -5.5V to 5.5V	50	70		dB
A_{VOL}	Open-Loop Gain	-4.5V ≤ V_{OUT} ≤ 4.5V	75	100		dB
OUTPUT CHARACTERISTICS						
V_{OH}	Output Swing High	I_L= 5mA, V_{IN} = V_{DD}	V_{DD}- 0.15	V_{DD}- 0.025		V
V_{OL}	Output Swing Low	I_L= -5mA,V_{IN} = V_{SS}		V_{SS}+ 0.025	V_{SS}+ 0.15	V
I_{SC}	Short-Circuit Current			±1.0		A
I_{OUT}	Continuous Output Current (Note 6)			±300		mA
DYNAMIC PERFORMANCE						
SR	Slew Rate (Note 3)	-4.0V ≤ V_{OUT} ≤ 4.0V		18		V/µs
t_S	Settling to 0.1% (Note 5)	A_V = +1, V_O = 2V step		80		ns
BW	-3dB Bandwidth	A_V = +1, R_L = 1kΩ, C_L= 8pF		25		MHz
PM	Phase Margin	R_L = 1kΩ, C_L= 8pF		44		°
THERMAL PERFORMANCE						
T_{TS}	Thermal Shutdown Temperature	Die temperature at which the device will shutdown until it cools by T_{TSH} °C		+165		°C
T_{TSH}	Thermal Shutdown Hysteresis	Die temperature below T_{TS} °C when the device will become operational after shutdown		15		°C

Electrical Specifications
V_{DD} = 5V, V_{SS} = GND = 0V, R_L = 1kΩ to 2.5V, T_A = +25°C, Unless Otherwise Specified.

PARAMETER	DESCRIPTION	CONDITION	MIN (Note 4)	TYP	MAX (Note 4)	UNIT
POWER SUPPLY PERFORMANCE						
V_{DD} - V_{SS}	Supply Voltage Range		4.5		19	V
I_S	Supply Current	No load		2.0	2.8	mA
PSRR	Power Supply Rejection Ratio	V_S is moved from +4.5V to +19V	60	80		dB
INPUT CHARACTERISTICS						
V_{OS}	Input Offset Voltage	V_{CM} = 2.5V		1.4	15	mV
TCV_{OS}	Average Offset Voltage Drift (Note 2)			1		µV/°C
I_{LEAK}	Input Leakage Current	V_{CM} = 2.5V		2	10	nA
R_{IN}	Input Resistance			1		GΩ
C_{IN}	Input Capacitance			2		pF
CMIR	Common-Mode Input Range		V_{SS}-0.5		V_{DD}+0.5	V
CMRR	Common-Mode Rejection Ratio	For V_{IN} from -0.5V to 5.5V	45	70		dB
A_{VOL}	Open-Loop Gain	0.5V ≤ V_{OUT} ≤ 4.5V	70	100		dB
OUTPUT CHARACTERISTICS						
V_{OH}	Output Swing High	I_L= 5mA, V_{IN} = V_{DD}	V_{DD}-0.15	V_{DD}-0.025		V
V_{OL}	Output Swing Low	I_L= -5mA,V_{IN} = V_{SS}		V_{SS}+0.025	V_{SS}+0.15	V
I_{SC}	Short-Circuit Current			±0.5		A
I_{OUT}	Continuous Output Current (Note 6)			±300		mA
DYNAMIC PERFORMANCE						
SR	Slew Rate (Note 3)	1V ≤ V_{OUT} ≤ 4V		15		V/µs
t_S	Settling to 0.1% (Note 5)	A_V = +1, V_O = 2V step		80		ns
BW	-3dB Bandwidth	A_V = +1, R_L = 1kΩ, C_L= 8pF		22		MHz
PM	Phase Margin	R_L = 1kΩ, C_L= 8pF		46		°
THERMAL PERFORMANCE						
T_{TS}	Thermal Shutdown Temperature	Die temperature at which the device will shutdown until it cools by T_{TSH} °C		+165		°C
T_{TSH}	Thermal Shutdown Hysteresis	Die temperature below T_{TS} °C when the device will become operational after shutdown		15		°C

Electrical Specifications
V_{DD} = 15V, V_{SS} = GND = 0V, R_L = 1kΩ to 7.5V, T_A = +25°C, Unless Otherwise Specified.

PARAMETER	DESCRIPTION	CONDITION	MIN (Note 4)	TYP	MAX (Note 4)	UNIT
POWER SUPPLY PERFORMANCE						
V_{DD} - V_{SS}	Supply Voltage Range		4.5		19	V
I_S	Supply Current	No load		2.2	2.8	mA
PSRR	Power Supply Rejection Ratio	V_S is moved from +4.5V to +19V	60	80		dB
INPUT CHARACTERISTICS						
V_{OS}	Input Offset Voltage	V_{CM} = 7.5V		1.4	15	mV
TCV_{OS}	Average Offset Voltage Drift (Note 2)			1		µV/°C

Electrical Specifications

V_{DD} = 15V, V_{SS} = GND = 0V, R_L = 1kΩ to 7.5V, T_A = +25°C, Unless Otherwise Specified. **(Continued)**

PARAMETER	DESCRIPTION	CONDITION	MIN (Note 4)	TYP	MAX (Note 4)	UNIT
I_{LEAK}	Input Leakage Current	V_{CM} = 7.5V		2	10	nA
R_{IN}	Input Resistance			1		GΩ
C_{IN}	Input Capacitance			2		pF
CMIR	Common-Mode Input Range		V_{SS}- 0.5		V_{DD}+ 0.5	V
CMRR	Common-Mode Rejection Ratio	For V_{IN} from -0.5V to 15.5V	50	70		dB
A_{VOL}	Open-Loop Gain	0.5V ≤ V_{OUT} ≤ 14.5V	75	95		dB
OUTPUT CHARACTERISTICS						
V_{OH}	Output Swing High	I_L= 100mA, V_{IN} = V_{DD}		V_{DD} - 0.4		V
		I_L= 7.5mA, V_{IN} = V_{DD}	V_{DD} - 0.15	V_{DD} - 0.025		V
V_{OL}	Output Swing Low	I_L= -100mA,V_{IN} = V_{SS}		V_{SS} + 0.4		V
		I_L= -7.5mA,V_{IN} = V_{SS}		V_{SS} + 0.025	V_{SS} + 0.15	V
I_{SC}	Short-Circuit Current			±1.0		A
I_{OUT}	Continuous Output Current (Note 6)			±300		mA
DYNAMIC PERFORMANCE						
SR	Slew Rate (Note 3)	1V ≤ V_{OUT} ≤ 14V		19		V/µs
t_S	Settling to 0.1% (Note 5)	A_V = +1, V_O = 2V step		80		ns
BW	-3dB Bandwidth	A_V = +1, R_L = 1kΩ, C_L= 8pF		27		MHz
PM	Phase Margin	R_L = 1kΩ, C_L= 8pF		42		°
THERMAL PERFORMANCE						
T_{TS}	Thermal Shutdown Temperature	Die temperature at which the device will shutdown until it cools by T_{TSH} °C		+165		°C
T_{TSH}	Thermal Shutdown Hysteresis	Die temperature below T_{TS} °C when the device will become operational after shutdown		15		°C

NOTES:

2. Measured over the -40°C to +85°C ambient operating temperature range.
3. Typical slew rate is an average of the slew rates measured on the rising (20% to 80%) and the falling (80% to 20%) edges of the output signal.
4. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.
5. Settling time measured from [Full Scale - (0.1%*StepSize)] on the rising edge to when the output is bounded within ±0.1% of full scale.
6. Continuous output current with a typical of ±300mA. Care should be taken to ensure the maximum package power dissipation is not exceeded, refer to "Power Dissipation" on page 10.

Pin Descriptions

PIN NUMBER	PIN NAME	PIN TYPE	PIN FUNCTION
1, 5, 8	NC		No Connection
2	INN	Analog Input	Amplifier negative input
3	INP	Analog Input	Amplifier positive input
4	VSS	Analog Power	Negative power supply (connect to GND for single supply operation)
6	OUT	Analog Output	Amplifier output
7	VDD	Analog Power	Positive power supply

Typical Performance Curves

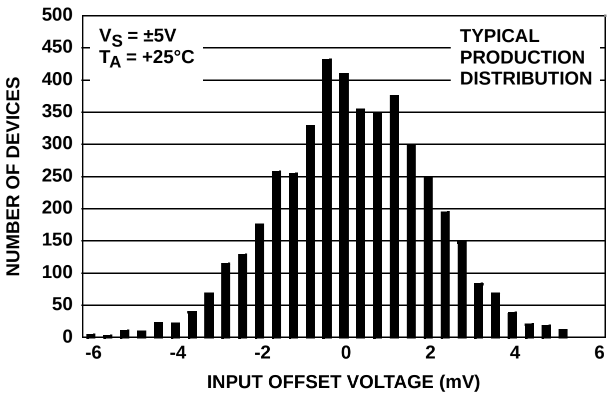


FIGURE 1. INPUT OFFSET VOLTAGE DISTRIBUTION

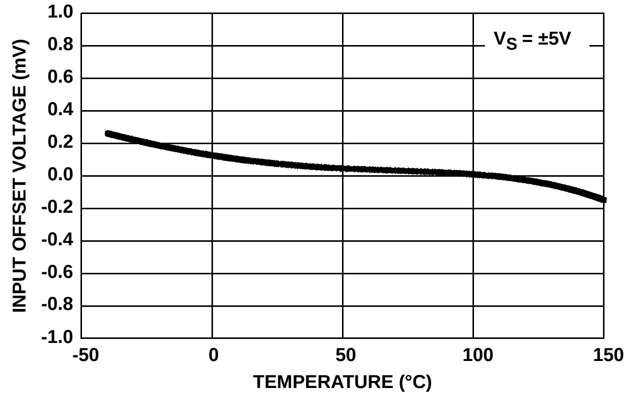


FIGURE 2. INPUT OFFSET VOLTAGE vs TEMPERATURE

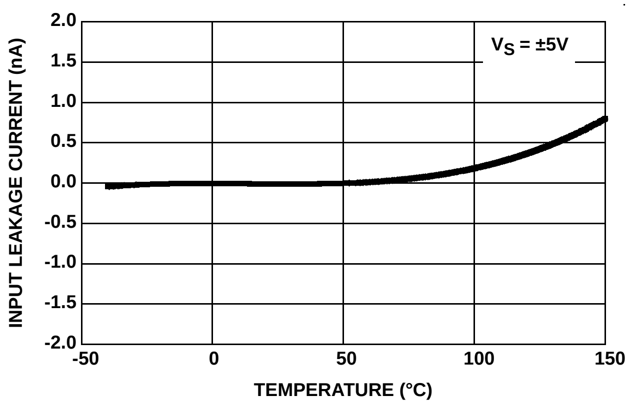


FIGURE 3. INPUT LEAKAGE CURRENT vs TEMPERATURE

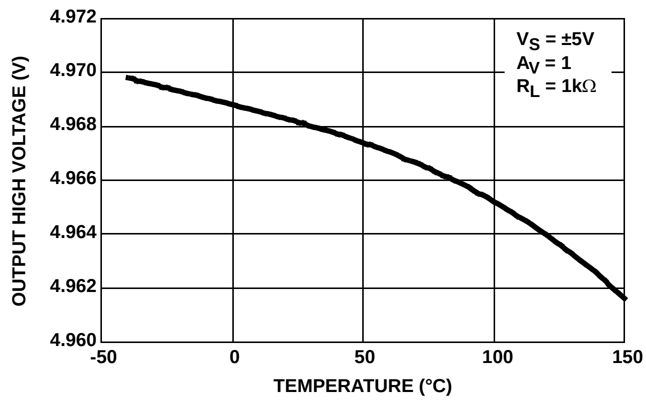


FIGURE 4. OUTPUT HIGH VOLTAGE vs TEMPERATURE

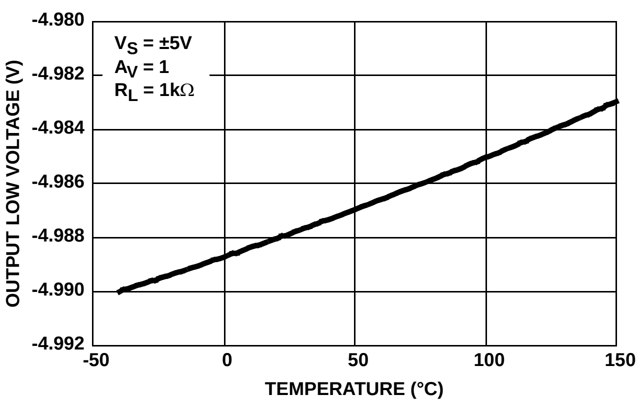


FIGURE 5. OUTPUT LOW VOLTAGE vs TEMPERATURE

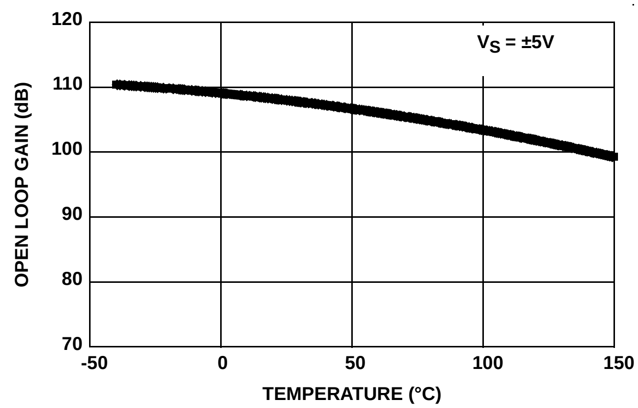


FIGURE 6. OPEN-LOOP GAIN vs TEMPERATURE

Typical Performance Curves (Continued)

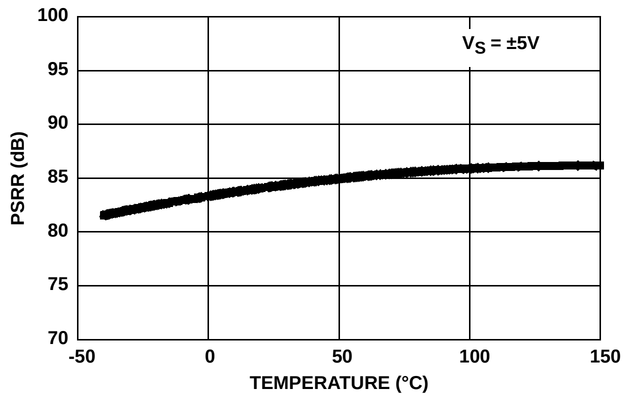


FIGURE 7. PSRR vs TEMPERATURE

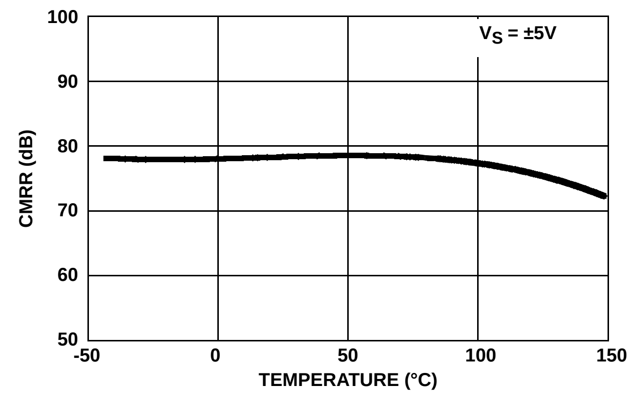


FIGURE 8. CMRR vs TEMPERATURE

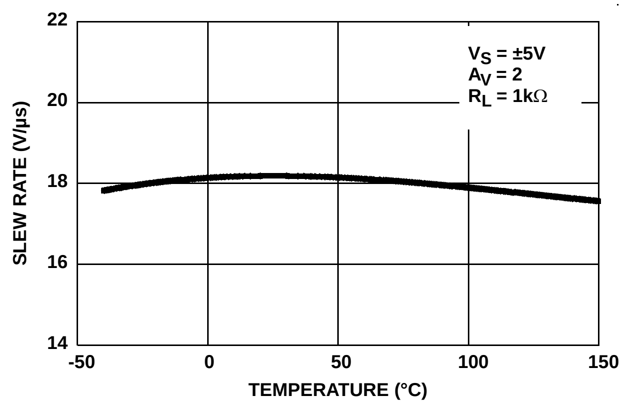


FIGURE 9. SLEW RATE vs TEMPERATURE

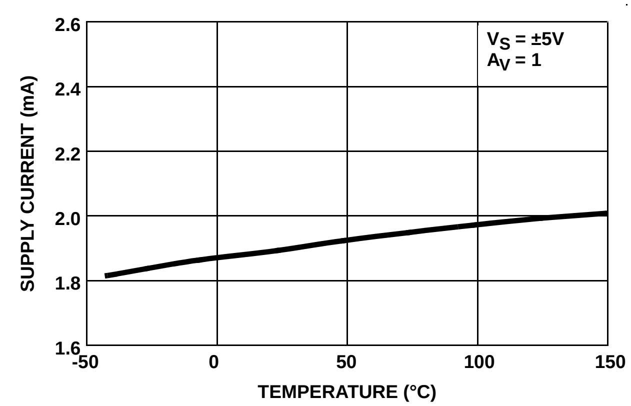


FIGURE 10. SUPPLY CURRENT vs TEMPERATURE

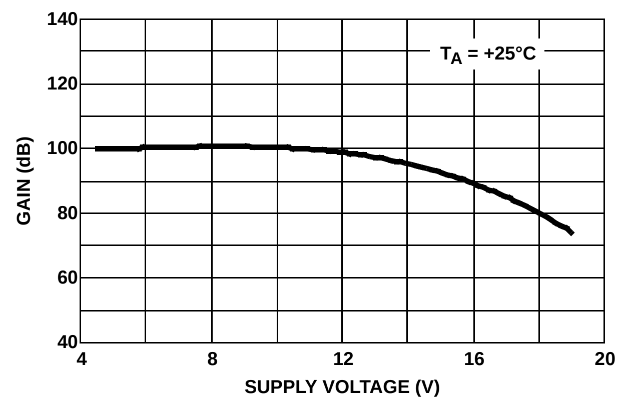


FIGURE 11. OPEN-LOOP GAIN vs SUPPLY VOLTAGE

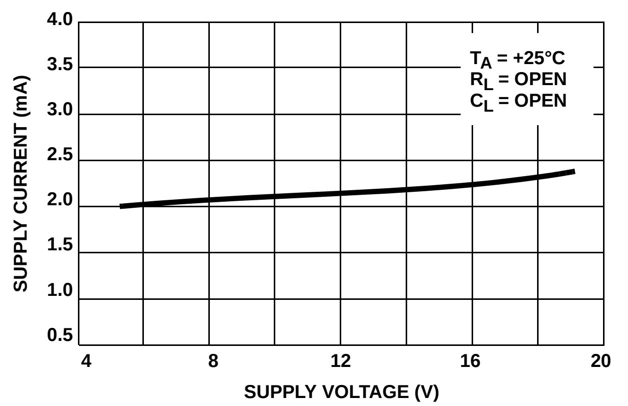


FIGURE 12. SUPPLY CURRENT vs SUPPLY VOLTAGE

Typical Performance Curves (Continued)

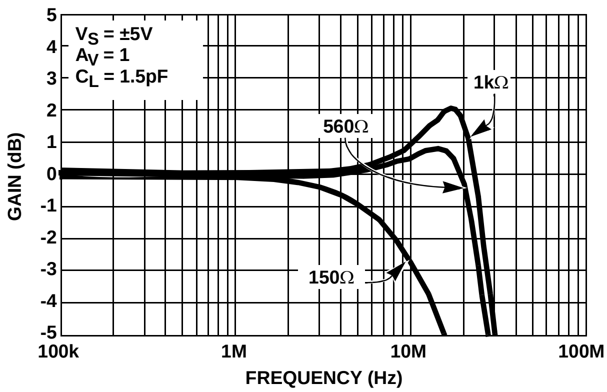


FIGURE 13. FREQUENCY RESPONSE FOR VARIOUS R_L

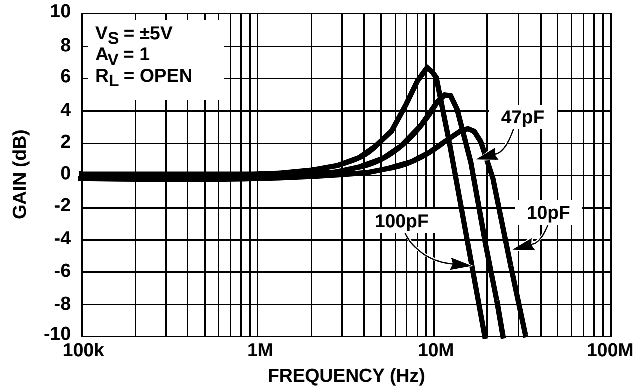


FIGURE 14. FREQUENCY RESPONSE FOR VARIOUS C_L

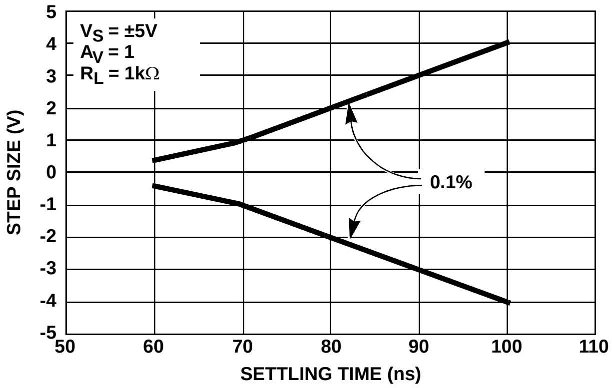


FIGURE 15. STEP SIZE vs SETTLING TIME

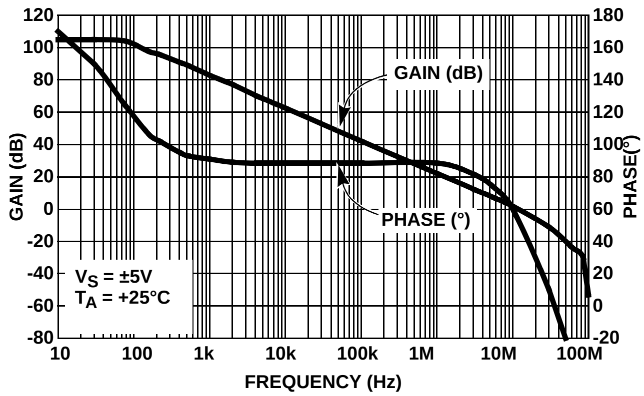


FIGURE 16. OPEN LOOP GAIN AND PHASE

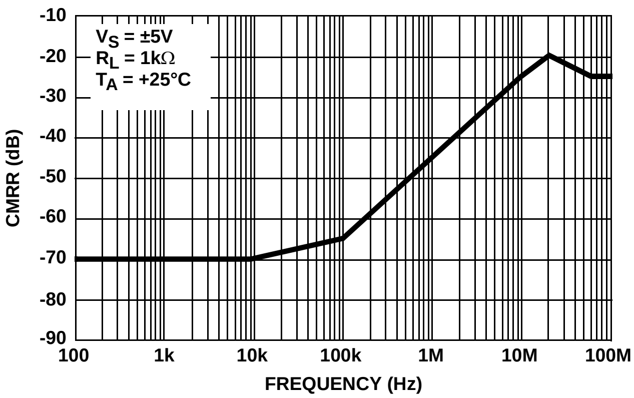


FIGURE 17. CMRR vs FREQUENCY

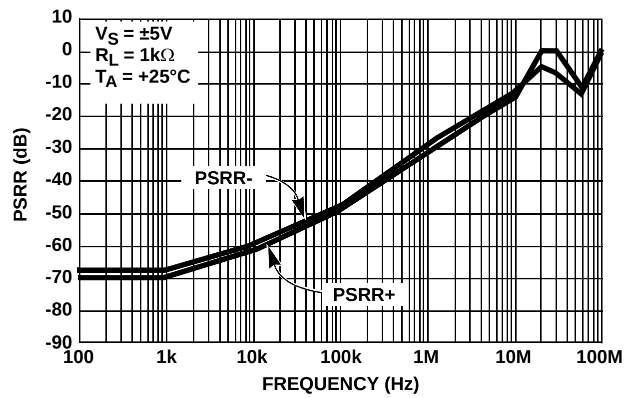


FIGURE 18. PSRR vs FREQUENCY

Typical Performance Curves (Continued)

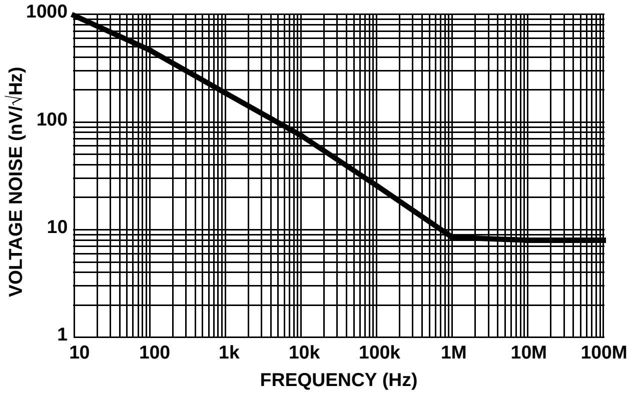


FIGURE 19. INPUT VOLTAGE NOISE SPECTRAL DENSITY

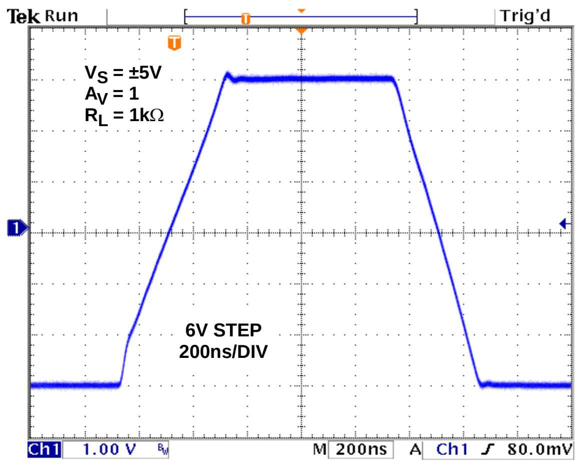


FIGURE 20. LARGE SIGNAL TRANSIENT RESPONSE

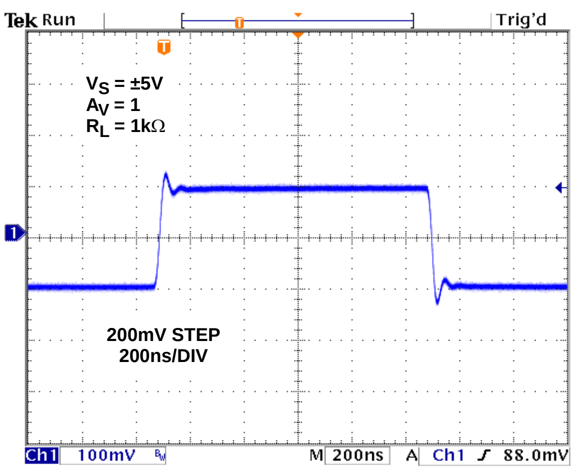


FIGURE 21. SMALL SIGNAL TRANSIENT RESPONSE

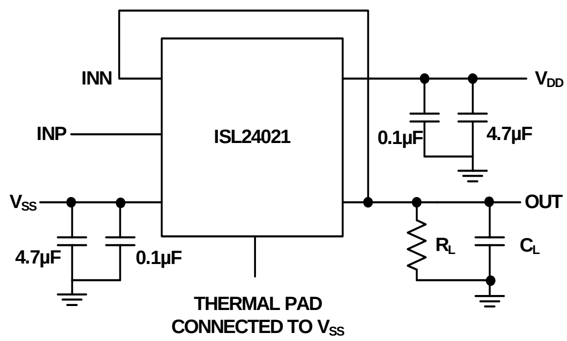


FIGURE 22. TEST CIRCUIT

Applications Information

Product Description

The ISL24021 is a high output current, high voltage, rail-to-rail voltage feedback amplifier. The ISL24021 is capable of ±1A peak output short circuit current. The amplifier exhibits beyond the rail input capability, rail-to-rail output capability and is unity gain stable. Other features include fast slew rate and settling time which is important in many applications, such as TFT-LCD panels.

The ISL24021 is available in a 8 Ld 3mmx3mm TDFN package featuring a standard operational amplifier pinout and a lead pitch of 0.65mm. The device utilizes a thermally enhanced package and has a built-in thermal protection circuit. It is specified for operation over an ambient temperature range of -40°C to +85°C.

Operating Voltage, Input and Output Capability

The ISL24021 can operate on a single supply or dual supply configuration. The ISL24021 operating voltage ranges from a minimum of 4.5V to a maximum of 19V. This range allows for a standard 5V (or ±2.5V) supply voltage to dip to -10%, or a standard 18V (or ±9V) to rise by +5.5% without affecting performance or reliability.

The input common mode voltage range extends 0.5V beyond the supply rails. For this range, the ISL24021 amplifier is immune to phase reversal. If the common mode input voltage exceeds the supply voltage by more than 0.5V, electrostatic protection diodes in the input stage of the device begin to conduct. It is suggested to not overdrive the inputs. Figure 23 shows the input voltage driven beyond the supply rails and the device output swinging between the supply rails.

The output swings of the ISL24021 typically extend to within 25mV of positive and negative supply rails with load currents of ±5mA. Decreasing load currents will extend the output voltage range even closer to the supply rails. Figure 24 shows the input and output waveforms for the device in a unity-gain configuration. Operation is from ±5V supply with a 1kΩ load connected to GND. The input is a $10V_{P-P}$ sinusoid and the output voltage is approximately $9.95V_{P-P}$.

Refer to the "Electrical Specifications" tables beginning on page 2 for specific device parameters. Parameter variations with operating voltage, loading and/or temperature are shown in the "Typical Performance Curves" on page 5.

V_S = ±2.5V, T_A = +25°C, A_V = 1, V_{IN} = $6V_{P-P}$

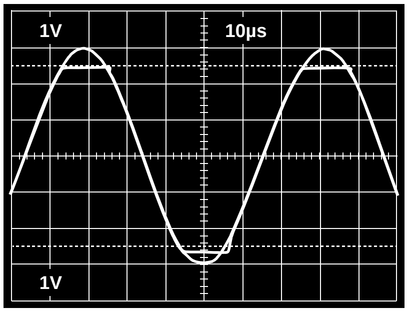


FIGURE 23. OPERATION WITH BEYOND-THE-RAILS INPUT

V_S = ±5V, T_A = +25°C, A_V = 1, V_{IN} = $10V_{P-P}$

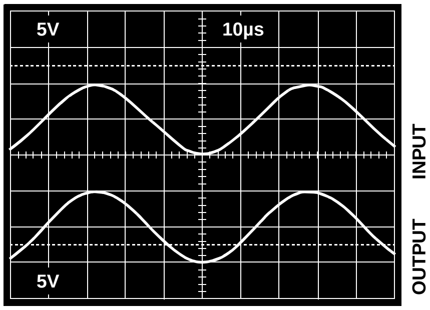


FIGURE 24. OPERATION WITH RAIL-TO-RAIL INPUT AND OUTPUT

Output Current Limit

The ISL24021 is capable of ±1A peak output short circuit current. The device will limit the current to ±1A. Maximum reliability is maintained if the output continuous current never exceeds ±300mA. This limit is set by the characteristics of the internal metal interconnects. See "Power Dissipation" on page 10 for detailed information about ensuring device operation with temperature and load conditions.

Driving Capacitive Loads

As load capacitance increases, the -3dB bandwidth will decrease and peaking can occur. Depending on the application, it may be necessary to reduce peaking and to improve device stability. To improve device stability a snubber circuit or a series resistor may be added to the output of the ISL24021.

A snubber is a shunt load consisting of a resistor in series with a capacitor, see Figure 25. An optimized snubber can improve the phase margin and the stability of the ISL24021. The advantage of a snubber circuit is that it does not draw any DC load current or reduce the gain.

Another method to reduce peaking is to add a series output resistor (typically between 1Ω to 10Ω; see Figure 26). Depending on the capacitive loading, a small value resistor may be the most appropriate choice to minimize any reduction in gain.

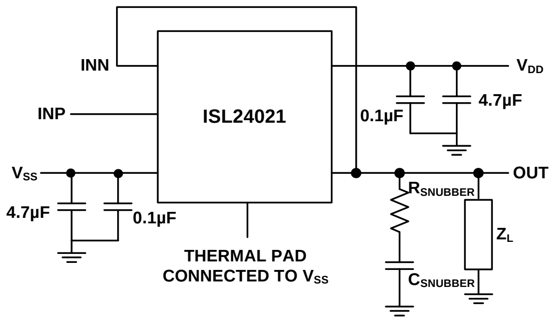


FIGURE 25. OUTPUT SNUBBER CIRCUIT

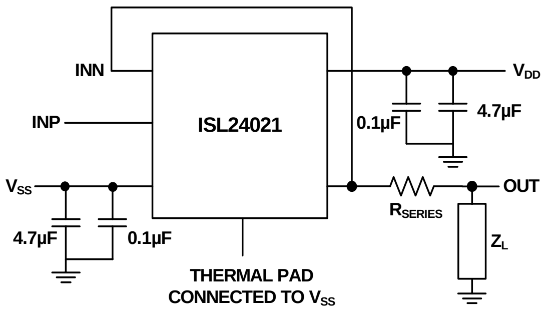


FIGURE 26. OUTPUT SERIES RESISTOR CIRCUIT

Typical Application Circuit

A typical application of the ISL24021 is as a TFT-LCD V_{COM} driver (see Figure 27). A V_{COM} driver maintains the backplane common voltage of a TFT-LCD panel. Maintaining the V_{COM} voltage at a steady level is critical to panel performance. The ability of the ISL24021 to source/sink large peak short circuit currents make it ideal as a V_{COM} driver. The ±1A short circuit current capability combined with a large bandwidth and fast settling time give the ISL24021 ideal V_{COM} driver characteristics, and make it a great choice for TFT-LCD applications.

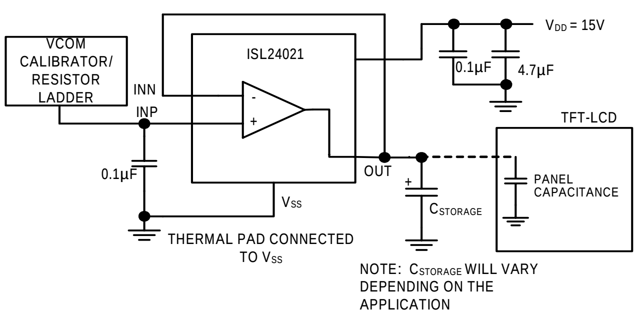


FIGURE 27. TYPICAL APPLICATION CIRCUIT: TFT-LCD V_{COM}

Power Dissipation

With a 300mA maximum continuous output drive capability, it is possible to exceed the rated +150°C maximum junction temperature. It is important to calculate the maximum power dissipation of the ISL24021 for the application. Proper load conditions will ensure that the ISL24021 junction temperature stays within a safe operating region.

The ISL24021 has a built-in thermal protection, which automatically shuts the output OFF (high impedance) when the die temperature reaches +165°C. This ensures safe operation and prevents internal damage to the device. When the die cools by +15°C the output will automatically turn ON.

The maximum power dissipation allowed in a package is determined according to Equation 1:

$$P_{DMAX} = \frac{T_{JMAX} - T_{AMAX}}{\Theta_{JA}} \quad \text{(EQ. 1)}$$

where:

- T_{JMAX} = Maximum junction temperature
- T_{AMAX} = Maximum ambient temperature
- θ_{JA} = Thermal resistance of the package
- P_{DMAX} = Maximum power dissipation in the package

The actual maximum power dissipation of the IC is the total quiescent supply current, times the total power supply voltage, plus the power dissipation in the IC caused by the loading condition.

Sourcing:

$$P_{DMAX} = V_S \times I_S + [(V_{DD} - V_{OUT}) \times I_{LOAD}] \quad \text{(EQ. 2)}$$

Sinking:

$$P_{DMAX} = V_S \times I_S + [(V_{OUT} - V_{SS}) \times I_{LOAD}] \quad \text{(EQ. 3)}$$

- V_S = Total supply voltage range (V_{DD} - V_{SS})
- I_S = Device supply current
- V_{DD} = Positive supply voltage
- V_{SS} = Negative supply voltage
- V_{OUT} = Output voltage
- I_{LOAD} = Load current

Device overheating can be avoided by calculating the minimum resistive load condition, R_{LOAD}, resulting in the highest power dissipation. To find R_{LOAD}, set the two P_{DMAX} equations equal to each other and solve for V_{OUT}/I_{LOAD}. Reference the package power dissipation curve, Figure 28, for further information.

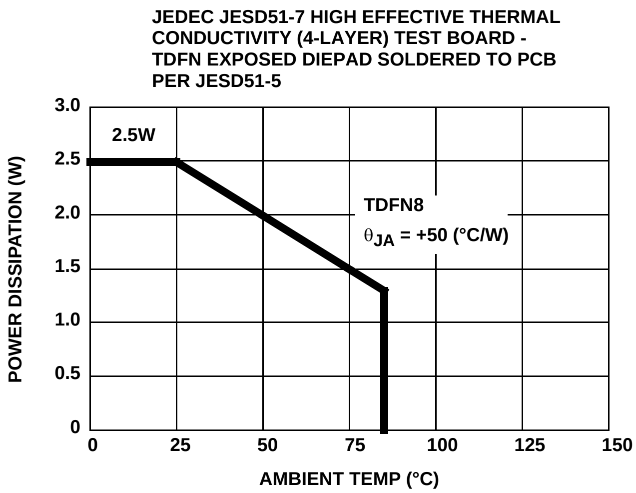


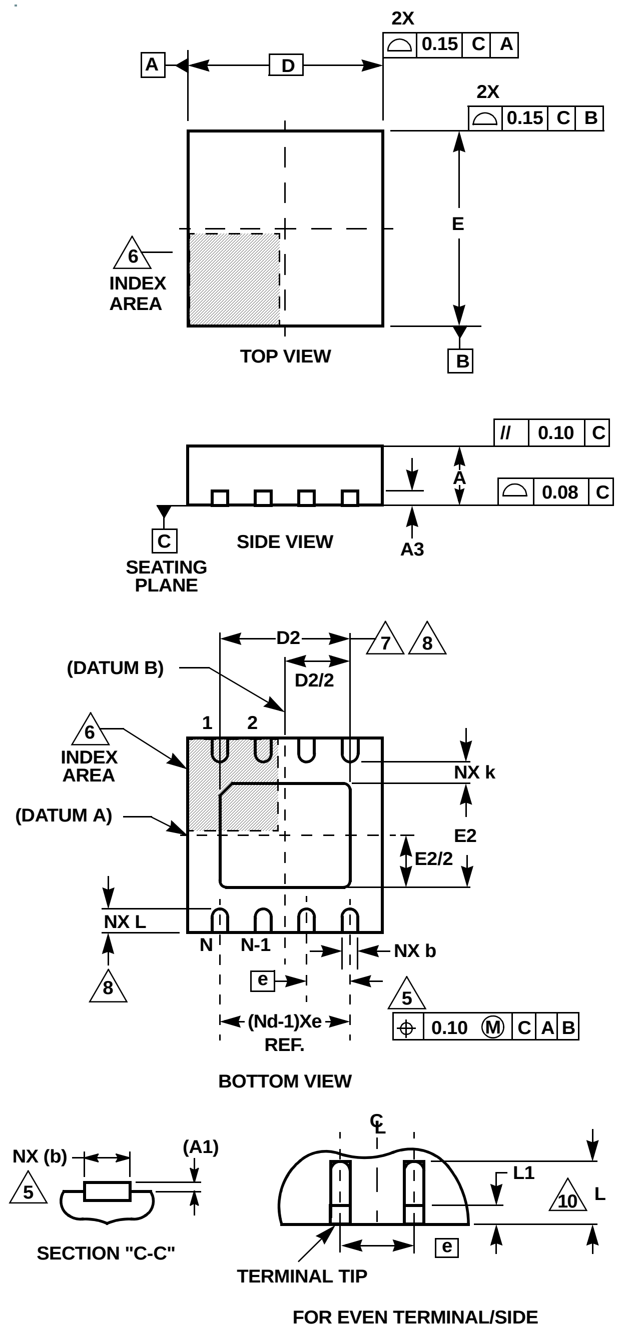
FIGURE 28. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

Printed Circuit Board Layout

As with any high-frequency device, good printed circuit board layout is necessary for optimum performance. For the ISL24021 low impedance analog power and ground planes are recommended, and trace lengths should be as short as possible. The power supply pins must be well bypassed to reduce the risk of oscillation. For optimal thermal and operating performance the ISL24021 thermal pad should always be connected to the lowest potential, V_{SS}.

For normal single supply operation (the V_{SS} pin is connected to GND) a 4.7µF capacitor should be placed from V_{DD} to GND, then a parallel 0.1µF capacitor should be connected as close to the amplifier as possible. For dual supply operation the same bypassing techniques should be utilized by connecting capacitors from each supply to GND.

Thin Dual Flat No-Lead Plastic Package (TDFN)



L8.3x3A

8 LEAD THIN DUAL FLAT NO-LEAD PLASTIC PACKAGE

SYMBOL	MILLIMETERS			NOTES
	MIN	NOMINAL	MAX	
A	0.70	0.75	0.80	-
A1	-	0.02	0.05	-
A3		0.20 REF		-
b	0.25	0.30	0.35	5, 8
D		3.00 BSC		-
D2	2.20	2.30	2.40	7, 8, 9
E		3.00 BSC		-
E2	1.40	1.50	1.60	7, 8, 9
e		0.65 BSC		-
k	0.25	-	-	-
L	0.20	0.30	0.40	8
N		8		2
Nd		4		3

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NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5-1994.
2. N is the number of terminals.
3. Nd refers to the number of terminals on D.
4. All dimensions are in millimeters. Angles are in degrees.
5. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.
7. Dimensions D2 and E2 are for the exposed pads which provide improved electrical and thermal performance.
8. Nominal dimensions are provided to assist with PCB Land Pattern Design efforts, see Intersil Technical Brief TB389.
9. Compliant to JEDEC MO-WEEC-2 except for the “L” min dimension.