

## LMH6642Q / LMH6643Q Low Power, 130MHz, 75mA Rail-to-Rail Output Amplifiers

Check for Samples: [LMH6642Q](#), [LMH6643Q](#)

### FEATURES

- ( $V_S = \pm 5V$ ,  $T_A = 25^\circ C$ ,  $R_L = 2k\Omega$ ,  $A_V = +1$ . Typical Values Unless Specified).
- $-3dB$  BW ( $A_V = +1$ ) 130MHz
- Supply Voltage Range 2.7V to 10V
- Slew Rate <sup>(1)</sup>, ( $A_V = -1$ ) 130V/ $\mu s$
- Supply Current (no load) 2.7mA/amp
- Output Short Circuit Current +115mA/~145mA
- Linear Output Current  $\pm 75mA$
- Input Common Mode Voltage 0.5V Beyond  $V^-$ , 1V from  $V^+$
- Output Voltage Swing 40mV from Rails
- Input Voltage Noise (100kHz) 17nV/ $\sqrt{Hz}$
- Input Current Noise (100kHz) 0.9pA/ $\sqrt{Hz}$
- THD (5MHz,  $R_L = 2k\Omega$ ,  $V_O = 2V_{PP}$ ,  $A_V = +2$ )  $-62dBc$
- Settling Time 68ns
- Fully Characterized for 3V, 5V, and  $\pm 5V$
- Overdrive Recovery 100ns
- Output Short Circuit Protected <sup>(2)</sup>
- No Output Phase Reversal with CMVR Exceeded
- LMH6643QMM and LMH6642QMF are AEC-Q100 Grade 3 Qualified and are Manufactured on an Automotive Grade Flow

### APPLICATIONS

- Active Filters
- CD/DVD ROM
- ADC Buffer Amp
- Portable Video
- Current Sense Buffer
- Automotive

- (1) Slew rate is the average of the rising and falling slew rates.  
(2) Output short circuit duration is infinite for  $V_S < 6V$  at room temperature and below. For  $V_S > 6V$ , allowable short circuit duration is 1.5ms.

### DESCRIPTION

The LMH664X family true single supply voltage feedback amplifiers offer high speed (130MHz), low distortion ( $-62dBc$ ), and exceptionally high output current (approximately 75mA) at low cost and with reduced power consumption when compared against existing devices with similar performance.

Input common mode voltage range extends to 0.5V below  $V^-$  and 1V from  $V^+$ . Output voltage range extends to within 40mV of either supply rail, allowing wide dynamic range especially desirable in low voltage applications. The output stage is capable of approximately 75mA in order to drive heavy loads. Fast output Slew Rate (130V/ $\mu s$ ) ensures large peak-to-peak output swings can be maintained even at higher speeds, resulting in exceptional full power bandwidth of 40MHz with a 3V supply. These characteristics, along with low cost, are ideal features for a multitude of industrial and commercial applications.

Careful attention has been paid to ensure device stability under all operating voltages and modes. The result is a very well behaved frequency response characteristic (0.1dB gain flatness up the 12MHz under 150 $\Omega$  load and  $A_V = +2$ ) with minimal peaking (typically 2dB maximum) for any gain setting and under both heavy and light loads. This along with fast settling time (68ns) and low distortion allows the device to operate well in ADC buffer, and high frequency filter applications as well as other applications.

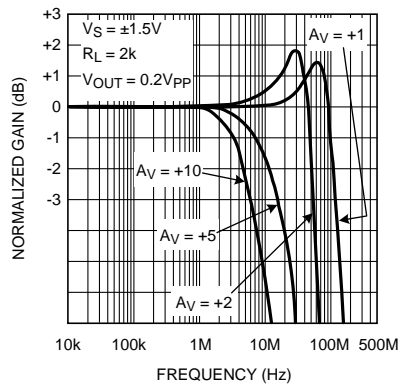
This device family offers professional quality video performance with low DG (0.01%) and DP (0.01°) characteristics. Differential Gain and Differential Phase characteristics are also well maintained under heavy loads (150 $\Omega$ ) and throughout the output voltage range. The LMH664X family is offered in single (LMH6642), dual (LMH6643).



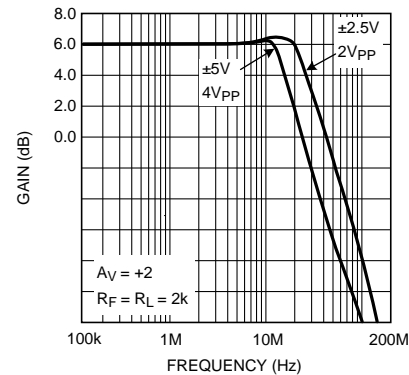
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Closed Loop Gain vs. Frequency for Various Gain



Large Signal Frequency Response



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### Absolute Maximum Ratings <sup>(1)(2)</sup>

ESD Tolerance	2KV <sup>(3)</sup> 200V <sup>(4)</sup> 1000V <sup>(5)</sup>
V <sub>IN</sub> Differential	±2.5V
Output Short Circuit Duration	See <sup>(6)</sup> and <sup>(7)</sup>
Supply Voltage (V <sup>+</sup> - V <sup>-</sup> )	13.5V
Voltage at Input/Output pins	V <sup>+</sup> +0.8V, V <sup>-</sup> -0.8V
Input Current	±10mA
Storage Temperature Range	-65°C to +150°C
Junction Temperature <sup>(8)</sup>	+150°C
Soldering Information	
Infrared or Convection Reflow (20 sec)	235°C
Wave Soldering Lead Temp.(10 sec)	260°C

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) Human body model, 1.5kΩ in series with 100pF.
- (4) Machine Model, 0Ω in series with 200pF.
- (5) CDM: Charge Device Model
- (6) Applies to both single-supply and split-supply operation. Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C.
- (7) Output short circuit duration is infinite for V<sub>S</sub> < 6V at room temperature and below. For V<sub>S</sub> > 6V, allowable short circuit duration is 1.5ms.
- (8) The maximum power dissipation is a function of T<sub>J(MAX)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any ambient temperature is P<sub>D</sub> = (T<sub>J(MAX)</sub> - T<sub>A</sub>) / θ<sub>JA</sub>. All numbers apply for packages soldered directly onto a PC board.

### Operating Ratings <sup>(1)</sup>

Supply Voltage (V <sup>+</sup> - V <sup>-</sup> )	2.7V to 10V
Junction Temperature Range <sup>(2)</sup>	-40°C to +85°C
Package Thermal Resistance <sup>(2)</sup> (θ <sub>JA</sub> )	
5-Pin SOT-23	265°C/W
8-Pin VSSOP	235°C/W

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.
- (2) The maximum power dissipation is a function of T<sub>J(MAX)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any ambient temperature is P<sub>D</sub> = (T<sub>J(MAX)</sub> - T<sub>A</sub>) / θ<sub>JA</sub>. All numbers apply for packages soldered directly onto a PC board.

### 3V Electrical Characteristics

Unless otherwise specified, all limits guaranteed for at  $T_J = 25^\circ\text{C}$ ,  $V^+ = 3\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = V_O = V^+/2$ ,  $V_{ID}$  (input differential voltage) as noted (where applicable) and  $R_L = 2\text{k}\Omega$  to  $V^+/2$ . **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
BW	–3dB BW	$A_V = +1$ , $V_{OUT} = 200\text{mV}_{PP}$	80	115		MHz
		$A_V = +2$ , $-1$ , $V_{OUT} = 200\text{mV}_{PP}$		46		
$BW_{0.1dB}$	0.1dB Gain Flatness	$A_V = +2$ , $R_L = 150\Omega$ to $V^+/2$ , $R_L = 402\Omega$ , $V_{OUT} = 200\text{mV}_{PP}$		19		MHz
PBW	Full Power Bandwidth	$A_V = +1$ , $-1\text{dB}$ , $V_{OUT} = 1\text{V}_{PP}$		40		MHz
$e_n$	Input-Referred Voltage Noise	$f = 100\text{kHz}$		17		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 1\text{kHz}$		48		
$i_n$	Input-Referred Current Noise	$f = 100\text{kHz}$		0.90		$\text{pA}/\sqrt{\text{Hz}}$
		$f = 1\text{kHz}$		3.3		
THD	Total Harmonic Distortion	$f = 5\text{MHz}$ , $V_O = 2\text{V}_{PP}$ , $A_V = -1$ , $R_L = 100\Omega$ to $V^+/2$		–48		dBc
DG	Differential Gain	$V_{CM} = 1\text{V}$ , NTSC, $A_V = +2$ $R_L = 150\Omega$ to $V^+/2$		0.17		%
		$R_L = 1\text{k}\Omega$ to $V^+/2$		0.03		
DP	Differential Phase	$V_{CM} = 1\text{V}$ , NTSC, $A_V = +2$ $R_L = 150\Omega$ to $V^+/2$		0.05		deg
		$R_L = 1\text{k}\Omega$ to $V^+/2$		0.03		
CT Rej.	Cross-Talk Rejection	$f = 5\text{MHz}$ , Receiver: $R_f = R_g = 510\Omega$ , $A_V = +2$		47		dB
$T_S$	Settling Time	$V_O = 2\text{V}_{PP}$ , $\pm 0.1\%$ , $8\text{pF}$ Load, $V_S = 5\text{V}$		68		ns
SR	Slew Rate <sup>(3)</sup>	$A_V = -1$ , $V_I = 2\text{V}_{PP}$	90	120		$\text{V}/\mu\text{s}$
$V_{OS}$	Input Offset Voltage	For LMH6642		$\pm 1$	$\pm 5$ <b><math>\pm 7</math></b>	mV
		For LMH6643		$\pm 1$	$\pm 3.4$ <b><math>\pm 7</math></b>	
TC $V_{OS}$	Input Offset Average Drift	<sup>(4)</sup>		$\pm 5$		$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current	<sup>(5)</sup>		–1.50	–2.60 <b>–3.25</b>	$\mu\text{A}$
$I_{OS}$	Input Offset Current			20	800 <b>1000</b>	nA
$R_{IN}$	Common Mode Input Resistance			3		M $\Omega$
$C_{IN}$	Common Mode Input Capacitance			2		pF
CMVR	Input Common-Mode Voltage Range	CMRR $\geq 50\text{dB}$		–0.5	–0.2 <b>–0.1</b>	V
			1.8 <b>1.6</b>	2.0		
CMRR	Common Mode Rejection Ratio	$V_{CM}$ Stepped from $0\text{V}$ to $1.5\text{V}$	72	95		dB
$A_{VOL}$	Large Signal Voltage Gain	$V_O = 0.5\text{V}$ to $2.5\text{V}$ $R_L = 2\text{k}\Omega$ to $V^+/2$	80 <b>75</b>	96		dB
		$V_O = 0.5\text{V}$ to $2.5\text{V}$ $R_L = 150\Omega$ to $V^+/2$	74 <b>70</b>	82		
$V_O$	Output Swing High	$R_L = 2\text{k}\Omega$ to $V^+/2$ , $V_{ID} = 200\text{mV}$	2.90	2.98		V
		$R_L = 150\Omega$ to $V^+/2$ , $V_{ID} = 200\text{mV}$	2.80	2.93		
	Output Swing Low	$R_L = 2\text{k}\Omega$ to $V^+/2$ , $V_{ID} = -200\text{mV}$		25	75	mV
		$R_L = 150\Omega$ to $V^+/2$ , $V_{ID} = -200\text{mV}$		75	150	

(1) All limits are guaranteed by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

(3) Slew rate is the average of the rising and falling slew rates.

(4) Offset voltage average drift determined by dividing the change in  $V_{OS}$  at temperature extremes by the total temperature change.

(5) Positive current corresponds to current flowing into the device.

### 3V Electrical Characteristics (continued)

Unless otherwise specified, all limits guaranteed for at  $T_J = 25^\circ\text{C}$ ,  $V^+ = 3\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V_O = V^+/2$ ,  $V_{\text{ID}}$  (input differential voltage) as noted (where applicable) and  $R_L = 2\text{k}\Omega$  to  $V^+/2$ . **Boldface** limits apply at the temperature extremes.

Parameter	Test Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
$I_{\text{SC}}$	Output Short Circuit Current	Sourcing to $V^+/2$ $V_{\text{ID}} = 200\text{mV}$ <sup>(6)</sup>	50 <b>35</b>	95	mA
		Sinking to $V^+/2$ $V_{\text{ID}} = -200\text{mV}$ <sup>(6)</sup>	55 <b>40</b>	110	
$I_{\text{OUT}}$	Output Current	$V_{\text{OUT}} = 0.5\text{V}$ from either supply		$\pm 65$	mA
+PSRR	Positive Power Supply Rejection Ratio	$V^+ = 3.0\text{V}$ to $3.5\text{V}$ , $V_{\text{CM}} = 1.5\text{V}$	75	85	dB
$I_S$	Supply Current (per channel)	No Load		2.70 <b>4.00</b> <b>4.50</b>	mA

(6) Short circuit test is a momentary test. Output short circuit duration is infinite for  $V_S < 6\text{V}$  at room temperature and below. For  $V_S > 6\text{V}$ , allowable short circuit duration is 1.5ms.

### 5V Electrical Characteristics

Unless otherwise specified, all limits guaranteed for at  $T_J = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V_O = V^+/2$ ,  $V_{\text{ID}}$  (input differential voltage) as noted (where applicable) and  $R_L = 2\text{k}\Omega$  to  $V^+/2$ . **Boldface** limits apply at the temperature extremes.

Parameter	Test Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
BW	-3dB BW	$A_V = +1$ , $V_{\text{OUT}} = 200\text{mV}_{\text{PP}}$	90	120	MHz
		$A_V = +2, -1$ , $V_{\text{OUT}} = 200\text{mV}_{\text{PP}}$		46	
$\text{BW}_{0.1\text{dB}}$	0.1dB Gain Flatness	$A_V = +2$ , $R_L = 150\Omega$ to $V^+/2$ , $R_f = 402\Omega$ , $V_{\text{OUT}} = 200\text{mV}_{\text{PP}}$		15	MHz
PBW	Full Power Bandwidth	$A_V = +1$ , -1dB, $V_{\text{OUT}} = 2\text{V}_{\text{PP}}$		22	MHz
$e_n$	Input-Referred Voltage Noise	$f = 100\text{kHz}$		17	$\text{nV}/\sqrt{\text{Hz}}$
		$f = 1\text{kHz}$		48	
$i_n$	Input-Referred Current Noise	$f = 100\text{kHz}$		0.90	$\text{pA}/\sqrt{\text{Hz}}$
		$f = 1\text{kHz}$		3.3	
THD	Total Harmonic Distortion	$f = 5\text{MHz}$ , $V_O = 2\text{V}_{\text{PP}}$ , $A_V = +2$		-60	dBc
DG	Differential Gain	NTSC, $A_V = +2$ $R_L = 150\Omega$ to $V^+/2$		0.16	%
		$R_L = 1\text{k}\Omega$ to $V^+/2$		0.05	
DP	Differential Phase	NTSC, $A_V = +2$ $R_L = 150\Omega$ to $V^+/2$		0.05	deg
		$R_L = 1\text{k}\Omega$ to $V^+/2$		0.01	
CT Rej.	Cross-Talk Rejection	$f = 5\text{MHz}$ , Receiver: $R_f = R_g = 510\Omega$ , $A_V = +2$		47	dB
$T_S$	Settling Time	$V_O = 2\text{V}_{\text{PP}}$ , $\pm 0.1\%$ , 8pF Load		68	ns
SR	Slew Rate <sup>(3)</sup>	$A_V = -1$ , $V_I = 2\text{V}_{\text{PP}}$	95	125	$\text{V}/\mu\text{s}$
$V_{\text{OS}}$	Input Offset Voltage	For LMH6642		$\pm 1$ <b><math>\pm 5</math></b> <b><math>\pm 7</math></b>	mV
		For LMH6643		$\pm 1$ <b><math>\pm 3.4</math></b> <b><math>\pm 7</math></b>	
TC $V_{\text{OS}}$	Input Offset Average Drift	<sup>(4)</sup>		$\pm 5$	$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current	<sup>(5)</sup>		-1.70 <b>-2.60</b> <b>-3.25</b>	$\mu\text{A}$
$I_{\text{OS}}$	Input Offset Current			20 <b>800</b> <b>1000</b>	nA
$R_{\text{IN}}$	Common Mode Input Resistance			3	M $\Omega$

(1) All limits are guaranteed by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

(3) Slew rate is the average of the rising and falling slew rates.

(4) Offset voltage average drift determined by dividing the change in  $V_{\text{OS}}$  at temperature extremes by the total temperature change.

(5) Positive current corresponds to current flowing into the device.

## 5V Electrical Characteristics (continued)

Unless otherwise specified, all limits guaranteed for at  $T_J = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = V_O = V^+/2$ ,  $V_{ID}$  (input differential voltage) as noted (where applicable) and  $R_L = 2\text{k}\Omega$  to  $V^+/2$ . **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
$C_{IN}$	Common Mode Input Capacitance			2		pF
CMVR	Input Common-Mode Voltage Range	CMRR $\geq 50\text{dB}$		-0.5	-0.2 <b>-0.1</b>	V
			3.8 <b>3.6</b>	4.0		
CMRR	Common Mode Rejection Ratio	$V_{CM}$ Stepped from 0V to 3.5V	72	95		dB
$A_{VOL}$	Large Signal Voltage Gain	$V_O = 0.5\text{V}$ to $4.50\text{V}$ $R_L = 2\text{k}\Omega$ to $V^+/2$	86 <b>82</b>	98		dB
		$V_O = 0.5\text{V}$ to $4.25\text{V}$ $R_L = 150\Omega$ to $V^+/2$	76 <b>72</b>	82		
$V_O$	Output Swing High	$R_L = 2\text{k}\Omega$ to $V^+/2$ , $V_{ID} = 200\text{mV}$	4.90	4.98		V
		$R_L = 150\Omega$ to $V^+/2$ , $V_{ID} = 200\text{mV}$	4.65	4.90		
	Output Swing Low	$R_L = 2\text{k}\Omega$ to $V^+/2$ , $V_{ID} = -200\text{mV}$		25	100	mV
		$R_L = 150\Omega$ to $V^+/2$ , $V_{ID} = -200\text{mV}$		100	150	
$I_{SC}$	Output Short Circuit Current	Sourcing to $V^+/2$ $V_{ID} = 200\text{mV}$ <sup>(6)</sup>	55 <b>40</b>	115		mA
		Sinking to $V^+/2$ $V_{ID} = -200\text{mV}$ <sup>(6)</sup>	70 <b>55</b>	140		
$I_{OUT}$	Output Current	$V_O = 0.5\text{V}$ from either supply		$\pm 70$		mA
+PSRR	Positive Power Supply Rejection Ratio	$V^+ = 4.0\text{V}$ to $6\text{V}$	79	90		dB
$I_S$	Supply Current (per channel)	No Load		2.70	4.25 <b>5.00</b>	mA

(6) Short circuit test is a momentary test. Output short circuit duration is infinite for  $V_S < 6\text{V}$  at room temperature and below. For  $V_S > 6\text{V}$ , allowable short circuit duration is 1.5ms.

## $\pm 5\text{V}$ Electrical Characteristics

Unless otherwise specified, all limits guaranteed for at  $T_J = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = -5\text{V}$ ,  $V_{CM} = V_O = 0\text{V}$ ,  $V_{ID}$  (input differential voltage) as noted (where applicable) and  $R_L = 2\text{k}\Omega$  to ground. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
BW	-3dB BW	$A_V = +1$ , $V_{OUT} = 200\text{mV}_{PP}$	95	130		MHz
		$A_V = +2$ , $-1$ , $V_{OUT} = 200\text{mV}_{PP}$		46		
$BW_{0.1dB}$	0.1dB Gain Flatness	$A_V = +2$ , $R_L = 150\Omega$ to $V^+/2$ , $R_f = 806\Omega$ , $V_{OUT} = 200\text{mV}_{PP}$		12		MHz
PBW	Full Power Bandwidth	$A_V = +1$ , $-1\text{dB}$ , $V_{OUT} = 2V_{PP}$		24		MHz
$e_n$	Input-Referred Voltage Noise	$f = 100\text{kHz}$		17		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 1\text{kHz}$		48		
$i_n$	Input-Referred Current Noise	$f = 100\text{kHz}$		0.90		$\text{pA}/\sqrt{\text{Hz}}$
		$f = 1\text{kHz}$		3.3		
THD	Total Harmonic Distortion	$f = 5\text{MHz}$ , $V_O = 2V_{PP}$ , $A_V = +2$		-62		dBc
DG	Differential Gain	NTSC, $A_V = +2$ $R_L = 150\Omega$ to $V^+/2$		0.15		%
		$R_L = 1\text{k}\Omega$ to $V^+/2$		0.01		
DP	Differential Phase	NTSC, $A_V = +2$ $R_L = 150\Omega$ to $V^+/2$		0.04		deg
		$R_L = 1\text{k}\Omega$ to $V^+/2$		0.01		

(1) All limits are guaranteed by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

## ±5V Electrical Characteristics (continued)

Unless otherwise specified, all limits guaranteed for at  $T_J = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = -5\text{V}$ ,  $V_{CM} = V_O = 0\text{V}$ ,  $V_{ID}$  (input differential voltage) as noted (where applicable) and  $R_L = 2\text{k}\Omega$  to ground. **Boldface** limits apply at the temperature extremes.

Parameter	Test Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
CT Rej.	Cross-Talk Rejection $f = 5\text{MHz}$ , Receiver: $R_f = R_g = 510\Omega$ , $A_V = +2$		47		dB
$T_S$	Settling Time $V_O = 2V_{PP}$ , $\pm 0.1\%$ , $8\text{pF}$ Load, $V_S = 5\text{V}$		68		ns
SR	Slew Rate <sup>(3)</sup> $A_V = -1$ , $V_I = 2V_{PP}$	100	135		$\text{V}/\mu\text{s}$
$V_{OS}$	Input Offset Voltage For LMH6642		$\pm 1$	$\pm 5$ <b><math>\pm 7</math></b>	mV
	For LMH6643		$\pm 1$	$\pm 3.4$ <b><math>\pm 7</math></b>	
TC $V_{OS}$	Input Offset Average Drift <sup>(4)</sup>		$\pm 5$		$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current <sup>(5)</sup>		-1.60	-2.60 <b>-3.25</b>	$\mu\text{A}$
$I_{OS}$	Input Offset Current		20	800 <b>1000</b>	nA
$R_{IN}$	Common Mode Input Resistance		3		$\text{M}\Omega$
$C_{IN}$	Common Mode Input Capacitance		2		pF
CMVR	Input Common-Mode Voltage Range CMRR $\geq 50\text{dB}$		-5.5	-5.2 <b>-5.1</b>	V
		3.8 <b>3.6</b>	4.0		
CMRR	Common Mode Rejection Ratio $V_{CM}$ Stepped from -5V to 3.5V	74	95		dB
$A_{VOL}$	Large Signal Voltage Gain $V_O = -4.5\text{V}$ to $4.5\text{V}$ , $R_L = 2\text{k}\Omega$	88 <b>84</b>	96		dB
		$V_O = -4.0\text{V}$ to $4.0\text{V}$ , $R_L = 150\Omega$	82		
$V_O$	Output Swing High $R_L = 2\text{k}\Omega$ , $V_{ID} = 200\text{mV}$	4.90	4.96		V
		$R_L = 150\Omega$ , $V_{ID} = 200\text{mV}$	4.80		
	Output Swing Low $R_L = 2\text{k}\Omega$ , $V_{ID} = -200\text{mV}$		-4.96	-4.90	V
		$R_L = 150\Omega$ , $V_{ID} = -200\text{mV}$	-4.80	-4.65	
$I_{SC}$	Output Short Circuit Current Sourcing to Ground $V_{ID} = 200\text{mV}$ <sup>(6)</sup>	60 <b>35</b>	115		mA
		Sinking to Ground $V_{ID} = -200\text{mV}$ <sup>(6)</sup>	85 <b>65</b>	145	
$I_{OUT}$	Output Current $V_O = 0.5\text{V}$ from either supply	$\pm 75$			mA
PSRR	Power Supply Rejection Ratio ( $V^+$ , $V^-$ ) = (4.5V, -4.5V) to (5.5V, -5.5V)	78	90		dB
$I_S$	Supply Current (per channel) No Load		2.70	4.50 <b>5.50</b>	mA

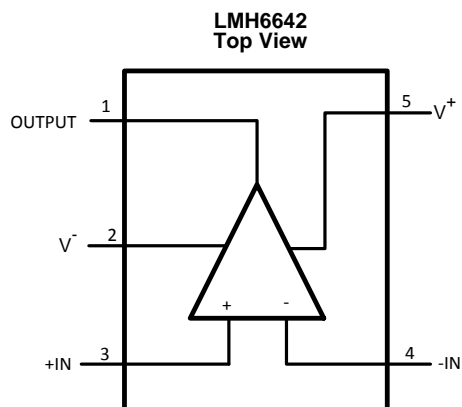
(3) Slew rate is the average of the rising and falling slew rates.

(4) Offset voltage average drift determined by dividing the change in  $V_{OS}$  at temperature extremes by the total temperature change.

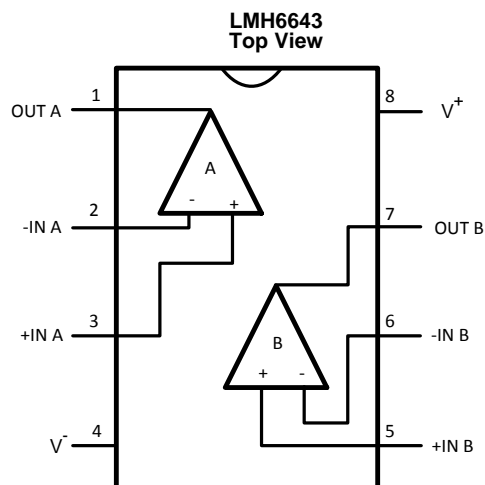
(5) Positive current corresponds to current flowing into the device.

(6) Short circuit test is a momentary test. Output short circuit duration is infinite for  $V_S < 6\text{V}$  at room temperature and below. For  $V_S > 6\text{V}$ , allowable short circuit duration is 1.5ms.

## Connection Diagrams



**Figure 1. 5-Pin SOT-23 Package  
See Package Number DBV0005A**

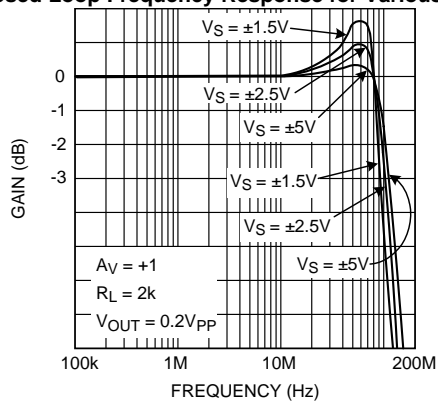


**Figure 2. 8-Pin VSSOP Package  
See Package Number DGK0008A**

## Typical Performance Characteristics

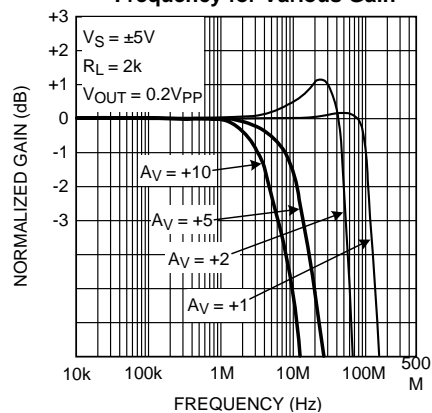
At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5\text{V}$ ,  $V^- = -5\text{V}$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

**Closed Loop Frequency Response for Various Supplies**



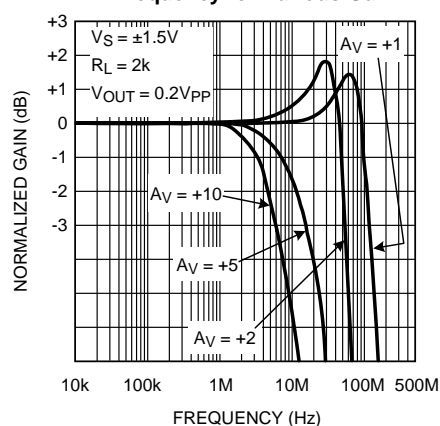
**Figure 3.**

**Closed Loop Gain  
vs.  
Frequency for Various Gain**



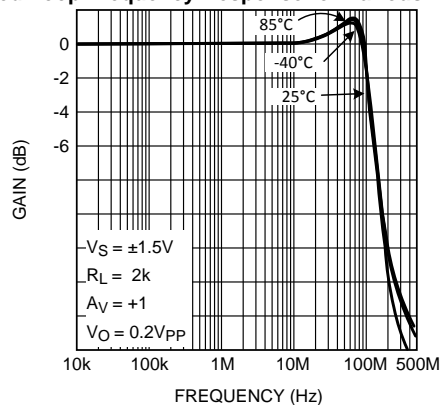
**Figure 4.**

**Closed Loop Gain  
vs.  
Frequency for Various Gain**



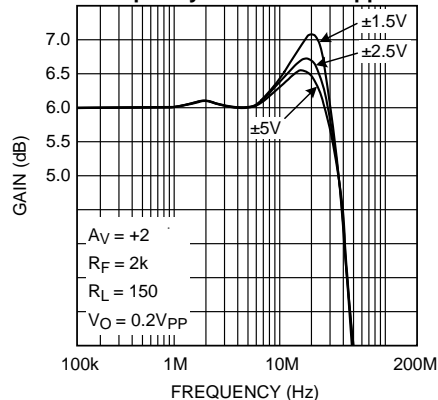
**Figure 5.**

**Closed Loop Frequency Response for Various Temperature**



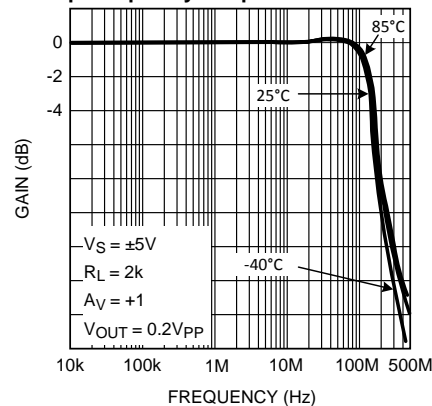
**Figure 6.**

**Closed Loop Gain  
vs.  
Frequency for Various Supplies**



**Figure 7.**

**Closed Loop Frequency Response for Various Temperature**



**Figure 8.**



## Typical Performance Characteristics (continued)

At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5\text{V}$ ,  $V^- = -5\text{V}$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

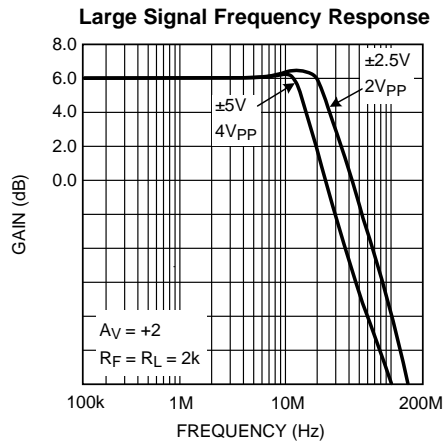


Figure 9.

## Closed Loop Small Signal Frequency Response for Various Supplies

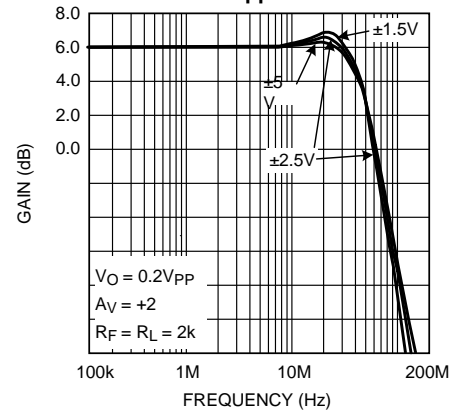


Figure 10.

## Closed Loop Frequency Response for Various Supplies

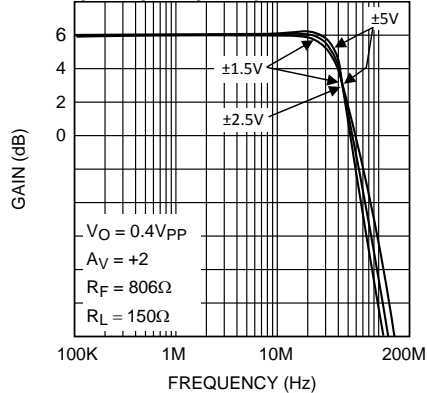


Figure 11.

## $\pm 0.1\text{dB}$ Gain Flatness for Various Supplies

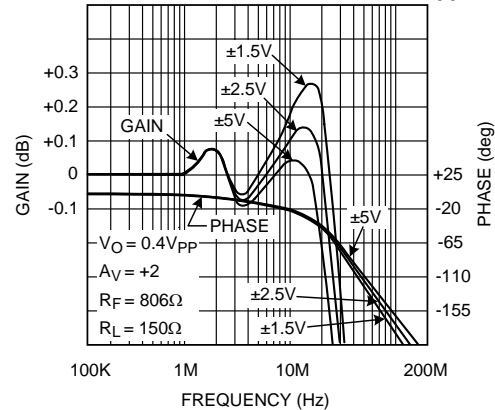


Figure 12.

## $V_{OUT}$ (Vpp) for THD < 0.5%

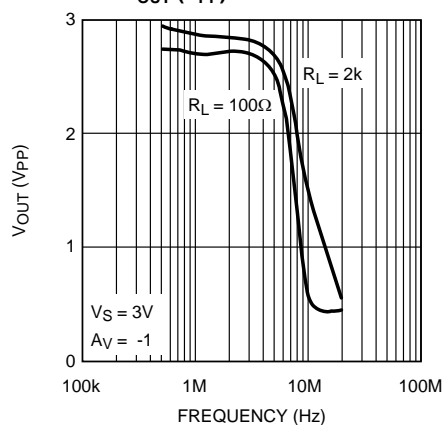


Figure 13.

## $V_{OUT}$ (Vpp) for THD < 0.5%

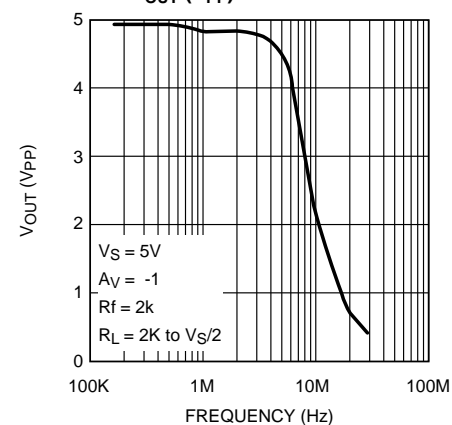


Figure 14.

### Typical Performance Characteristics (continued)

At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5\text{V}$ ,  $V^- = -5\text{V}$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

$V_{\text{OUT}} (V_{\text{PP}})$  for THD < 0.5%

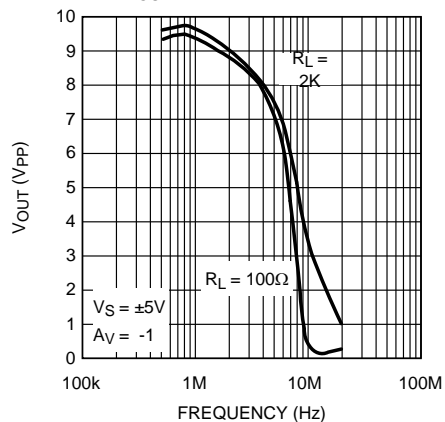


Figure 15.

Open Loop Gain/Phase for Various Temperature

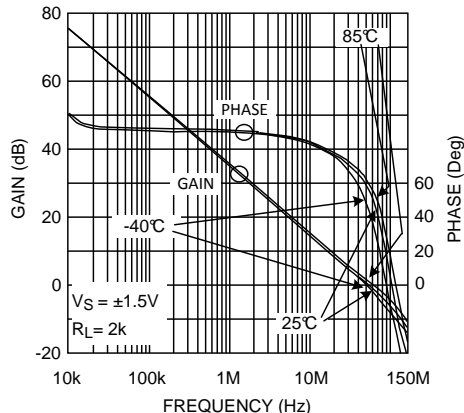


Figure 16.

Open Loop Gain/Phase for Various Temperature

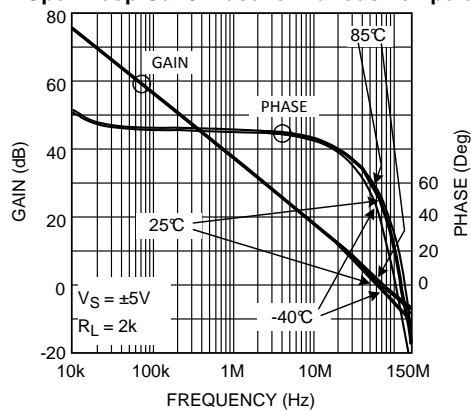


Figure 17.

HD2 (dBc)  
vs.  
Output Swing

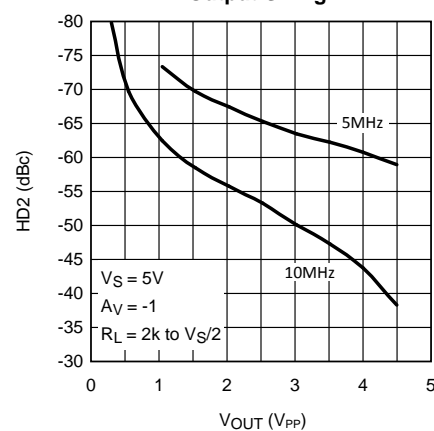


Figure 18.

HD3 (dBc)  
vs.  
Output Swing

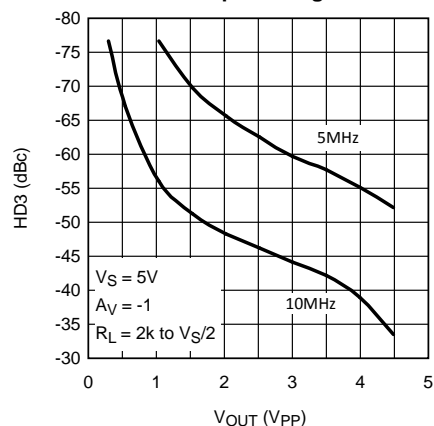


Figure 19.

HD2  
vs.  
Output Swing

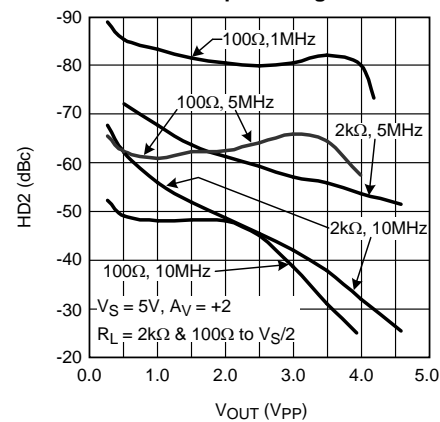


Figure 20.

## Typical Performance Characteristics (continued)

At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5$ ,  $V^- = -5\text{V}$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

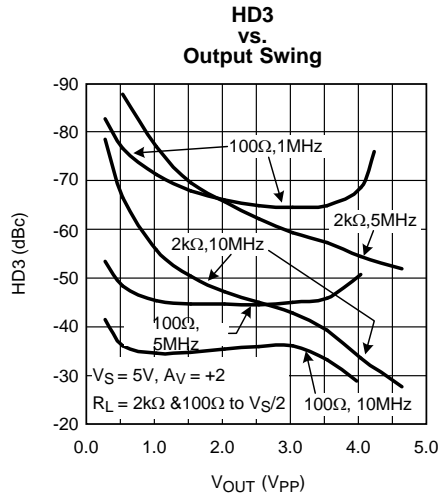


Figure 21.

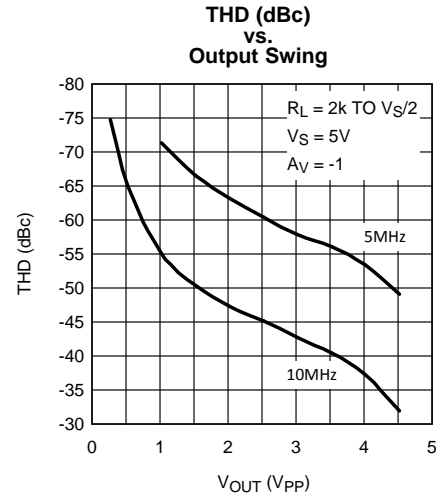


Figure 22.

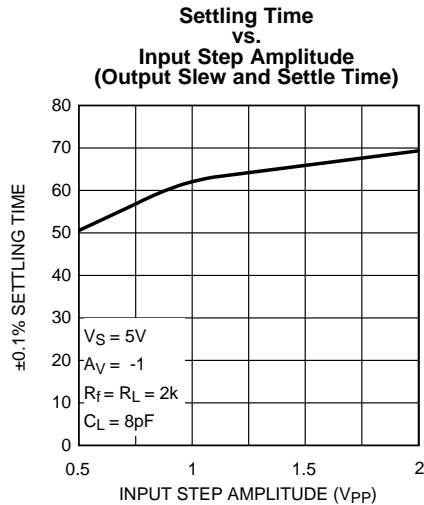


Figure 23.

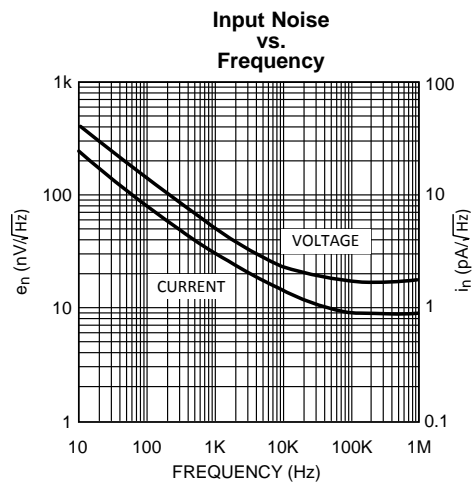


Figure 24.

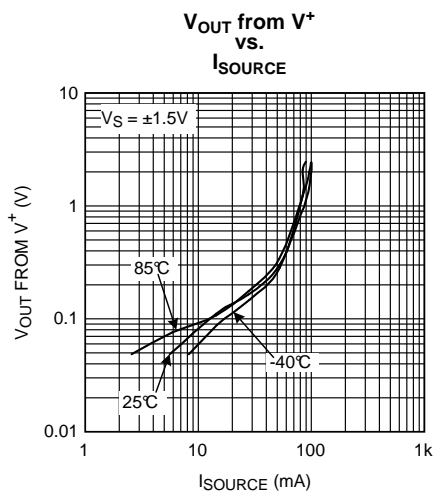


Figure 25.

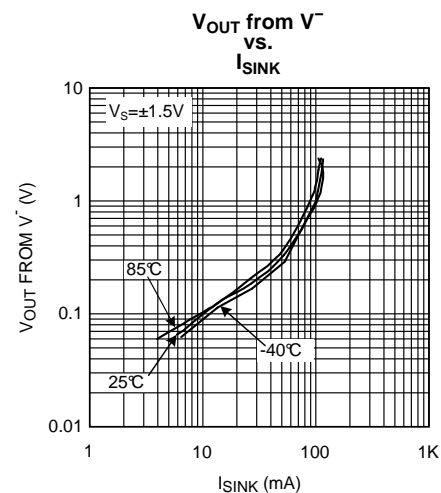


Figure 26.

### Typical Performance Characteristics (continued)

At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5\text{V}$ ,  $V^- = -5\text{V}$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

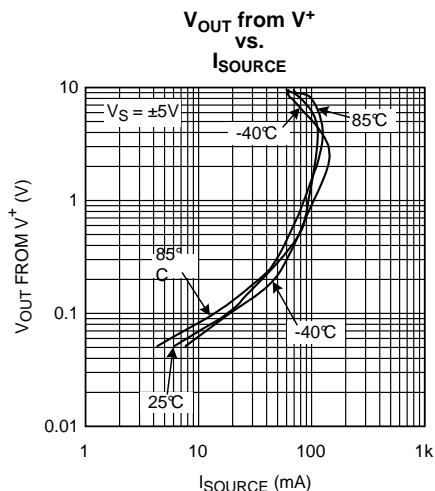


Figure 27.

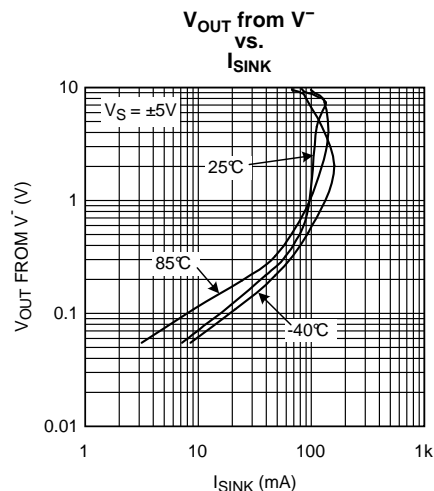


Figure 28.

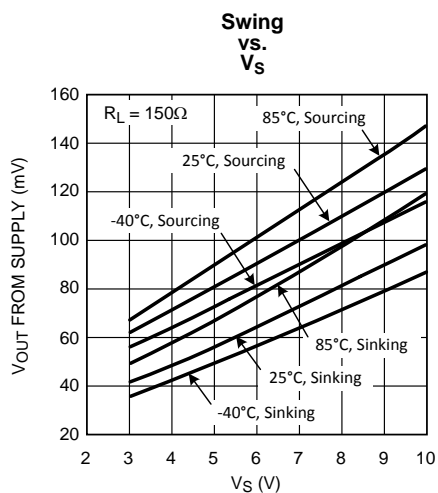


Figure 29.

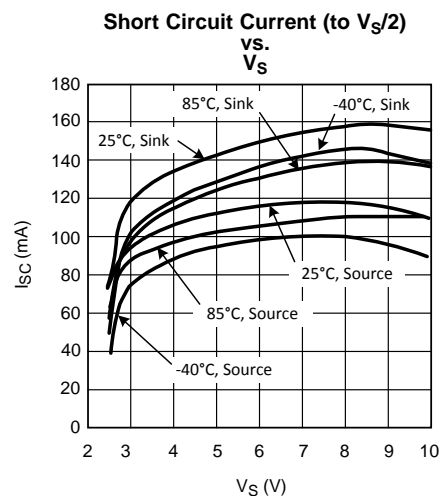


Figure 30.

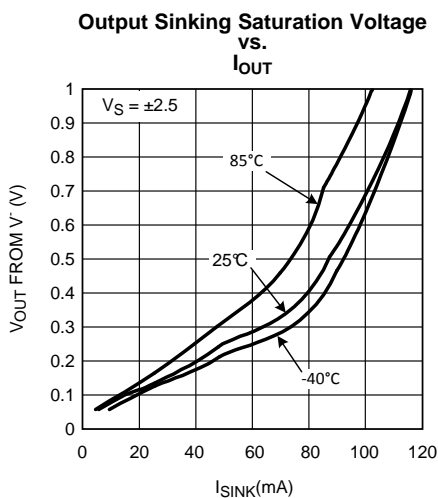


Figure 31.

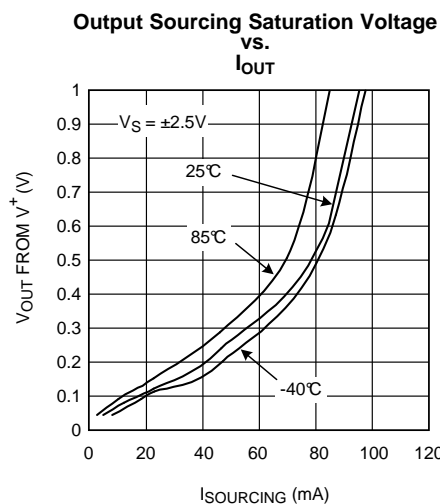


Figure 32.

## Typical Performance Characteristics (continued)

At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5$ ,  $V^- = -5$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

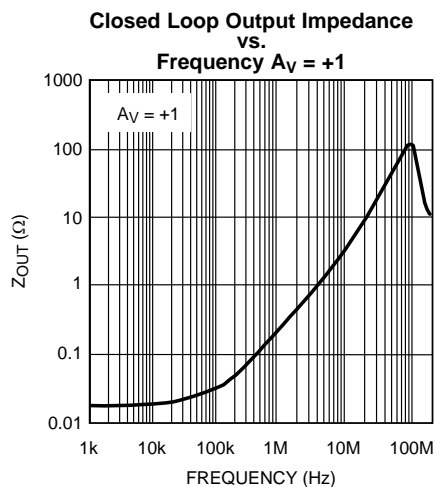


Figure 33.

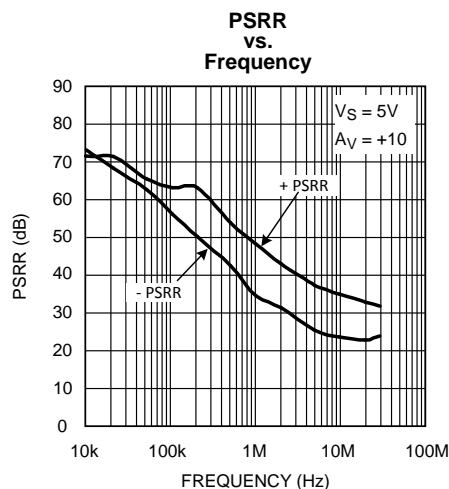


Figure 34.

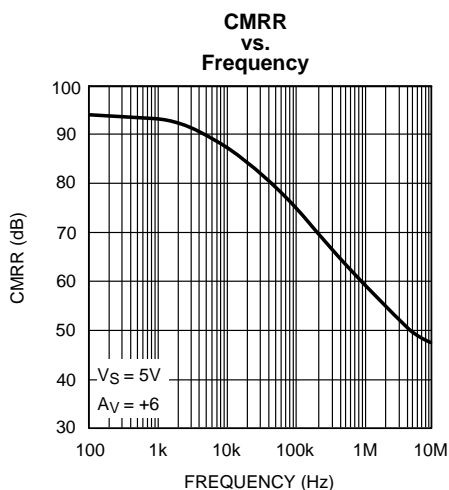


Figure 35.

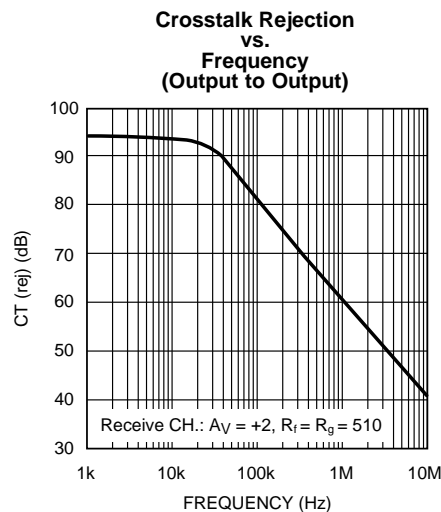


Figure 36.

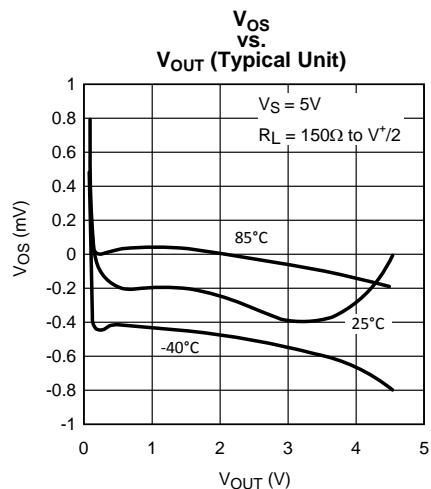


Figure 37.

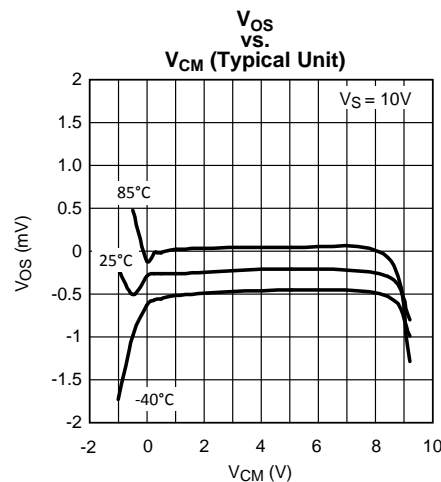


Figure 38.

### Typical Performance Characteristics (continued)

At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5$ ,  $V^- = -5\text{V}$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

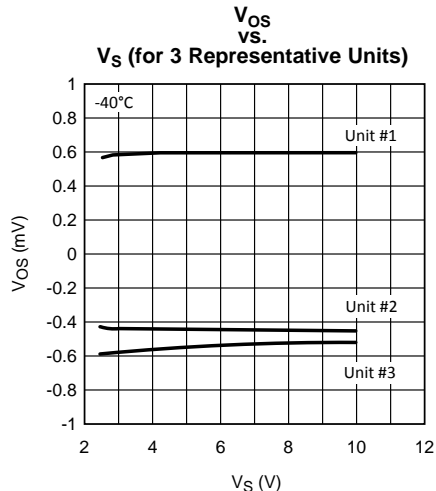


Figure 39.

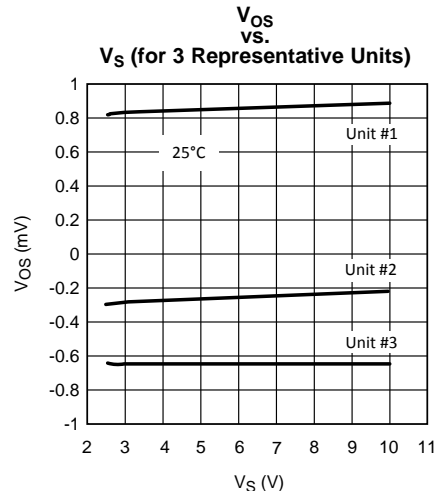


Figure 40.

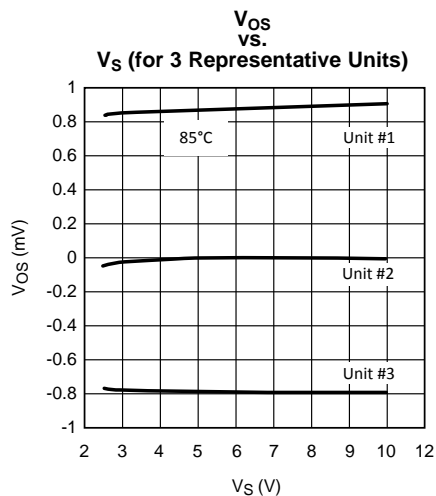


Figure 41.

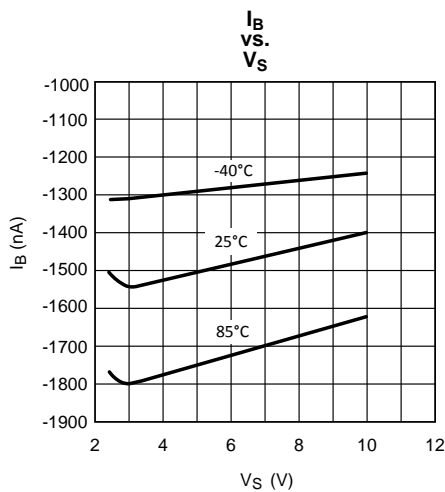


Figure 42.

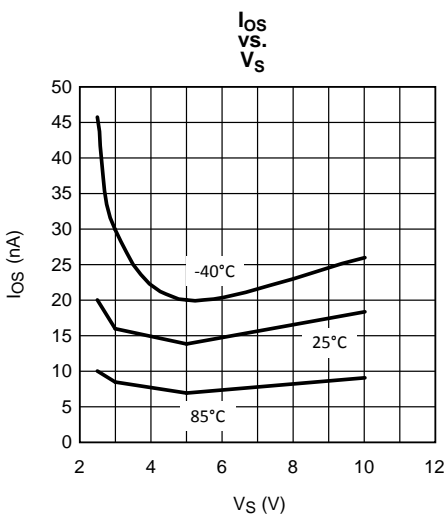


Figure 43.

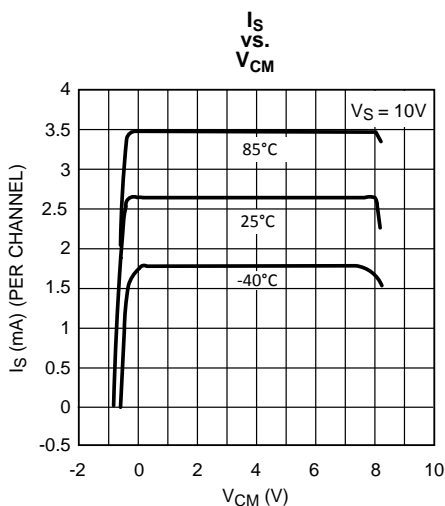


Figure 44.

## Typical Performance Characteristics (continued)

At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5$ ,  $V^- = -5$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

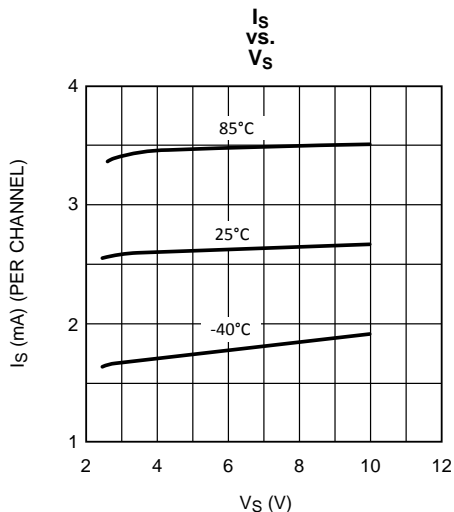


Figure 45.

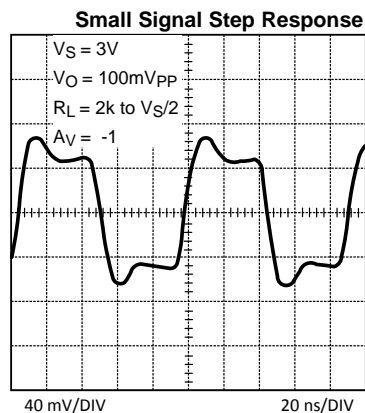


Figure 46.

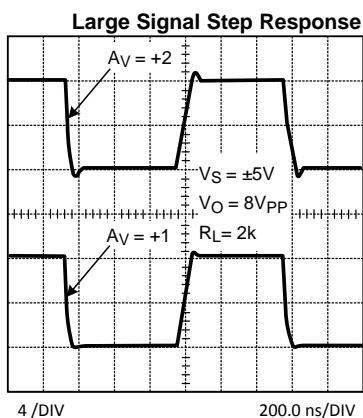


Figure 47.

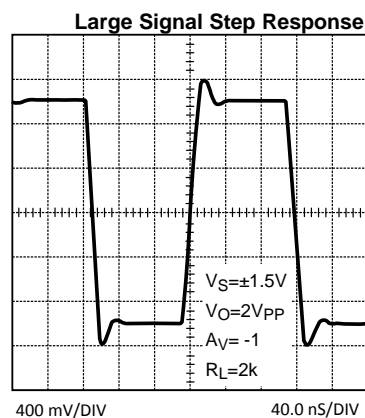


Figure 48.

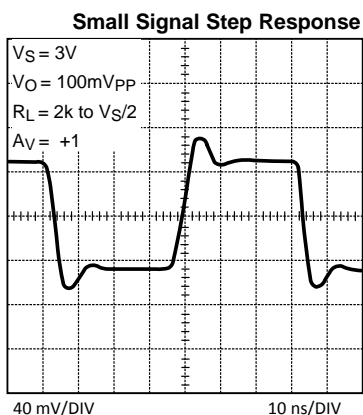


Figure 49.

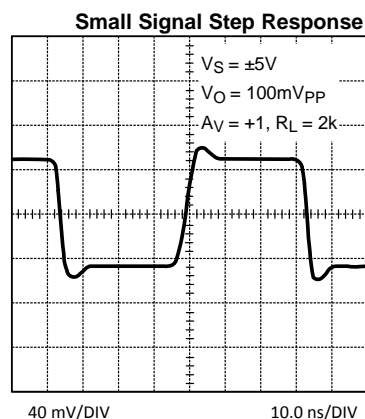
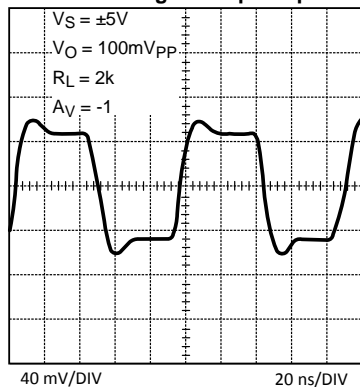


Figure 50.

### Typical Performance Characteristics (continued)

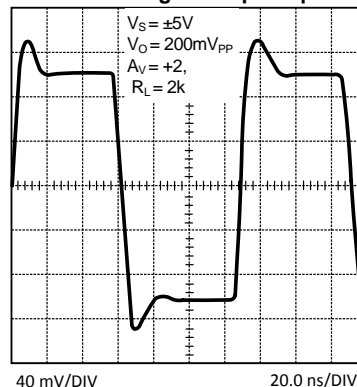
At  $T_J = 25^\circ\text{C}$ ,  $V^+ = +5\text{V}$ ,  $V^- = -5\text{V}$ ,  $R_F = R_L = 2\text{k}\Omega$ . Unless otherwise specified.

**Small Signal Step Response**



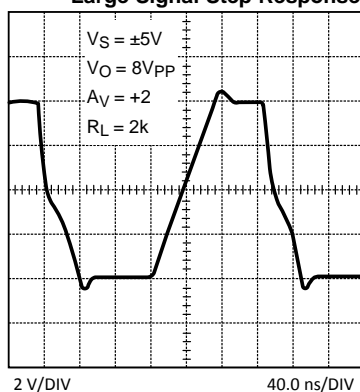
**Figure 51.**

**Small Signal Step Response**



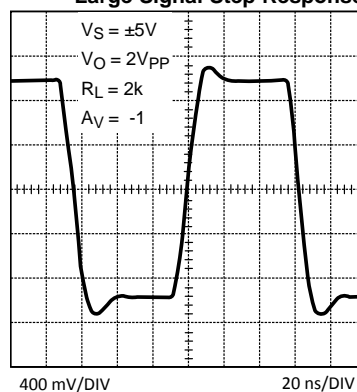
**Figure 52.**

**Large Signal Step Response**



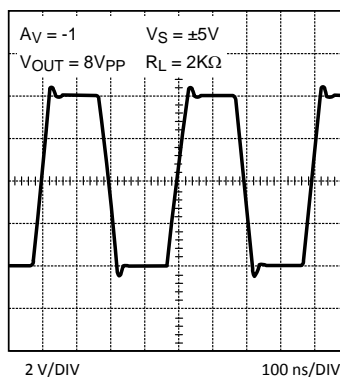
**Figure 53.**

**Large Signal Step Response**



**Figure 54.**

**Large Signal Step Response**



**Figure 55.**



## APPLICATION INFORMATION

### CIRCUIT DESCRIPTION

The LMH664X family is based on Texas Instruments' proprietary VIP10 dielectrically isolated bipolar process.

This device family architecture features the following:

- Complimentary bipolar devices with exceptionally high  $f_t$  (~8GHz) even under low supply voltage (2.7V) and low bias current.
- A class A-B “turn-around” stage with improved noise, offset, and reduced power dissipation compared to similar speed devices (patent pending).
- Common Emitter push-push output stage capable of 75mA output current (at 0.5V from the supply rails) while consuming only 2.7mA of total supply current per channel. This architecture allows output to reach within milli-volts of either supply rail.
- Consistent performance over the entire operating supply voltage range with little variation for the most important specifications (e.g. BW, SR,  $I_{OUT}$ , etc.)
- Significant power saving (~40%) compared to competitive devices on the market with similar performance.

### Application Hints

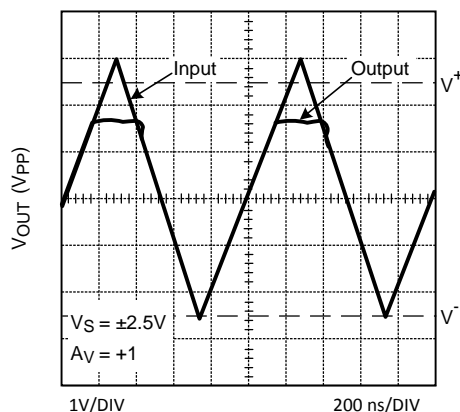
This Op Amp family is a drop-in replacement for the AD805X family of high speed Op Amps in most applications. In addition, the LMH664X will typically save about 40% on power dissipation, due to lower supply current, when compared to competition. All AD805X family's guaranteed parameters are included in the list of LMH664X guaranteed specifications in order to ensure equal or better level of performance. However, as in most high performance parts, due to subtleties of applications, it is strongly recommended that the performance of the part to be evaluated is tested under actual operating conditions to ensure full compliance to all specifications.

With 3V supplies and a common mode input voltage range that extends 0.5V below  $V^-$ , the LMH664X find applications in low voltage/low power applications. Even with 3V supplies, the -3dB BW (@  $A_V = +1$ ) is typically 115MHz with a tested limit of 80MHz. Production testing guarantees that process variations will not compromise speed. High frequency response is exceptionally stable confining the typical -3dB BW over the industrial temperature range to  $\pm 2.5\%$ .

As can be seen from the [Typical Performance Characteristics](#), the LMH664X output current capability (~75mA) is enhanced compared to AD805X. This enhancement, increases the output load range, adding to the LMH664X's versatility.

Because of the LMH664X's high output current capability attention should be given to device junction temperature in order not to exceed the Absolute Maximum Rating.

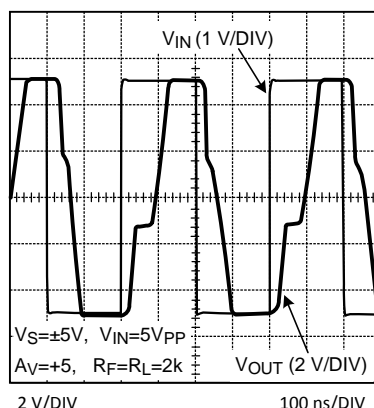
This device family was designed to avoid output phase reversal. With input overdrive, the output is kept near supply rail (or as closed to it as mandated by the closed loop gain setting and the input voltage). See [Figure 56](#):



**Figure 56. Input and Output Shown with CMVR Exceeded**

However, if the input voltage range of -0.5V to 1V from  $V^+$  is exceeded by more than a diode drop, the internal ESD protection diodes will start to conduct. The current in the diodes should be kept at or below 10mA.

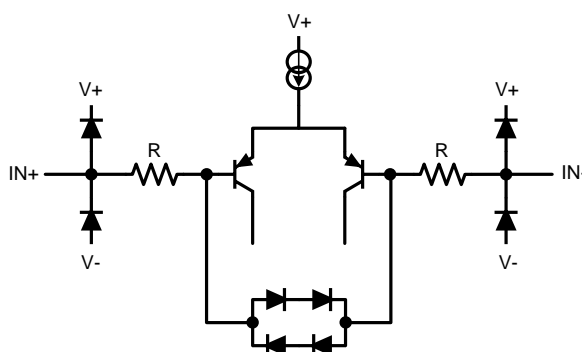
Output overdrive recovery time is less than 100ns as can be seen from [Figure 57](#) plot:



**Figure 57. Overload Recovery Waveform**

## INPUT AND OUTPUT TOPOLOGY

All input / output pins are protected against excessive voltages by ESD diodes connected to  $V^+$  and  $V^-$  rails (see [Figure 58](#)). These diodes start conducting when the input / output pin voltage approaches  $1V_{be}$  beyond  $V^+$  or  $V^-$  to protect against over voltage. These diodes are normally reverse biased. Further protection of the inputs is provided by the two resistors ( $R$  in [Figure 58](#)), in conjunction with the string of anti-parallel diodes connected between both bases of the input stage. The combination of these resistors and diodes reduces excessive differential input voltages approaching  $2V_{be}$ . The most common situation when this occurs is when the device is used as a comparator (or with little or no feedback) and the device inputs no longer follow each other. In such a case, the diodes may conduct. As a consequence, input current increases and the differential input voltage is clamped. It is important to make sure that the subsequent current flow through the device input pins does not violate the Absolute Maximum Ratings of the device. To limit the current through this protection circuit, extra series resistors can be placed. Together with the built-in series resistors of several hundred ohms, these external resistors can limit the input current to a safe number (i.e.  $< 10\text{mA}$ ). Be aware that these input series resistors may impact the switching speed of the device and could slow down the device.



**Figure 58. Input Equivalent Circuit**

## SINGLE SUPPLY, LOW POWER PHOTODIODE AMPLIFIER

The circuit shown in Figure 59 is used to amplify the current from a photo-diode into a voltage output. In this circuit, the emphasis is on achieving high bandwidth and the transimpedance gain setting is kept relatively low. Because of its high slew rate limit and high speed, the LMH664X family lends itself well to such an application.

This circuit achieves approximately 1V/mA of transimpedance gain and capable of handling up to 1mA<sub>pp</sub> from the photodiode. Q1, in a common base configuration, isolates the high capacitance of the photodiode (C<sub>d</sub>) from the Op Amp input in order to maximize speed. Input is AC coupled through C1 to ease biasing and allow single supply operation. With 5V single supply, the device input/output is shifted to near half supply using a voltage divider from V<sub>CC</sub>. Note that Q1 collector does not have any voltage swing and the Miller effect is minimized. D1, tied to Q1 base, is for temperature compensation of Q1's bias point. Q1 collector current was set to be large enough to handle the peak-to-peak photodiode excitation and not too large to shift the U1 output too far from mid-supply.

No matter how low an R<sub>f</sub> is selected, there is a need for C<sub>f</sub> in order to stabilize the circuit. The reason for this is that the Op Amp input capacitance and Q1 equivalent collector capacitance together (C<sub>IN</sub>) will cause additional phase shift to the signal fed back to the inverting node. C<sub>f</sub> will function as a zero in the feedback path counteracting the effect of the C<sub>IN</sub> and acting to stabilize the circuit. By proper selection of C<sub>f</sub> such that the Op Amp open loop gain is equal to the inverse of the feedback factor at that frequency, the response is optimized with a theoretical 45° phase margin.

$$C_F = \sim \text{SQRT} \left[ (C_{IN}) / (2\pi \cdot \text{GBWP} \cdot R_F) \right]$$

where GBWP is the Gain Bandwidth Product of the Op Amp (1)

Optimized as such, the I-V converter will have a theoretical pole, f<sub>p</sub>, at:

$$f_p = \text{SQRT} \left[ \text{GBWP} / (2\pi R_F \cdot C_{IN}) \right] \quad (2)$$

With Op Amp input capacitance of 3pF and an estimate for Q1 output capacitance of about 3pF as well, C<sub>IN</sub> = 6pF. From Typical Performance Characteristics, LMH6642/6643 family GBWP is approximately 57MHz. Therefore, with R<sub>f</sub> = 1k, from Equation 1 and Equation 2 above.

C<sub>f</sub> = ~4.1pF, and f<sub>p</sub> = 39MHz

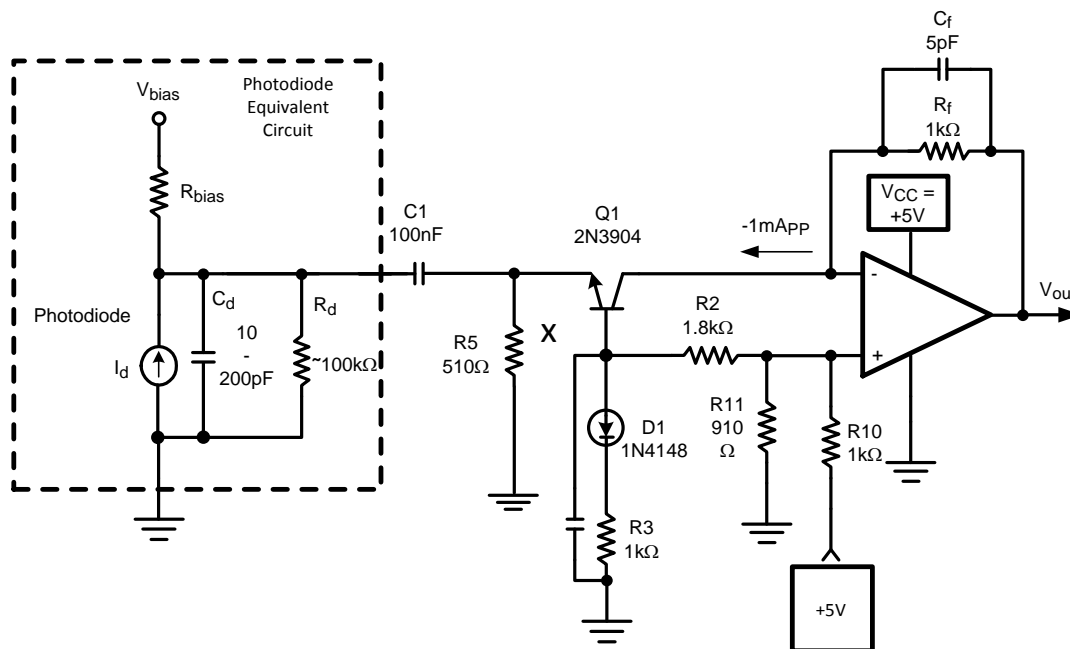
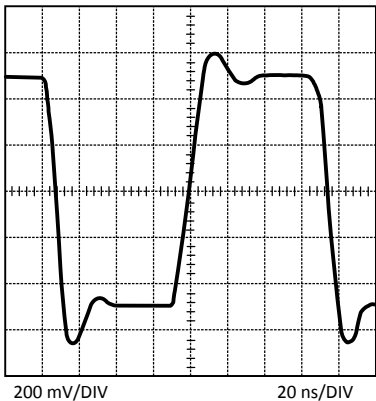


Figure 59. Single Supply Photodiode I-V Converter

For this example, optimum  $C_f$  was empirically determined to be around 5pF. This time domain response is shown in [Figure 60](#) below showing about 9ns rise/fall times, corresponding to about 39MHz for  $f_p$ . The overall supply current from the +5V supply is around 5mA with no load.



**Figure 60. Converter Step Response (1V<sub>pp</sub>, 20 ns/DIV)**

**PRINTED CIRCUIT BOARD LAYOUT AND COMPONENT VALUES SECTION**

Generally, a good high frequency layout will keep power supply and ground traces away from the inverting input and output pins. Parasitic capacitances on these nodes to ground will cause frequency response peaking and possible circuit oscillations (see Application Note OA-15 ([SNOA367](#)) for more information). Texas Instruments suggests the following evaluation boards as a guide for high frequency layout and as an aid in device testing and characterization:

Device	Package	Evaluation Board PN
LMH6642QMF	5-Pin SOT-23	LMH730216
LMH6643QMM	8-Pin VSSOP	LMH730123

Another important parameter in working with high speed/high performance amplifiers, is the component values selection. Choosing external resistors that are large in value will effect the closed loop behavior of the stage because of the interaction of these resistors with parasitic capacitances. These capacitors could be inherent to the device or a by-product of the board layout and component placement. Either way, keeping the resistor values lower, will diminish this interaction to a large extent. On the other hand, choosing very low value resistors could load down nodes and will contribute to higher overall power dissipation.

## REVISION HISTORY

### Changes from Revision A (March 2013) to Revision B

### Page

- Changed layout of National Data Sheet to TI format ..... [20](#)

## PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LMH6642QMF/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	A64Q	<a href="#">Samples</a>
LMH6642QMFX/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	A64Q	<a href="#">Samples</a>
LMH6643QMM/NOPB	ACTIVE	VSSOP	DGK	8	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	643Q	<a href="#">Samples</a>
LMH6643QMMX/NOPB	ACTIVE	VSSOP	DGK	8	3500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	643Q	<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LMH6642QMF/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMH6642QMFX/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMH6643QMM/NOPB	VSSOP	DGK	8	1000	178.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LMH6643QMMX/NOPB	VSSOP	DGK	8	3500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1



## TAPE AND REEL BOX DIMENSIONS

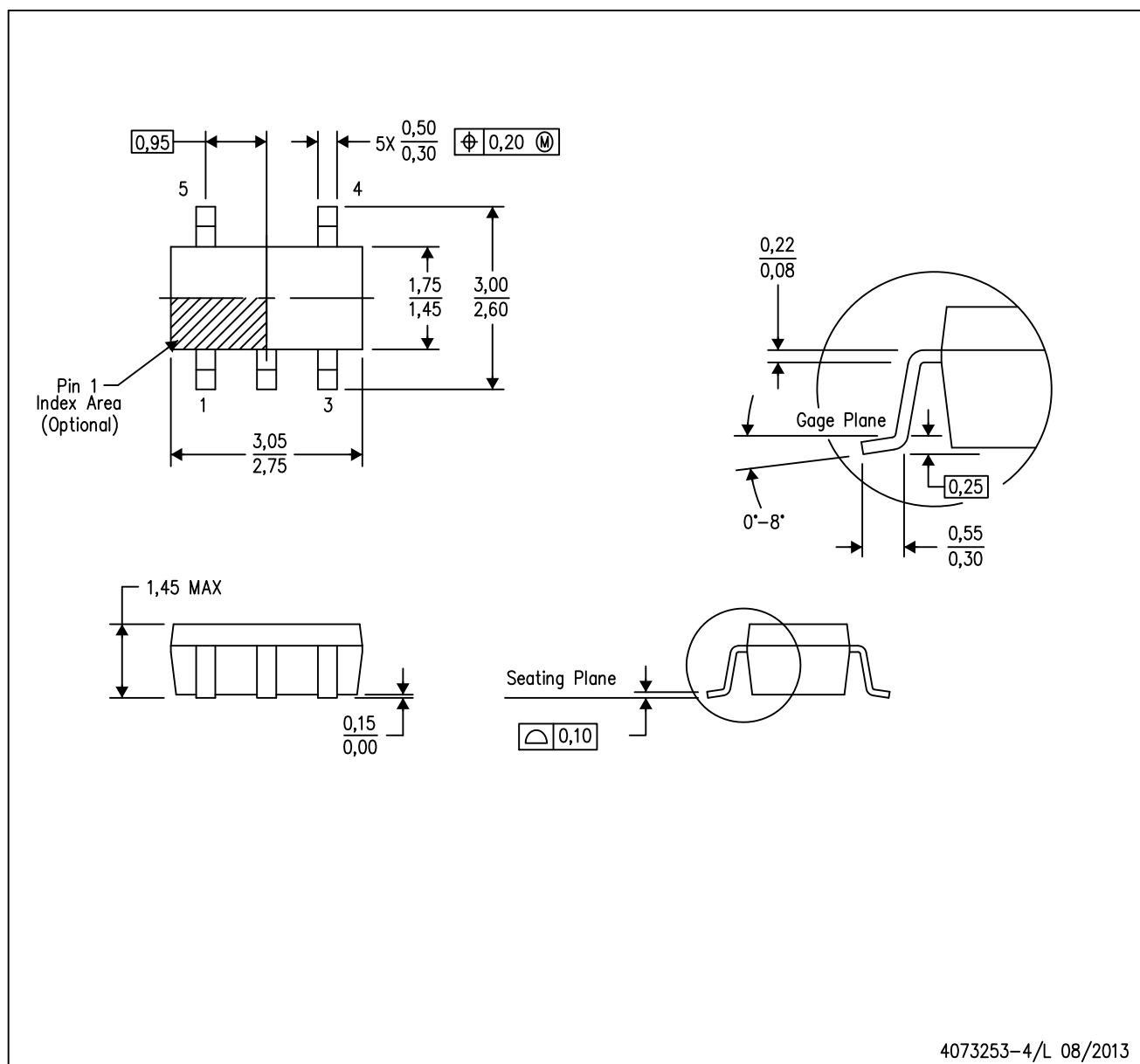


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMH6642QMF/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LMH6642QMFX/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LMH6643QMM/NOPB	VSSOP	DGK	8	1000	210.0	185.0	35.0
LMH6643QMMX/NOPB	VSSOP	DGK	8	3500	367.0	367.0	35.0

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



## NOTES:

- All linear dimensions are in millimeters.
- This drawing is subject to change without notice.
- Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
- Falls within JEDEC MO-178 Variation AA.

DBV (R-PDSO-G5)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



## NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
- E. Falls within JEDEC MO-187 variation AA, except interlead flash.

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