









THS4021, THS4022

SLOS265F - AUGUST 1999 - REVISED JULY 2024

THS402x 2GHz, 10V/V Stable, Low-Noise, High-Speed Amplifiers

1 Features

- Ultra-low 1.2nV/√Hz voltage noise
- High speed:
 - 2GHz gain-bandwidth product
 - 470V/µs slew rate
 - 30ns settling time (0.1%)
- Stable at gains ≥10V/V
- Output drive, $I_0 = 200 \text{mA}$ (typical)
- Very low distortion:
 - THD = -68dBc (f = 1MHz, R₁ = 150Ω)
- Wide range of power supplies:
 - $V_{CC} = \pm 4.5 \text{V to } \pm 16 \text{V}$
- Offset nulling pins on the THS4021

2 Applications

- Ultrasound scanner
- Source measurement unit (SMU)
- Power quality meter

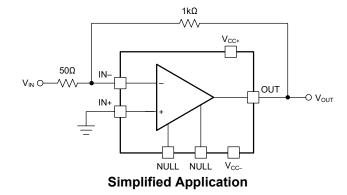
3 Description

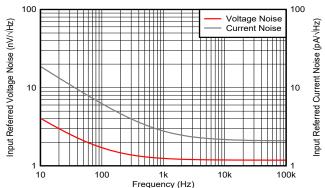
The THS4021 and THS4022 (THS402x) are ultra-low voltage noise, high-speed voltage-feedback amplifiers that are an excellent choice for applications requiring low voltage noise, including communication and imaging. The single-amplifier THS4021 and the dualamplifier THS4022 offer very good ac performance with a 290MHz closed-loop bandwidth, 470V/µs slew rate, and 30ns settling time (0.1%) for a gain of 10V/V. The THS402x are stable at gains of 10V/V or greater and -9V/V or less. These amplifiers have a high drive capability of 200mA and draw only 7.5mA of supply current per amplifier. With a total harmonic distortion (THD) of -68dBc at f = 1MHz, the THS402x are designed for applications requiring low distortion.

Device Information

PART NUMBER	AMPLIFIERS	PACKAGE ⁽¹⁾	
THS4021	One	D (SOIC, 8)	
11134021		DGN (HVSSOP, 8)	
THS4022	Two	DGN (HVSSOP, 8)	

For more information, see Section 10.





Voltage and Current Noise vs Frequency



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4 Pin Configuration and Functions

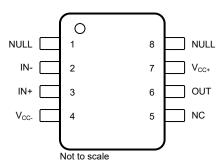


Figure 4-1. THS4021: D Package, 8-Pin SOIC, or DGN Package, 8-pin HVSSOP (Top View)

Table 4-1. Pin Functions: THS4021

PIN		TYPE	DESCRIPTION		
NAME	NO.	ITPE	DESCRIPTION		
IN-	2	Input	Inverting input		
IN+	3	Input	Noninverting input		
NC	5	_	No connection		
NULL	1, 8	Input	Voltage offset adjust		
OUT	6	Output	Output of amplifier		
V _{CC} -	4	_	Negative power supply		
V _{CC+}	7	_	Positive power supply		

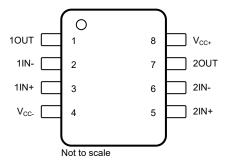


Figure 4-2. THS4022: DGN Package, 8-pin HVSSOP (Top View)

Table 4-2. Pin Functions: THS4022

	PIN	TYPE	DESCRIPTION	
NAME	NO.	ITPE	DESCRIPTION	
1IN-	2	Input	Channel 1 inverting input	
1IN+	3	Input	Channel 1 noninverting input	
10UT	1	Output	nnel 1 output	
2IN-	6	Input	el 2 inverting input	
2IN+	5	Input	Channel 2 noninverting input	
2OUT	7	Output	Channel 2 output	
V _{CC} -	4	_	Negative power supply	
V _{CC+}	8	_	Positive power supply	

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		·	MIN	MAX	UNIT
V _{CC} - to V _{CC} +	Supply voltage			33	V
VI	Input voltage			±V _{CC}	V
Io	Output current ⁽²⁾			240	mA
V _{IO}	Differential input voltage			±1.5	V
I _{IN}	Continuous input current	Continuous input current		10	mA
TJ	Maximum junction temperature	Maximum junction temperature		150	°C
_	Operating free cir temperature	C-suffix	0	70	°C
I A	Operating free-air temperature	I-suffix	-40	85	C
T _{stg}	Storage temperature		-65	150	°C
	Lead temperature 1.6 mm (1/16 inch) fr	rom case for 10 seconds		300	°C

⁽¹⁾ Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

5.2 ESD Ratings

			VALUE	UNIT
V	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/ JEDEC JS-001, all pins ⁽¹⁾	±1000	V
V _(ESD)	Electrostatic discharge	Charged device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1000	V

⁽¹⁾ JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

			MIN	NOM	MAX	UNIT
V	V _{CC} Supply voltage	Dual-supply	±4.5	±15	±16	V
V CC		Single-supply	9	30	32	v
т	Operating free air temperature	C-suffix	0	25	70	°C
'A	T _A Operating free-air temperature	I-suffix	-40	25	85	

⁽²⁾ When continuously operating at any output current, do not exceed the maximum junction temperature. Keep the output current less than the absolute maximum rating regardless of time interval.

⁽²⁾ JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.



5.4 Thermal Information - THS4021

		THS	4021	
	THERMAL METRIC ⁽¹⁾	D (SOIC)	DGN (HVSSOP)	UNIT
		8 PINS	8 PINS	
R _{0JA}	Junction-to-ambient thermal resistance	124.5	58.4	°C/W
R _{0JC(top)}	Junction-to-case (top) thermal resistance	65.0	4.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	72.2	N/A	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	13.6	N/A	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	71.4	N/A	°C/W
R _{0JC(bot)}	Junction-to-case (bottom) thermal resistance	N/A	N/A	°C/W

⁽¹⁾ For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

5.5 Thermal Information - THS4022

		THS4022	
	THERMAL METRIC ⁽¹⁾	DGN (HVSSOP)	UNIT
		8 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	52	°C/W
R _{0JC(top)}	Junction-to-case (top) thermal resistance	75.2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	24.5	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	4	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	24.5	°C/W
R _{0JC(bot)}	Junction-to-case (bottom) thermal resistance	9.1	°C/W

⁽¹⁾ For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.



5.6 Electrical Characteristics - THS4021D and THS4022DGN

at $T_A = 25$ °C, $V_{CC} = \pm 15$ V, and $R_L = 150$ Ω (unless otherwise noted)

	PARAMETER	TEST COM	NDITIONS	MIN	TYP	MAX	UNIT
DYNAI	MIC PERFORMANCE						
			V _{CC} = ±15 V		290		
	Small-signal bandwidth	Gain = 10	V _{CC} = ±5 V		250		
	(–3 dB)		V _{CC} = ±15 V		110		
		Gain = 20	V _{CC} = ±5 V		100		MHz
BW			V _{CC} = ±15 V		17		
	Bandwidth for 0.1-dB flatness	Gain = 10	V _{CC} = ±5 V		17		
	(1)	V _{O(pp)} = 20 V, V _{CC} = ±15 V			7.5		
	Full-power bandwidth ⁽¹⁾	V _{O(pp)} = 5 V, V _{CC} = ±5 V			23.6		
	(2)		V _{CC} = ±15 V, 20-V step		470		
SR	Slew rate ⁽²⁾	Gain = 10	V _{CC} = ±5 V, 5-V step		370		V/µs
			V _{CC} = ±15 V, 5-V step		30		
	Settling time to 0.1%	Gain = -10	V _{CC} = ±5 V, 2-V step		30		
t _s			V _{CC} = ±15 V, 5-V step		160		ns
	Settling time to 0.01%	Gain = -10	V _{CC} = ±5 V, 2-V step		160		
NOISE	AND DISTORTION PERFORMA	NCE					
	Total harmonic distortion	V _{O(pp)} = 2 V, f = 1 MHz, gain = 10, V _{CC} = ±15 V			-68		dBc
			R _L = 1 kΩ		-77		
THD		V _{O(pp)} = 2 V, f = 1 MHz, gain = 10, V _{CC} = ±5 V			-69		
			R _L = 1 kΩ		-78		
V _n	Input voltage noise	V _{CC} = ±5 V or ±15 V, f > 10 F	(Hz		1.2		nV/√Hz
In	Input current noise	V _{CC} = ±5 V or ±15 V, f > 10 F	(Hz		2.3		pA/√Hz
	Diff	Gain = 10, NTSC, 40 IRE	V _{CC} = ±15		0.02		0/
	Differential gain error	modulation, ±100 IRE ramp	V _{CC} = ±5 V		0.02		- %
	Differential whose sweet	Gain = 10, NTSC, 40 IRE	V _{CC} = ±15		0.08		۰
	Differential phase error	modulation, ±100 IRE ramp	V _{CC} = ±5 V		0.06		
X _T	Channel-to-channel crosstalk (THS4022 only)	V _{CC} = ±5 V or ±15 V, f = 1 M	Hz		-54		dBc
DC PE	RFORMANCE						
		$V_{CC} = \pm 15 \text{ V}, V_{O} = \pm 10 \text{ V},$	T _A = 25°C	92	100		
		$R_L = 1 k\Omega$	T _A = full range	91			
	Open-loop gain	V _{CC} = ±5 V, V _O = ±2.5 V,	T _A = 25°C	86	98		dB
		$R_L = 1 k\Omega$	T _A = full range	84			
		V .5V .45V	T _A = 25°C		0.3	2	.,
V _{OS}	Input offset voltage	$V_{CC} = \pm 5 \text{ V or } \pm 15 \text{ V}$	T _A = full range			3	mV
	Offset voltage drift	$V_{CC} = \pm 5 \text{ V or } \pm 15 \text{ V, } T_A = \text{fu}$	ll range		2		μV/°C
	Innut hina august	V = 15 V av : 45 V	T _A = 25°C		9	20	μA
I _{IB}	Input bias current	$V_{CC} = \pm 5 \text{ V or } \pm 15 \text{ V}$	T _A = full range			33	μA
	land offer at a comment	V = 15 V av : 45 V	T _A = 25°C		30	250	nA
los	Input offset current	$V_{CC} = \pm 5 \text{ V or } \pm 15 \text{ V}$	T _A = full range			400	nA
	Input offset current drift	V _{CC} = ±5 V or ±15 V, T _A = fu	ll range		0.2		nA/°C

5.6 Electrical Characteristics - THS4021D and THS4022DGN (continued)

at $T_A = 25$ °C, $V_{CC} = \pm 15$ V, and $R_L = 150$ Ω (unless otherwise noted)

	PARAMETER	TEST CO	NDITIONS	MIN	TYP	MAX	UNIT
INPUT (CHARACTERISTICS						
\ /	Common model in much well-	V _{CC} = ±15 V		±13.8	±14.3		V
V_{ICR}	Common-mode input voltage	V _{CC} = ±5 V		±3.8	±4.3		V
		V _{CC} = ±15 V, V _{ICR} = ±12 V	T _A = 25 °C		95		
CMRR	Common-mode rejection ratio	V _{CC} - ±15 V, V _{ICR} - ±12 V	T _A = full range	74			dB
CIVIKK	Common-mode rejection ratio	V _{CC} = ±5 V, V _{ICR} = ±2.5 V	T _A = 25 °C		100		uБ
		VCC - 13 V, VICR - 12.3 V	T _A = full range	85			
r _i	Input resistance				1		ΜΩ
Ci	Input capacitance				1.5		pF
OUTPU	T CHARACTERISTICS						
V _O Outp	Output voltage swing	$V_{CC} = \pm 15 \text{ V}, R_L = 250 \Omega$		±12	±12.9		V
		$V_{CC} = \pm 5 \text{ V}, R_L = 150 \Omega$		±3	±3.5		
		$V_{CC} = \pm 15 \text{ V}, R_L = 1 \text{ k}\Omega$		±13	±13.6		
		$V_{CC} = \pm 5 \text{ V}, R_L = 1 \text{ k}\Omega$		±3.4	±3.8		
I _O	Output current	V_{CC} = ±15 V, R_{L} = 10 Ω		80	200		mA
10	Output current	V_{CC} = ±5 V, R_L = 10 Ω		50	160		ША
R_0	Output resistance ⁽³⁾	Open-loop			5		Ω
POWER	SUPPLY						
V _{CC}	Supply voltage	Dual supply		±4.5		±16.5	V
v CC	Supply voltage	Single supply		9		33	V
		V _{CC} = ±15 V	T _A = 25°C		7.5	10	
L	Supply current (per amplifier)	VCC - 113 V	T _A = full range			11	mA
I _{CC}	Supply current (per ampliner)	V = +5 V	T _A = 25°C		6.5	9	ША
		$V_{CC} = \pm 5 \text{ V}$	T _A = full range			10.5	
PSRR	Power-supply rejection ratio	V _{CC} = ±5 V or ±15 V	T _A = 25 °C		95		dB
I SIXIX	i ower-supply rejection ratio	ACC - 72 A OL 7.12 A	T _A = full range	80			uБ

 ⁽¹⁾ Full-power bandwidth = slew rate / [π V_{O(P-P)}].
 (2) Slew rate is measured from an output level range of 25% to 75%.

⁽³⁾ Keep junction temperature less than the absolute maximum rating when the output is heavily loaded or shorted; see also Section 5.1.



5.7 Electrical Characteristics - THS4021DGN

at $T_A = 25$ °C, $V_{CC} = \pm 15$ V, $R_L = 150$ Ω (unless otherwise noted)

	PARAMETER	TEST CONE	DITIONS	MIN	TYP	MAX	UNIT	
DYNAI	MIC PERFORMANCE							
		0 : 40	V _{CC} = ±15 V		350			
	Small-signal bandwidth	Gain = 10	V _{CC} = ±5 V		280			
	(-3 dB)	Outro 00	V _{CC} = ±15 V	,	80			
DIA		Gain = 20	V _{CC} = ±5 V	,	70			
BW	Donato idda for O.A. ID floto	Outro 40	V _{CC} = ±15 V		17		MHz	
	Bandwidth for 0.1-dB flatness	Gain = 10	V _{CC} = ±5 V		17			
	F. II	$V_{O(pp)} = 20 \text{ V}, V_{CC} = \pm 15 \text{ V}$			3.7			
	Full-power bandwidth ⁽¹⁾	V _{O(pp)} = 5 V, V _{CC} = ±5 V			11.8			
SR	Slew rate ⁽²⁾	Gain = 10	V _{CC} = ±15 V, 10-V step		470		V/µs	
			V _{CC} = ±5 V, 5-V step		370			
	Cattling times to 0.40/	Onin - 40	V _{CC} = ±15 V, 5-V step		40			
	Settling time to 0.1%	Gain = -10	V _{CC} = ±5 V, 2-V step		50			
t _s	0 - 411 41 4 - 0 040/	Only 40	V _{CC} = ±15 V, 5-V step		145		ns ns	
	Settling time to 0.01%	Gain = -10	V _{CC} = ±5 V, 2-V step		150			
NOISE	/DISTORTION PERFORMANCE	1				'		
	Total harmonic distortion	V _{O(pp)} = 2 V, f = 1 MHz,			-68			
THD		gain = 2, V _{CC} = ±15 V	R _L = 1 kΩ		-77		4D-	
		V _{O(pp)} = 2 V, f = 1 MHz,			-69		- dBc	
		gain = 2, V _{CC} = ±5 V	$R_L = 1 k\Omega$		-78			
V _n	Input voltage noise	V _{CC} = ±5 V or ±15 V, f > 10 kH	·lz		1.5		nV/√Hz	
In	Input current noise	V _{CC} = ±5 V or ±15 V, f > 10 kH	·lz		2		pA/√Hz	
	Differential gain error	Gain = 2, NTSC, 40 IRE	V _{CC} = ±15		0.02		%	
	Differential gain error	modulation, ±100 IRE ramp	V _{CC} = ±5 V		0.02		70	
	Differential phase error	Gain = 2, NTSC, 40 IRE	V _{CC} = ±15		0.08		0	
	Differential phase error	modulation, ±100 IRE ramp	V _{CC} = ±5 V		0.06			
DC PE	RFORMANCE							
		$V_{CC} = \pm 15 \text{ V}, V_{O} = \pm 10 \text{ V},$	T _A = 25°C	40	60			
	Onen leen gein	$R_L = 1 k\Omega$	T _A = full range	35			V/mV	
	Open-loop gain	V _{CC} = ±5 V, V _O = ±2.5 V,	T _A = 25°C	20	35		V/IIIV	
		$R_L = 250 \Omega$	T _A = full range	15				
.,	Input offset voltage	V _{CC} = ±5 V or ±15 V	T _A = 25°C		0.5	2		
Vos	input onset voltage	ACC - ±2 A OL ±12 A	T _A = full range			3	mV	
	Offset voltage drift V _{CC} = ±5 V or ±15 V		T _A = full range		15		μV/°C	
	Input bias current	V _{CC} = ±5 V or ±15 V	T _A = 25°C		3	6	,	
I _{IB}	input bias current	ACC - IS A OL I 12 A	T _A = full range	,		6	μA	
ı	Input offset ourrent	\\ - +5\\ or +45\\	T _A = 25°C		30	250	r 1	
los	Input offset current	$V_{CC} = \pm 5 \text{ V or } \pm 15 \text{ V}$	T _A = full range			400	nA	
	Input offset current drift	T _A = full range	'		0.3		nA/°C	

5.7 Electrical Characteristics - THS4021DGN (continued)

at $T_A = 25^{\circ}C$, $V_{CC} = \pm 15 \text{ V}$, $R_L = 150 \Omega$ (unless otherwise noted)

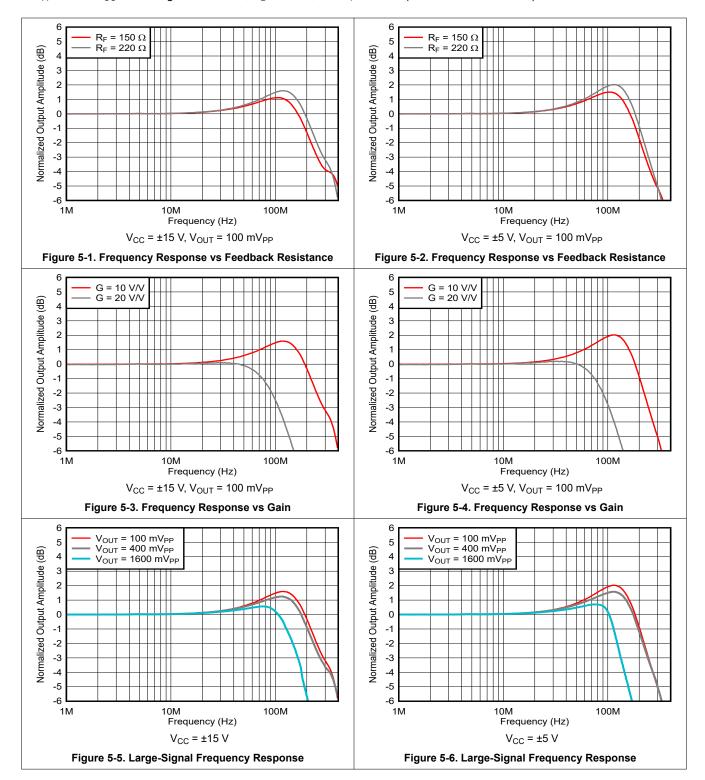
	PARAMETER	TEST	MIN	TYP	MAX	UNIT		
INPUT (CHARACTERISTICS							
V		V _{CC} = ±15 V		±13.8	±14.3		V	
V_{ICR}	Common-mode input voltage	V _{CC} = ±5 V		±3.8	±4.3		V	
CMRR	Common-mode rejection ratio	$V_{CC} = \pm 15 \text{ V}, V_{ICR} = \pm 12$	2 V, T _A = full range	74	95		dB	
r _i	Input resistance				1		ΜΩ	
Ci	Input capacitance				1.5		pF	
OUTPU	T CHARACTERISTICS	1						
.,		$V_{CC} = \pm 15 \text{ V}, R_L = 250 \text{ G}$	Ω	±12	±12.5			
	Output voltage swing	V_{CC} = ±5 V, R_L = 150 Ω	±3	±3.3		V		
V _O		V _{CC} = ±15 V, R _L = 150 C	±13	±13.5				
		V_{CC} = ±5 V, R_L = 150 Ω		±3.4	±3.8			
	Output current	D = 20 O	V _{CC} = ±15 V	80	100		mA	
I _O		R _L = 20 Ω	$V_{CC} = \pm 5 \text{ V}$	50	75			
I _{SC}	Short-circuit current ⁽³⁾	V _{CC} = ±15 V			150		mA	
R _O	Output resistance ⁽³⁾	Open loop			13		Ω	
POWER	SUPPLY							
V	Completed	Dual supply	±4.5		±16.5			
V_{CC}	Supply voltage	Single supply	9		33	V		
		\/ - \45\/	T _A = 25°C		7.8	10		
	Cumply ourrent (nor amplifier)	V _{CC} = ±15 V	T _A = full range			11	1 9 mA	
I _{CC}	Supply current (per amplifier)	V - 15 V	T _A = 25°C		6.7	9		
		$V_{CC} = \pm 5 \text{ V}$	T _A = full range			10.5		
PSRR	Power-supply rejection ratio	V_{CC} = ±5 V or ±15 V, T_A	= full range	80	95		dB	

 $[\]begin{array}{ll} \hbox{(1)} & \hbox{Full-power bandwidth = slew rate / } 2\pi \ V_{O(Peak)}. \\ \hbox{(2)} & \hbox{Slew rate is measured from an output level range of 25\% to 75\%}. \end{array}$

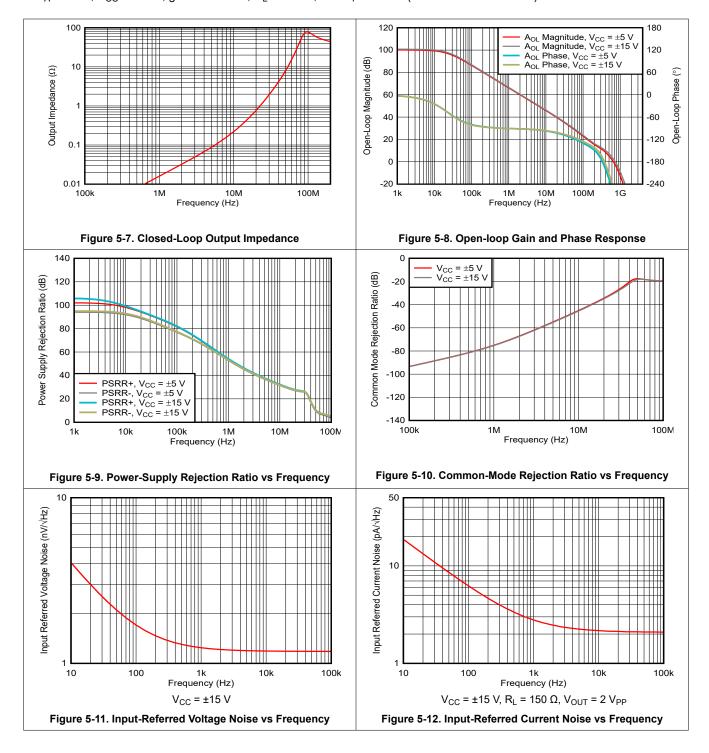
⁽³⁾ Keep junction temperature less than the absolute maximum rating when the output is heavily loaded or shorted; see also Section 5.1.



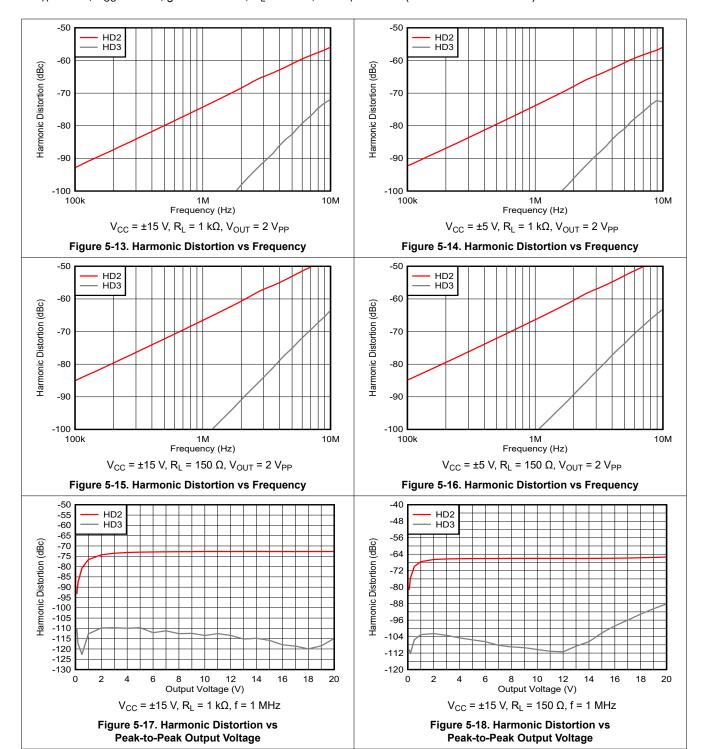
5.8 Typical Characteristics: THS4021D and THS4022DGN

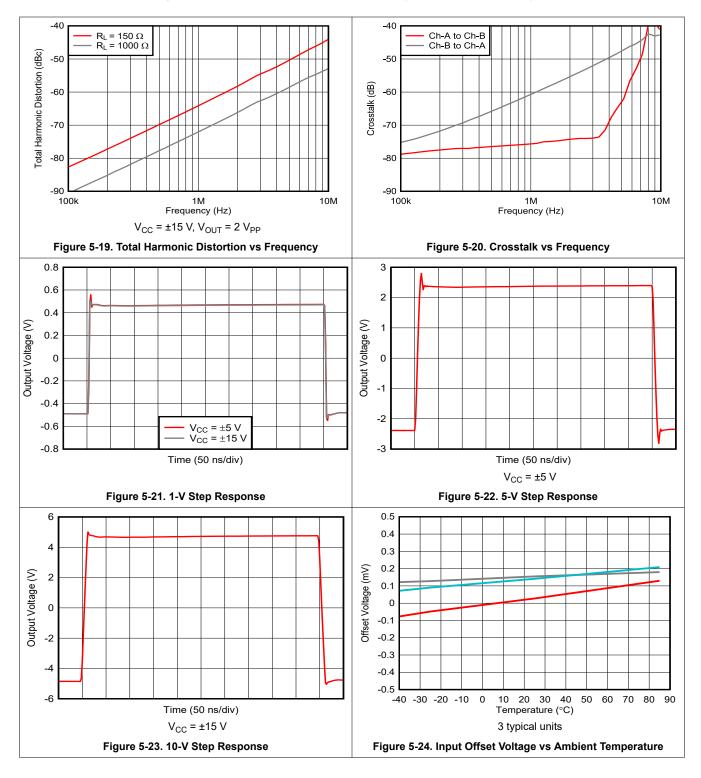




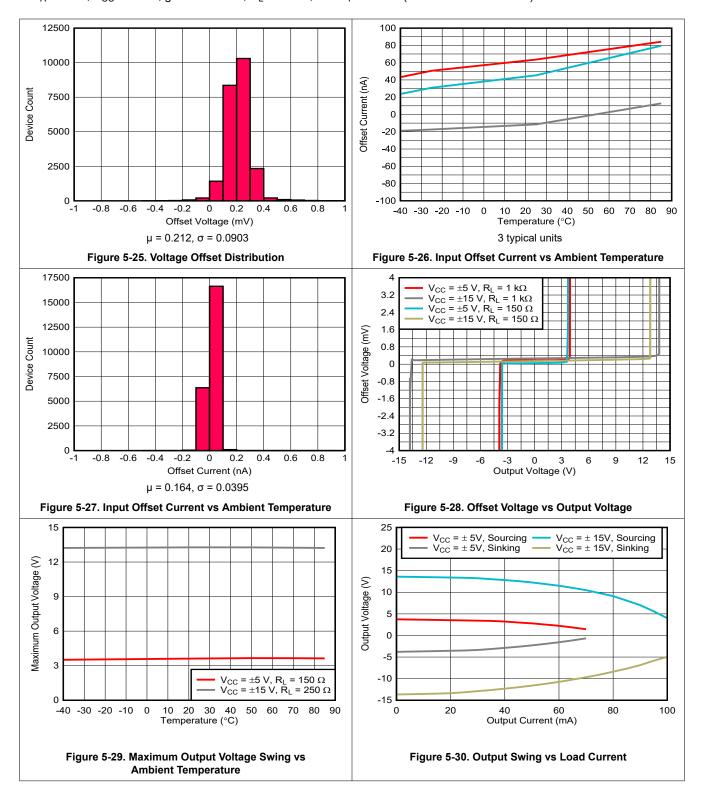




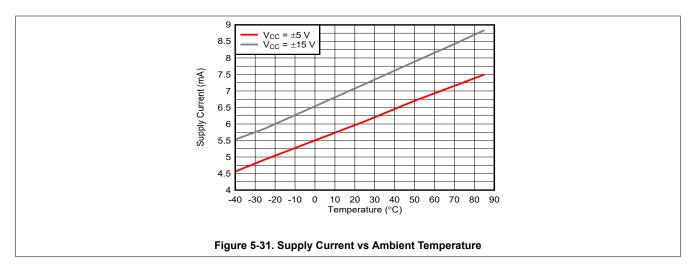






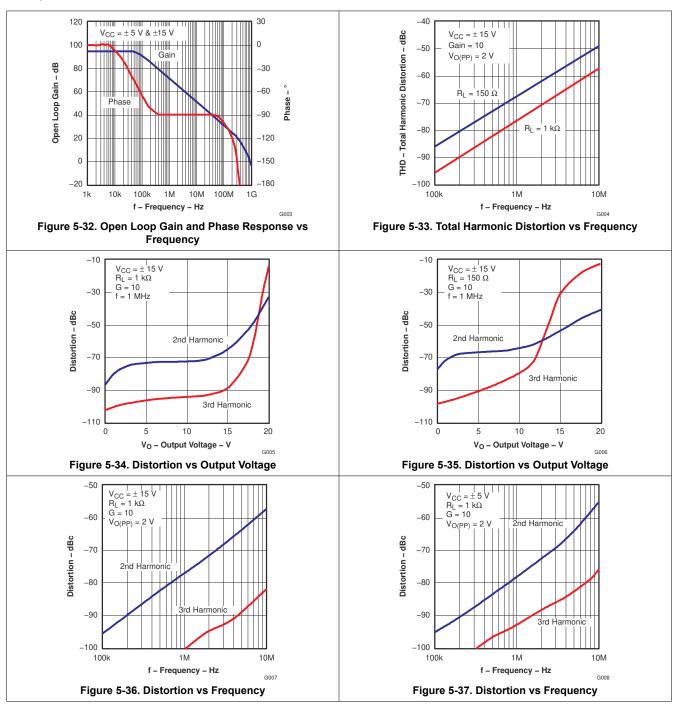




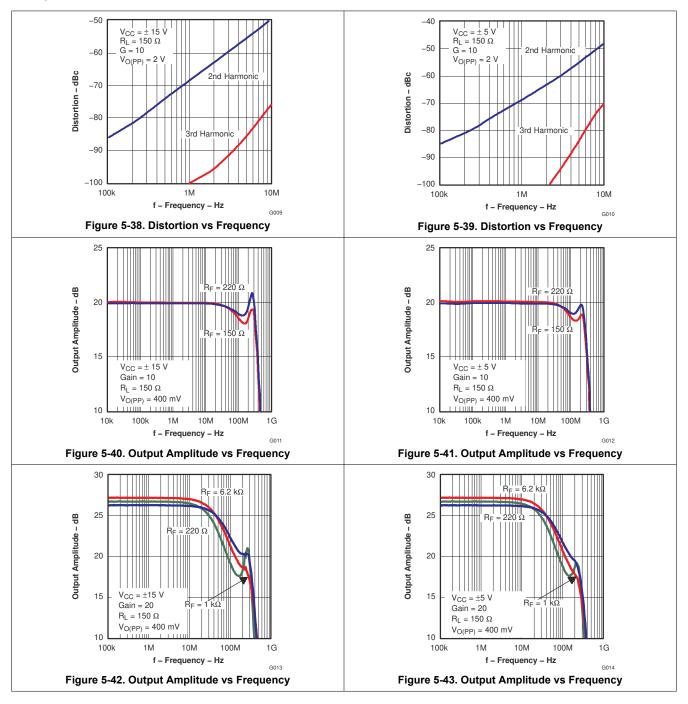




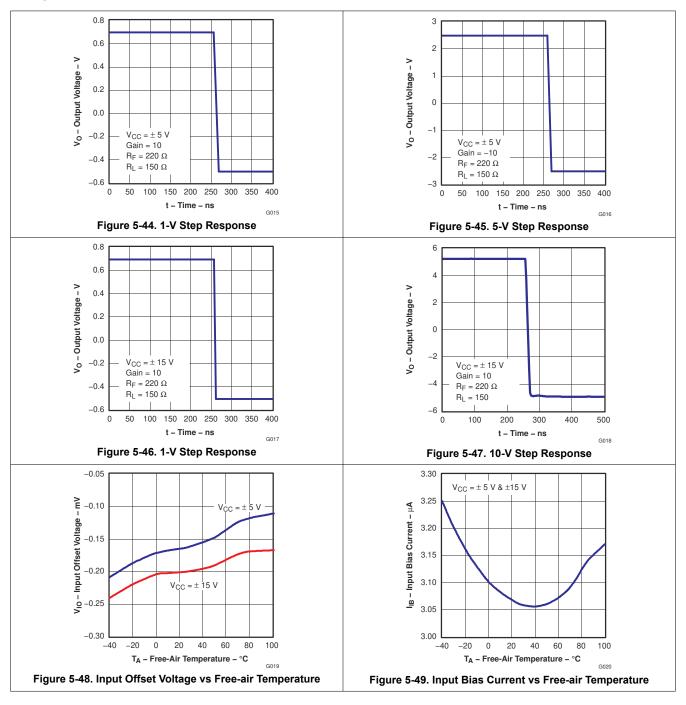
5.9 Typical Characteristics: THS4021DGN



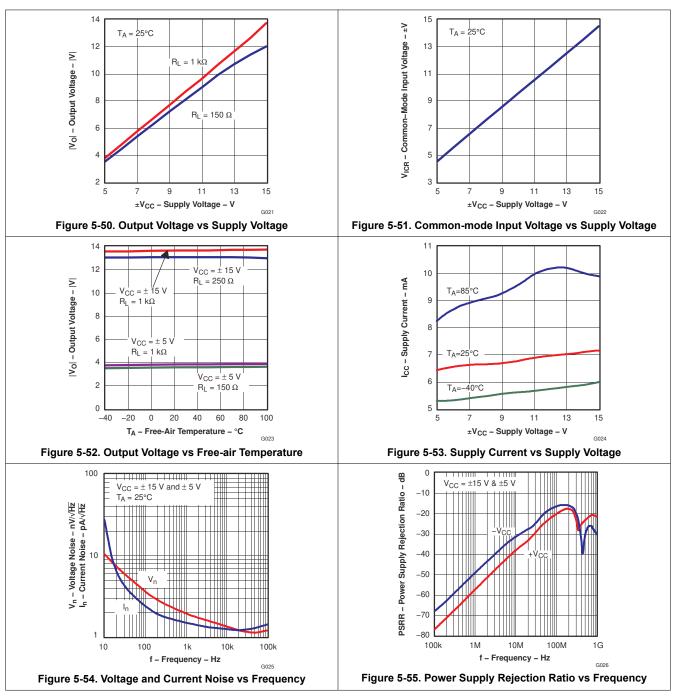




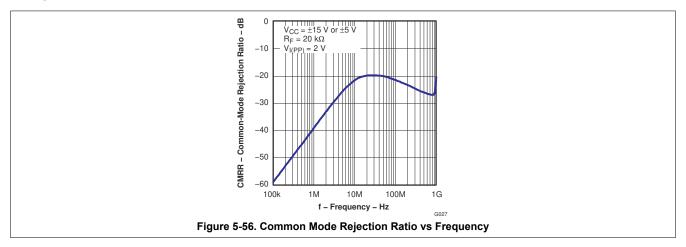












6 Detailed Description

6.1 Overview

The THS402x are high-speed operational amplifiers configured in a decompensated voltage-feedback architecture. The THS402x are stable with gain configurations of 10 V/V or greater. These amplifiers is built using a greater than 30-V, complementary, bipolar process with NPN and PNP transistors possessing an f_T of several GHz. This configuration results in exceptionally high-performance amplifiers with wide bandwidth, high slew rate, fast settling time, and low distortion.

6.2 Functional Block Diagram

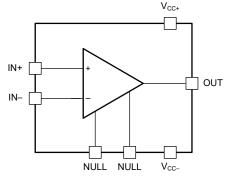


Figure 6-1. THS4021: Single Channel

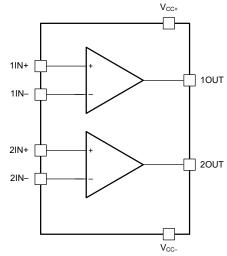


Figure 6-2. THS4022: Dual Channel

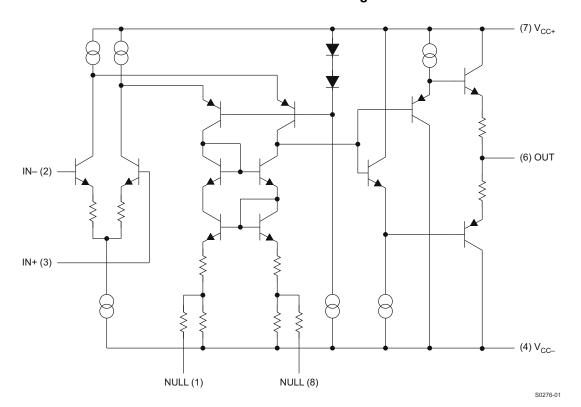


Figure 6-3. THS4021 Simplified Schematic

6.3 Feature Description

6.3.1 Offset Nulling

The THS402x have a very low input offset voltage for high-speed amplifiers. However, if additional correction is required, an offset nulling function has been provided on the THS4021. To adjust the input offset voltage, place a potentiometer between pin 1 and pin 8 of the device, and tie the wiper to the negative supply. Figure 6-4 shows this feature.

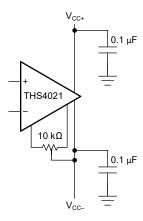


Figure 6-4. Offset Nulling Schematic

6.4 Device Functional Modes

The THS402x family has a single functional mode and can be used with both single-supply or split power-supply configurations. The power-supply voltage must be greater than $9 \text{ V} (\pm 4.5 \text{ V})$ and less than $33 \text{ V} (\pm 16.5 \text{ V})$.

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7 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

7.1 Application Information

7.1.1 Driving a Capacitive Load

The THS402x are internally compensated to maximize bandwidth and slew-rate performance. To maintain stability, take additional precautions when driving capacitive loads with a high-performance amplifier. As a result of the internal compensation, significant capacitive loading directly on the output node decreases the device phase margin, and potentially lead to high-frequency ringing or oscillations. Therefore, for capacitive loads greater than 10 pF, place an isolation resistor in series with the output of the amplifier. Figure 7-1 shows this configuration. For most applications, a minimum resistance of 20 Ω is recommended. In 75- Ω transmission systems, setting the series resistor value to 75 Ω is a beneficial choice because this value isolates any capacitance loading and provides source impedance matching.

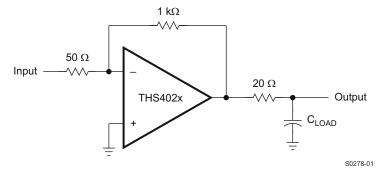


Figure 7-1. Driving a Capacitive Load

7.1.2 General Configuration

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. Figure 7-2 shows how the simplest way to accomplish this limiting is to place an RC filter at the noninverting pin of the amplifier.

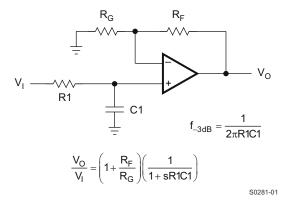


Figure 7-2. Single-Pole Low-Pass Filter

7.2 Power Supply Recommendations

The THS402x devices are designed to operate on power supplies ranging from ± 4.5 V to ± 16 V (single-ended supplies of 9 V to 32 V). Use a power-supply accuracy of 5% or better. When operated on a board with high-speed digital signals, make sure to provide isolation between digital signal noise and the analog input pins. The THS4021 and THS4022 are connected to the positive power supply (V_{CC-}) through pin 7 and pin 8, respectively. Both devices use pin 4 for the negative power supply (V_{CC-}). Decouple each supply pin to GND as close to the device as possible.

7.3 Layout

7.3.1 Layout Guidelines

To achieve the levels of high-frequency performance of the THS402x, follow proper printed-circuit board (PCB), high-frequency design techniques. The following is a general set of guidelines. In addition, a THS402x evaluation board is available to use as a guide for layout or for evaluating the device performance.

- **Ground planes**—make sure that the ground plane used on the board provides all components with a low-inductive ground connection. However, in the areas of the amplifier inputs and output, the ground plane can be removed to minimize stray capacitance.
- **Proper power-supply decoupling**—use a 6.8-µF tantalum capacitor in parallel with a 0.1-µF ceramic capacitor on each supply pin. Sharing the tantalum capacitor among several amplifiers is possible depending on the application, but always use a 0.1-µF ceramic capacitor on the supply pin of every amplifier. In addition, place the 0.1-µF capacitor as close as possible to the supply pin. As this distance increases, the inductance in the connecting trace makes the capacitor less effective. Strive for distances of less than 0.1 inch (2.54 mm) between the device power pins and the ceramic capacitors.
- Short trace runs or compact part placements—optimum high-frequency performance is achieved when
 stray series inductance has been minimized. To realize this, make the circuit layout as compact as possible,
 thereby minimizing the length of all trace runs. Pay particular attention to the inputs of the amplifier, keeping
 the trace lengths as short as possible. This layout helps to minimize stray capacitance at the input of the
 amplifier.

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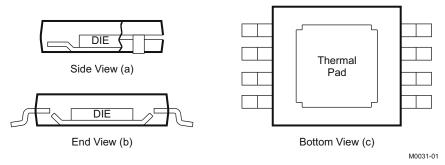
7.3.1.1 General PowerPAD™ Integrated Circuit Package Design Considerations

The THS402x is available in a thermally-enhanced DGN package, which is a member of the PowerPAD™ integrated circuit package family. Figure 7-3 **a** and Figure 7-3 **b** show that this package is constructed using a downset leadframe upon which the die is mounted. Figure 7-3 **c** that this arrangement results in the leadframe being exposed as a thermal pad on the underside of the package. Because this thermal pad has direct thermal contact with the die, excellent thermal performance can be achieved by providing a good thermal path away from the thermal pad.

The PowerPAD integrated circuit package allows for both assembly and thermal management in one manufacturing operation. During the surface-mount solder operation (when the leads are being soldered), the thermal pad can also be soldered to a copper area underneath the package. Through the use of thermal paths within this copper area, heat can be conducted away from the package into either a ground plane or other heat dissipating device.

The PowerPAD integrated circuit package represents a breakthrough in combining the small area and ease of assembly of the surface mount with the previously awkward mechanical methods of heat sinking.

More complete details of the PowerPAD installation process and thermal management techniques are found in *PowerPAD Thermally-Enhanced Package*. This document is found on the TI website (www.ti.com) by searching on the keyword PowerPAD. The document can also be ordered through your local TI sales office; refer to SLMA002 when ordering.



NOTE: The thermal pad (PowerPAD integrated circuit package) is electrically isolated from all other pins and can be connected to any potential from V_{CC-} to V_{CC+} . Typically, the thermal pad is connected to the ground plane because this plane tends to physically be the largest and is able to dissipate the most amount of heat.

Figure 7-3. Views of Thermally-enhanced DGN Package



7.3.2 Layout Example

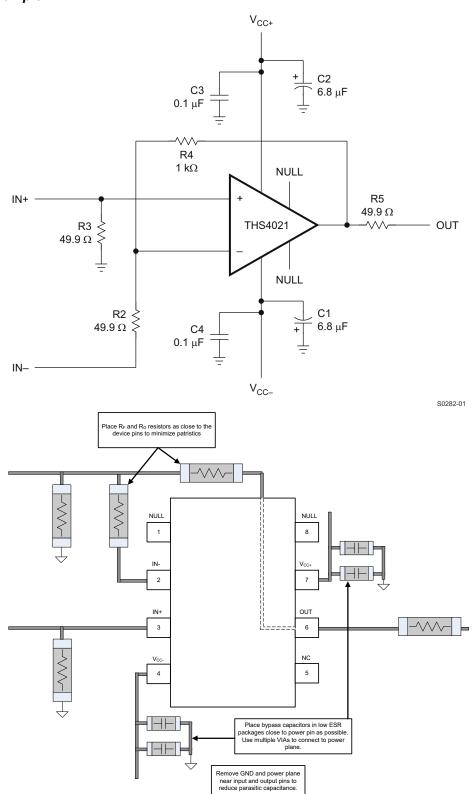


Figure 7-4. Layout Recommendations



8 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

8.1 Documentation Support

8.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, Noise Analysis in Operational Amplifier Circuits application report
- Texas Instruments, PowerPAD Thermally Enhanced Package application report
- Texas Instruments, THS4021 High-Speed Operational Amplifier Evaluation Module user's guide
- Texas Instruments, THS4022 Dual High-Speed Operational Amplifier Evaluation Module user's guide

8.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.3 Support Resources

TI E2E[™] support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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8.4 Trademarks

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8.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.6 Glossary

TI Glossary

This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision E (March 2024) to Revision F (July 2024) • Deleted Total harmonic distortion + noise and Intermodulation distortion specifications from Electrical Characteristics: THS4021D and THS4022DGN

Changes from Revision D (May 2023) to Revision E (March 2024)Page• Deleted THS4022 D package from the document1• Updated Simplified Application figure to show correct pin names1• Updated closed-loop bandwidth and supply current in Description1• Updated Thermal Information: THS40225



•	Changed title of Electrical Characteristics: THS4021 (D Package) to Electrical Characteristics: THS4021D and THS4022DGN	. 6
•	Changed Channel-to-channel crosstalk from –60 dB to –54 dB in <i>Electrical Characteristics THS4021D and THS4022DGN</i> B	. 6
•	Changed title of Electrical Characteristics: THS4021 (DGN Package) and THS4022 (D and DGN Packages, to Electrical Characteristics: THS4021DGN	
•	Changed title of <i>Typical Characteristics: THS4021 (D Package)</i> to <i>Typical Characteristics: THS4021D and THS4022DGN</i>	10
•	Changed V _{CC} from ±5 V to ±15 V in <i>Typical Characteristics: THS4021D and THS4022DGN</i> Updated <i>Power-Supply Rejection Ratio vs Frequency</i> figure legend in <i>Typical Characteristics: THS4021D a THS4022DGN</i>	nd
•	Changed title of <i>Typical Characteristics:THS4021 (DGN Package) and THS4022 (D and DGN Packages)</i> to Typical Characteristics:THS4021DGN	16 N
		16

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material	MSL rating/ Peak reflow	Op temp (°C)	Part marking (6)
THS4021CD	Obsolete	Production	SOIC (D) 8	-	=	Call TI	Call TI	0 to 70	4021C
THS4021CDGN	Active	Production	HVSSOP (DGN) 8	80 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	ACK
THS4021CDGN.A	Active	Production	HVSSOP (DGN) 8	80 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	ACK
THS4021CDGNR	Active	Production	HVSSOP (DGN) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	ACK
THS4021CDGNR.A	Active	Production	HVSSOP (DGN) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	ACK
THS4021ID	Obsolete	Production	SOIC (D) 8	-	-	Call TI	Call TI	-40 to 85	40211
THS4021IDGN	Active	Production	HVSSOP (DGN) 8	80 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	ACL
THS4021IDGN.A	Active	Production	HVSSOP (DGN) 8	80 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	ACL
THS4021IDGNR	Active	Production	HVSSOP (DGN) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	ACL
THS4021IDGNR.A	Active	Production	HVSSOP (DGN) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	ACL
THS4021IDR	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	40211
THS4021IDR.B	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	40211
THS4022CD	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	4022C
THS4022CD.A	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	4022C
THS4022ID	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	40221
THS4022ID.A	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	40221
THS4022IDGNR	Active	Production	HVSSOP (DGN) 8	2500 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ACB
THS4022IDGNR.B	Active	Production	HVSSOP (DGN) 8	2500 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ACB

⁽¹⁾ Status: For more details on status, see our product life cycle.

⁽²⁾ Material type: When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ RoHS values: Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

⁽⁴⁾ Lead finish/Ball material: Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.



PACKAGE OPTION ADDENDUM

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(5) MSL rating/Peak reflow: The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) Part marking: There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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PACKAGE MATERIALS INFORMATION

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TAPE AND REEL INFORMATION





A0	Dimension designed to accommodate the component width
В0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing		SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
THS4021CDGNR	HVSSOP	DGN	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
THS4021IDGNR	HVSSOP	DGN	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
THS4021IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
THS4022IDGNR	HVSSOP	DGN	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

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*All dimensions are nominal

7 till dillitoriolorio di o riorriiridi							
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
THS4021CDGNR	HVSSOP	DGN	8	2500	358.0	335.0	35.0
THS4021IDGNR	HVSSOP	DGN	8	2500	358.0	335.0	35.0
THS4021IDR	SOIC	D	8	2500	353.0	353.0	32.0
THS4022IDGNR	HVSSOP	DGN	8	2500	353.0	353.0	32.0

PACKAGE MATERIALS INFORMATION

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TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
THS4022CD	D	SOIC	8	75	505.46	6.76	3810	4
THS4022CD.A	D	SOIC	8	75	505.46	6.76	3810	4
THS4022ID	D	SOIC	8	75	505.46	6.76	3810	4
THS4022ID.A	D	SOIC	8	75	505.46	6.76	3810	4



SMALL OUTLINE INTEGRATED CIRCUIT



NOTES:

- 1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
- 2. This drawing is subject to change without notice.
- 3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
- 4. This dimension does not include interlead flash.
- 5. Reference JEDEC registration MS-012, variation AA.



SMALL OUTLINE INTEGRATED CIRCUIT



NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SMALL OUTLINE INTEGRATED CIRCUIT



NOTES: (continued)

- 8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
- 9. Board assembly site may have different recommendations for stencil design.



3 x 3, 0.65 mm pitch

SMALL OUTLINE PACKAGE

This image is a representation of the package family, actual package may vary. Refer to the product data sheet for package details.



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$\textbf{PowerPAD}^{^{\text{\tiny{TM}}}}\,\textbf{VSSOP - 1.1 mm max height}$

SMALL OUTLINE PACKAGE



NOTES:

PowerPAD is a trademark of Texas Instruments.

- 1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.

 2. This drawing is subject to change without notice.

 3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not
- exceed 0.15 mm per side.
- 4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
- 5. Reference JEDEC registration MO-187.



SMALL OUTLINE PACKAGE



NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
- 8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
- 9. Size of metal pad may vary due to creepage requirement.



SMALL OUTLINE PACKAGE



NOTES: (continued)

- 10. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
- 11. Board assembly site may have different recommendations for stencil design.



PowerPAD[™] VSSOP - 1.1 mm max height

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 2. This drawing is subject to change without notice.

 3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not
- exceed 0.15 mm per side.
- 4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
- 5. Reference JEDEC registration MO-187.
- 6. Features may differ or may not be present.



SMALL OUTLINE PACKAGE



NOTES: (continued)

- 7. Publication IPC-7351 may have alternate designs.
- 8. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
- 9. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
- 10. Size of metal pad may vary due to creepage requirement.



SMALL OUTLINE PACKAGE



NOTES: (continued)

- 11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
- 12. Board assembly site may have different recommendations for stencil design.



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