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MCP33131D/21D/11D-10

1 Msps 16/14/12-Bit Differential Input SAR ADC

Features

- Sample Rate (Throughput): 1 Msps
- 16/14/12-Bit Resolution with No Missing Codes
- No Latency Output
- Wide Operating Voltage Range:
  - Analog Supply Voltage (AV_{DD}): 1.8V
  - Digital Input/Output Interface Voltage (DV_{IO}): 1.7V - 5.5V
  - External Reference (V_{REF}): 2.5V - 5.1V
- Differential Input Operation
  - Input Full-Scale Range: $-V_{REF}$ to $+V_{REF}$
- Ultra Low Current:
  - Standby Mode (typical): ~ 0.8 µA
  - Conversion Mode (typical): ~1.6 mA
- SPI-Compatible Serial Communication:
  - SCLK Clock Rate: up to 100 MHz
- ADC Self-Calibration for Offset, Gain, and Linearity Errors:
  - During Power-Up (automatic)
  - On-Demand via user's command during normal operation
- Temperature Range: -40°C to +85°C
- Package Options: MSOP-10 and TDFN-10

Typical Applications

- High-Precision Data Acquisition
- Medical Instruments
- Industrial and Consumer Data Acquisition Systems
- Motor Control Applications
- Switch-Mode Power Supply Applications
- Battery-Powered Equipment

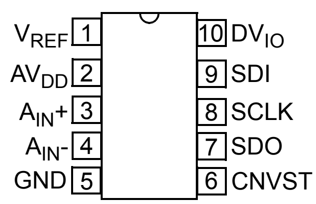
System Design Supports

The MCP331x1D Evaluation Kit demonstrates the performance of the MCP331x1D SAR ADC family devices. The evaluation kit includes: (a) MCP331x1D Evaluation Board, (b) PIC32MZ EF Curiosity Board for data collection, and (c) SAR ADC Utility PC GUI.

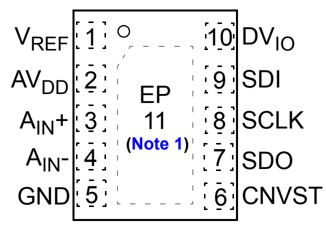
Contact Microchip Technology Inc. for the evaluation tools and the PIC32 MCU firmware example codes.

Package Types

MSOP-10



TDFN-10 (Note 2)



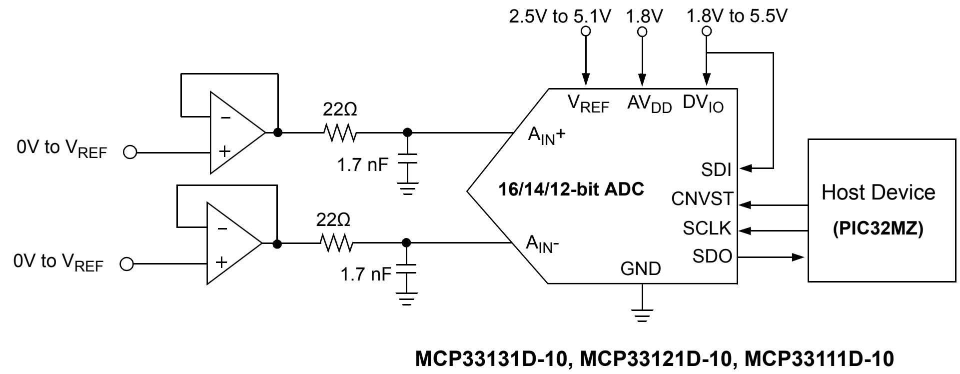
Note 1: Exposed to air.
2: Contact Microchip Technology Inc. for availability.

Device Offering (Note 1):

Part Number	Resolution	Sample Rate	Input Type	Input Range (Differential)	Performance (Typical)				
					SNR	SFDR	THD	INL	DNL
MCP33131D-10	16-bit	1 Msps	Differential	±5.1V	91.3 dBFS	103.5 dB	-99.3 dB	±2 LSB	±0.8 LSB
MCP33121D-10	14-bit	1 Msps	Differential	±5.1V	85.1 dBFS	103.5 dB	-99.2 dB	±0.5 LSB	±0.25 LSB
MCP33111D-10	12-bit	1 Msps	Differential	±5.1V	73.9 dBFS	99.3 dB	-96.7 dB	±0.12 LSB	±0.06 LSB

Note 1: SNR, SFDR, and THD are measured with f_{IN} = 10 kHz, V_{IN} = -1 dBFS, V_{REF} = 5V.

Application Diagram



Description

The MCP331x1D-10 are fully-differential 16, 14, and 12-bit, 1 Msps single-channel ADC family devices, featuring low power consumption and high performance, using a successive approximation register (SAR) architecture.

The device operates with a 2.5V to 5.1V external reference (V_{REF}), which supports a wide range of input full-scale range from -V_{REF} to +V_{REF}. The reference voltage setting is independent of the analog supply voltage (AV_{DD}) and is higher than AV_{DD}. The conversion output is available through an easy-to-use simple SPI- compatible 3-wire interface.

The device requires a 1.8V analog supply voltage (AV_{DD}) and a 1.7V to 5.5V digital I/O interface supply voltage (DV_{IO}). The wide digital I/O interface supply (DV_{IO}) range (1.7V - 5.5V) allows the device to interface with most host devices (Master) available in the current industry such as the PIC32 microcontrollers, without using external voltage level shifters.

When the device is first powered-up, it performs a self-calibration to minimize offset, gain and linearity errors. The device performance stays very stable across all temperature ranges without any noticeable degradation. However, when changes in the operating environment, such as temperature or reference voltage, are made with respect to the initial conditions, or the reference voltage was not fully settled during the initial power-up sequence, the user may send a recalibrate command anytime to initiate another self-calibration to maintain optimum performance.

When the initial power-up sequence is completed, the device enters a low-current input acquisition mode, where sampling capacitors are connected to the input pins. This mode is called Standby.

During Standby, most of the internal analog circuitry is shutdown in order to reduce current consumption. Typically, the device consumes less than 1 µA during Standby.

A new conversion is started on the rising edge of CNVST. When the conversion is complete and the host lowers CNVST, the output data is presented on SDO, and the device enters Standby to begin acquiring the next input sample. The user can clock out the ADC output data using the SPI-compatible serial clock during Standby.

The ADC system clock is generated by the internal on-chip clock, therefore the conversion is performed independent of the SPI serial clock (SCLK).

This device can be used for various high-speed and high-accuracy analog-to-digital data conversion applications, where design simplicity, low power, and no output latency are needed.

The device is available in a Pb-free small MSOP-10 and TDFN-10 packages. The device operates over the commercial temperature range of -40°C to +85°C.

1.0 KEY ELECTRICAL CHARACTERISTICS

1.1 Absolute Maximum Ratings†

External Analog Supply Voltage (AV_{DD})............ -0.3V to 2.0V
External Digital Supply Voltage (DV_{IO}).............. -0.3V to 5.8V
External Reference Voltage (V_{REF}).................... -0.3V to 5.8V
Analog inputs w.r.t GND .... –0.3V to V_{REF}+0.3V
Current at Input Pins ....±2 mA
Current at Output and Supply Pins ....±250 mA
Storage Temperature ....-65°C to +150°C
Maximum Junction Temperature (T_J). ....+150°C
ESD protection on all pins ....≤ 2 kV HBM, ≤ 200V MM

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

1.2 Electrical Specifications

TABLE 1-1: KEY ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all parameters apply for T_A = -40°C to +85°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS sine wave, f_{IN} = 10 kHz, SPI Clock Input (SCLK) = 60 MHz, Sample Rate (f_S) = 1 Msps.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Power Supply Requirements						
Analog Supply Voltage Range	AV_{DD}	1.7	1.8	1.9	V	**(Note 3)**
Digital Input/Output Interface Voltage Range	DV_{IO}	1.7	—	5.5	V	**(Note 3)**
Analog Supply Current at AV_{DD} pin: During Conversion During Standby	 I_{DDAN} I_{DDAN_STBY}	 — —	 1.6 0.8	 2.4 —	 mA µA	 f_s = 1 Msps Input acquisition (t_{ACQ})
Digital Supply Current At DV_{DD} pin: During Output Data Reading During Standby	 I_{IO_DATA} I_{IO_STBY}	 — —	 290 30	 — —	 µA nA	 f_s = 1 Msps Input acquisition (t_{ACQ})
External Reference Voltage Input						
Reference Voltage	V_{REF}	2.5		5.1	V	**(Note 2)**, **(Note 3)**
Reference Load Current at V_{REF} pin: During Conversion During Standby	 I_{REF} I_{REF_STBY}	 —	 450 240	 600 —	 µA nA	 f_s = 1 Msps Input acquisition (t_{ACQ})
Total Power Consumption						
Total Power Consumption at 1 Msps at 500 ksps at 100 ksps During Standby	 P_{DISS_TOTAL} P_{DISS_STBY}	 — — — —	 6.2 3.1 0.6 2.6	 — — — —	 mW mW mW µW	Including AV_{DD}, DV_{IO}, V_{REF} pins Averaged power for t_{ACQ} + t_{CNV} Input acquisition (t_{ACQ})

Note 1: This parameter is ensured by design and not 100% tested.
2: This parameter is ensured by characterization and not 100% tested.
3: Decoupling capacitor is recommended on the following pins:
(a) AV_{DD} pin: 1 µF ceramic capacitor, (b) DV_{IO} pin: 0.1 µF ceramic capacitor, (c) V_{REF} pin: 10 µF tantalum capacitor.
4: Differential Input Full-Scale Range (FSR) = 2 x V_{REF}
5: PSRR (dB) = -20 log (D_{VOUT}/AV_{DD}), where D_{VOUT} = change in conversion result.
6: ENOB = (SINAD - 1.76)/6.02

TABLE 1-1: KEY ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: Unless otherwise specified, all parameters apply for T_A = -40°C to +85°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS sine wave, f_{IN} = 10 kHz, SPI Clock Input (SCLK) = 60 MHz, Sample Rate (f_S) = 1 Msps.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Analog Inputs						
Input Voltage Range **(Note 2)**	A_{IN+}	-0.1	—	V_{REF}+0.1	V	Differential Input: V_{IN} = (A_{IN+} - A_{IN-})
	A_{IN-}	-0.1	—	V_{REF}+0.1	V	
Input Full-Scale Voltage Range	FSR	-V_{REF}	—	+V_{REF}	V_{PP}	Differential Input **(Note 2)**, **(Note 4)**
Input Common-Mode Voltage Range	V_{CM}	0	V_{REF}/2	V_{REF}		**(Note 2)**
Input Sampling Capacitance	C_S	—	31	—	pF	**(Note 1)**
Leakage Current at Analog Input Pin	$I_{LEAK\_AN\_INPUT}$	—	±2	±100	nA	During Standby
Sampling Dynamics						
Sample Rate	f_s	—	—	1	Msps	Throughput rate
Input Acquisition Time	t_{ACQ}	290	—	—	ns	**(Note 2)**
Data Conversion Time	t_{CNV}	—	560	710	ns	
Time between Conversions	t_{CYC}	1	—	—	µs	t_{CYC} = t_{ACQ} + t_{CNV}, f_S = 1 Msps
-3dB Input Bandwidth	BW_{-3dB}	—	25	—	MHz	**(Note 1)**
Aperture Delay **(Note 1)**		—	2.5	—	ns	Time delay between CNVST rising edge and when input is sampled
System Performance						
Resolution (No Missing Codes)		16	—	—	Bits	MCP33131D-10
		14	—	—	Bits	MCP33121D-10
		12	—	—	Bits	MCP33111D-10
Integral Nonlinearity	INL	-6	±2	+6	LSB	MCP33131D-10
		-1.5	±0.5	+1.5	LSB	MCP33121D-10
			±0.12		LSB	MCP33111D-10
Differential Nonlinearity	DNL	-0.98	±0.8	+1.8	LSB	MCP33131D-10
		-0.8	±0.25	+0.8	LSB	MCP33121D-10
		-0.3	±0.06	+0.3	LSB	MCP33111D-10
Offset Error			±0.1	±2.3	mV	MCP33131D-10
		—	±0.125	±3	mV	MCP33121D-10
		—	±0.8	±3.66	mV	MCP33111D-10
Offset Error Drift with Temperature		—	±0.5	—	µV/°C	
Gain Error	G_{ER}	—	±2	—	LSB	MCP33131D-10
		—	±0.5	—	LSB	MCP33121D-10
		—	±0.1	—	LSB	MCP33111D-10
Gain Error Drift with temperature		—	±0.35	—	µV/°C	
Input common-mode rejection ratio	CMRR	—	84	—	dB	
Power Supply Rejection Ratio	PSRR	—	70	—	dB	**(Note 5)**

Note
1: This parameter is ensured by design and not 100% tested.
2: This parameter is ensured by characterization and not 100% tested.
3: Decoupling capacitor is recommended on the following pins:
(a) AV_{DD} pin: 1 µF ceramic capacitor, (b) DV_{IO} pin: 0.1 µF ceramic capacitor, (c) V_{REF} pin: 10 µF tantalum capacitor.
4: Differential Input Full-Scale Range (FSR) = 2 x V_{REF}
5: PSRR (dB) = -20 log (D_{VOUT}/AV_{DD}), where D_{VOUT} = change in conversion result.
6: ENOB = (SINAD - 1.76)/6.02

TABLE 1-1: KEY ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: Unless otherwise specified, all parameters apply for T_A = -40°C to +85°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS sine wave, f_{IN} = 10 kHz, SPI Clock Input (SCLK) = 60 MHz, Sample Rate (f_S) = 1 Msps.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Dynamic Performance						
Signal-to-Noise Ratio	SNR	**MCP33131D-10: 16-bit ADC**				
		—	91.6	—	dBFS	V_{REF} = 5V, f_{IN} = 1 kHz
		—	86.6	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		88.7	91.3	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	86.6	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
		MCP33121D-10: 14-bit ADC				
		—	85.2	—	dBFS	V_{REF} = 5V, f_{IN} = 1 kHz
		—	83.5	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		81.7	85.1	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	83.5	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
		MCP33111D-10: 12-bit ADC				
		—	73.9	—	dBFS	V_{REF} = 5V, f_{IN} = 1 kHz
		—	73.8	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		71.1	73.9	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	73.8	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
Signal-to-Noise and Distortion Ratio **(Note 6)**	SINAD	**MCP33131D-10: 16-bit ADC**				
		—	91.5	—	dBFS	V_{REF} = 5V, f_{IN} = 1 kHz
		—	86.6	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	91	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	86.2	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
		MCP33121D-10: 14-bit ADC				
		—	85.2	—	dBFS	V_{REF} = 5V, f_{IN} = 1 kHz
		—	83.5	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	85	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	83.3	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
		MCP33111D-10: 12-bit ADC				
		—	73.9	—	dBFS	V_{REF} = 5V, f_{IN} = 1 kHz
		—	73.8	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	73.9	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	73.8	—		V_{REF} = 2.5V, f_{IN} = 10 kHz

Note 1: This parameter is ensured by design and not 100% tested.
2: This parameter is ensured by characterization and not 100% tested.
3: Decoupling capacitor is recommended on the following pins:
(a) AV_{DD} pin: 1 µF ceramic capacitor, (b) DV_{IO} pin: 0.1 µF ceramic capacitor, (c) V_{REF} pin: 10 µF tantalum capacitor.
4: Differential Input Full-Scale Range (FSR) = 2 x V_{REF}
5: PSRR (dB) = -20 log (D_{VOUT}/AV_{DD}), where D_{VOUT} = change in conversion result.
6: ENOB = (SINAD - 1.76)/6.02

TABLE 1-1: KEY ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: Unless otherwise specified, all parameters apply for T_A = -40°C to +85°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS sine wave, f_{IN} = 10 kHz, SPI Clock Input (SCLK) = 60 MHz, Sample Rate (f_S) = 1 Msps.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Spurious Free Dynamic Range	SFDR	**MCP33131D-10: 16-bit ADC**				
		—	103.7	—	dBc	V_{REF} = 5V, f_{IN} = 1 kHz
		—	98	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	103.5	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	97.5	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
		MCP33121D-10: 14-bit ADC				
		—	103.6	—	dBc	V_{REF} = 5V, f_{IN} = 1 kHz
		—	98	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	103.5	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	97.4	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
		MCP33111D-10: 12-bit ADC				
		—	99.3	—	dBc	V_{REF} = 5V, f_{IN} = 1 kHz
		—	97.7	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	99.3	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	97.2	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
Total Harmonic Distortion (first five harmonics)	THD	**MCP33131D-10: 16-bit ADC**				
		—	-100.4	—	dBc	V_{REF} = 5V, f_{IN} = 1 kHz
		—	-95.4	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	-99.3	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	-95.4	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
		MCP33121D-10: 14-bit ADC				
		—	-100.1	—	dBc	V_{REF} = 5V, f_{IN} = 1 kHz
		—	-95.3	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	-99.2	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	-95.3	—		V_{REF} = 2.5V, f_{IN} = 10 kHz
		MCP33111D-10: 12-bit ADC				
		—	-97.5	—	dBc	V_{REF} = 5V, f_{IN} = 1 kHz
		—	-94.4	—		V_{REF} = 2.5V, f_{IN} = 1 kHz
		—	-96.7	—		V_{REF} = 5V, f_{IN} = 10 kHz
		—	-94.4	—		V_{REF} = 2.5V, f_{IN} = 10 kHz

Note 1: This parameter is ensured by design and not 100% tested.
2: This parameter is ensured by characterization and not 100% tested.
3: Decoupling capacitor is recommended on the following pins:
(a) AV_{DD} pin: 1 µF ceramic capacitor, (b) DV_{IO} pin: 0.1 µF ceramic capacitor, (c) V_{REF} pin: 10 µF tantalum capacitor.
4: Differential Input Full-Scale Range (FSR) = 2 x V_{REF}
5: PSRR (dB) = -20 log (D_{VOUT}/AV_{DD}), where D_{VOUT} = change in conversion result.
6: ENOB = (SINAD - 1.76)/6.02

TABLE 1-1: KEY ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: Unless otherwise specified, all parameters apply for T_A = -40°C to +85°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS sine wave, f_{IN} = 10 kHz, SPI Clock Input (SCLK) = 60 MHz, Sample Rate (f_S) = 1 Msps.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
System Self-Calibration						
Self-Calibration Time	t_{CAL}	—	500	620	ms	(Note 2)
Number of SCLK Clocks for Recalibrate Command	$ReCal_{NSCLK}$	—	1024	—	clocks	Includes clocks for data bits
External Clock Frequency and Serial Interface Timing Information: See Table 1-2						
Digital Inputs/Outputs						
High-level Input voltage	V_{IH}	0.7 * DV_{IO}	—	DV_{IO} + 0.3	V	DV_{IO} ≥ 2.3V
		0.9 * DV_{IO}	—	DV_{IO} + 0.3	V	DV_{IO} < 2.3V
Low-level input voltage	V_{IL}	-0.3	—	0.3 * DV_{IO}	V	DV_{IO} ≥ 2.3V
		-0.3	—	0.2 * DV_{IO}	V	DV_{IO} < 2.3V
Hysteresis of Schmitt Trigger Inputs	V_{HYST}	—	0.2 * DV_{IO}	—	V	All digital inputs
Low-level output voltage	V_{OL}	—	—	0.2 * DV_{IO}	V	I_{OL} = 500 µA (sink)
High-level output voltage	V_{OH}	0.8 * DV_{IO}	—	—	V	I_{OL} = - 500 µA (source)
Input leakage current	I_{LI}	—	—	±1	µA	CNVST/SDI/SCLK = GND or DV_{IO}
Output leakage current	I_{LO}	—	—	±1	µA	Output is high-Z, SDO = GND or DV_{IO}
Internal capacitance (all digital inputs and outputs)	C_{INT}	—	7	—	pF	T_A = 25°C (Note 1)

Note 1: This parameter is ensured by design and not 100% tested.
2: This parameter is ensured by characterization and not 100% tested.
3: Decoupling capacitor is recommended on the following pins:
(a) AV_{DD} pin: 1 µF ceramic capacitor, (b) DV_{IO} pin: 0.1 µF ceramic capacitor, (c) V_{REF} pin: 10 µF tantalum capacitor.
4: Differential Input Full-Scale Range (FSR) = 2 x V_{REF}
5: PSRR (dB) = -20 log (D_{VOUT}/AV_{DD}), where D_{VOUT} = change in conversion result.
6: ENOB = (SINAD - 1.76)/6.02

TABLE 1-2: SERIAL INTERFACE TIMING SPECIFICATIONS

Electrical Specifications: Unless otherwise specified, all parameters apply for T_A = -40°C to +85°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, GND = 0V, Differential Analog Input (A_{IN}) = -1 dBFS sine wave, Resolution = 16-bit (MCP33131D-10), f_{IN} = 10 kHz, Sample Rate (f_S) = 1 Msps, +25°C is applied for typical value. All timings are measured at 50%. See Figure 1-1 for timing diagram.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Serial Clock frequency	f_{SCLK}	—	—	100	MHz	See t_{SCLK} specification
SCLK Period	t_{SCLK}	10	—	—	ns	DV_{IO} ≥ 3.3V, f_{SCLK} = 100 MHz (Max)
		12	—	—	ns	DV_{IO} ≥ 2.3V, f_{SCLK} = 83.3 MHz (Max)
		16	—	—	ns	DV_{IO} ≥ 1.7V, f_{SCLK} = 62.5 MHz (Max)
SCLK Low Time	t_{SCLK_L}	3	—	—	ns	DV_{IO} ≥ 1.7V
SCLK High Time	t_{SCLK_H}	3	—	—	ns	DV_{IO} ≥ 2.3V
		4.5	—	—	ns	DV_{IO} ≥ 1.7V
Output Valid from SCLK Low	t_{DO}	—	—	9.5	ns	DV_{IO} ≥ 3.3V
		—	—	12	ns	DV_{IO} ≥ 2.3V
		—	—	16	ns	DV_{IO} ≥ 1.7V
Quiet time	t_{QUIET}	10	—	—	ns	
3-Wire Operation:						
SDI Valid Setup time	$t_{SU\_SDIH\_CNV}$	5	—	—	ns	SDI High to CNVST Rising Edge
CNVST Pulse Width High Time	t_{CNVH}	10	—	—	ns	
Output Enable Time	t_{EN}	—	—	10	ns	DV_{IO} ≥ 2.3V
		—	—	15	ns	DV_{IO} ≥ 1.7V
Output Disable Time	t_{DIS}	—	—	15	ns	(Note 2), (Note 4)
Input Acquisition Time	t_{ACQ}	290	—	—	ns	See Sampling Dynamics in Table 1-1
Data Conversion Time	t_{CNV}	—	560	710	ns	
Time between Conversions	t_{CYC}	1	—	—	µs	

Note 1: This parameter is ensured by design and not 100% tested.
2: This parameter is ensured by characterization and not 100% tested.
3: CNVST low to valid MSB bit at SDO.
4: CNVST high or last SCLK falling edge to SDO High-Z state.

TABLE 1-3: TEMPERATURE CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all parameters apply for T_A = -40°C to +85°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, GND = 0V, V_{REF} = 5V, Analog Input (A_{IN}) = -1 dBFS sine wave, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Operating Temperature Range	T_A	-40	—	+85	°C	(Note 1)
Storage Temperature Range	T_A	-65	—	+150	°C	(Note 1)
Thermal Package Resistance						
Thermal Resistance, MSOP-10	θ_{JA}	—	202	—	°C/W	
Thermal Resistance, TDFN-10	θ_{JA}	—	68	—	°C/W	(Note 2)

Note 1: The internal junction temperature (T_j) must not exceed the absolute maximum specification of +150°C.
2: Contact Microchip Technology Inc. for availability.

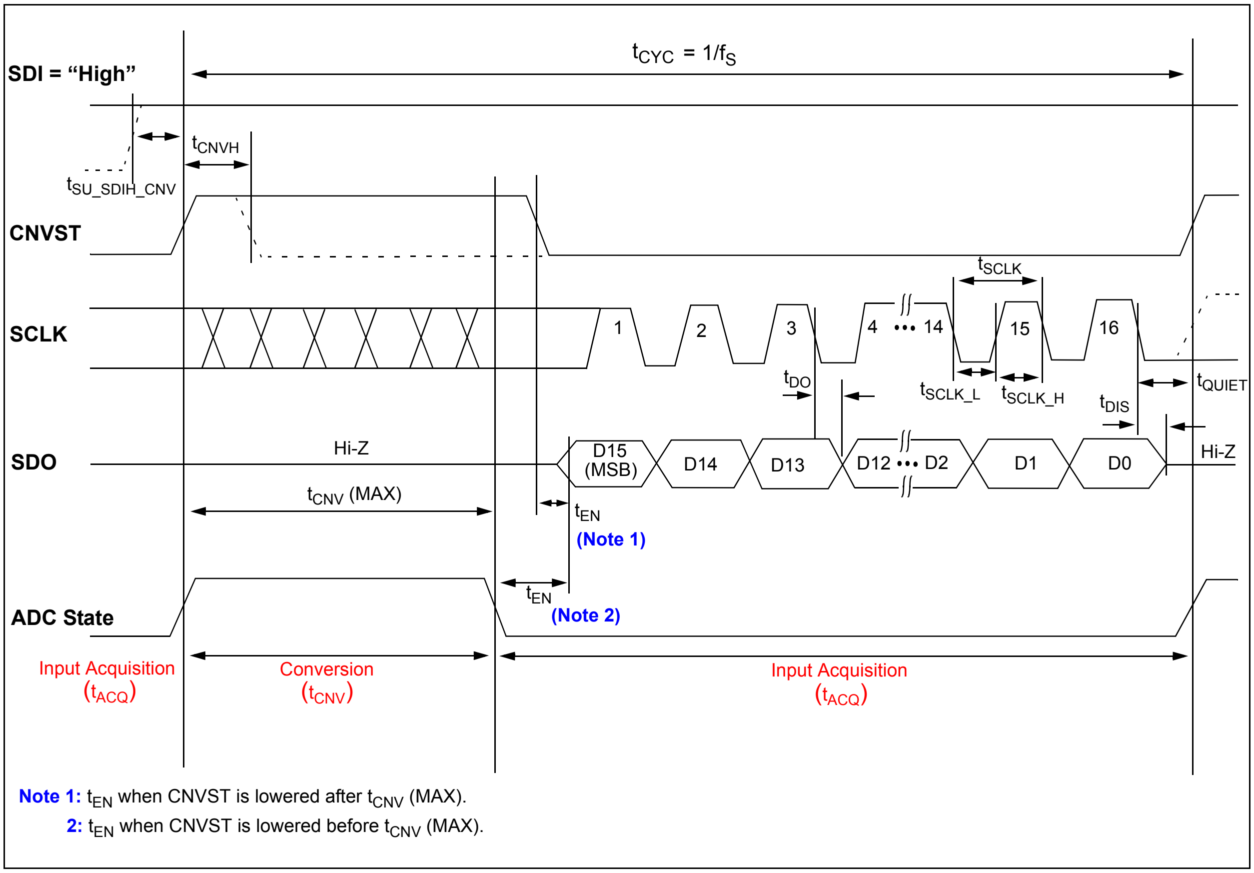


FIGURE 1-1: *Interface Timing Diagram (16-bit device). CNVST is used as chip select. See Figure 7-2 for More Details.*

NOTES:

2.0 TYPICAL PERFORMANCE CURVES FOR MCP33131D-10

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

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (VIN) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33131D-10**.

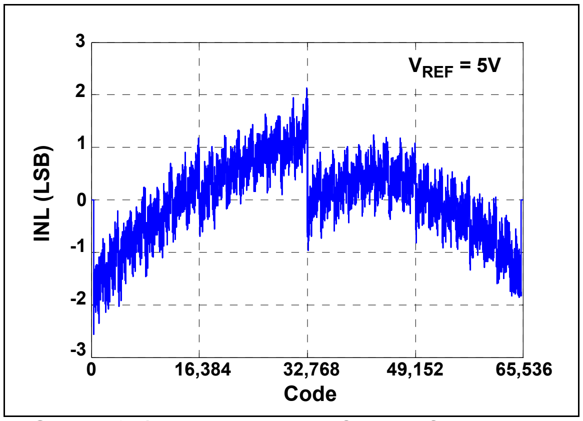


FIGURE 2-1: *INL vs. Output Code.*

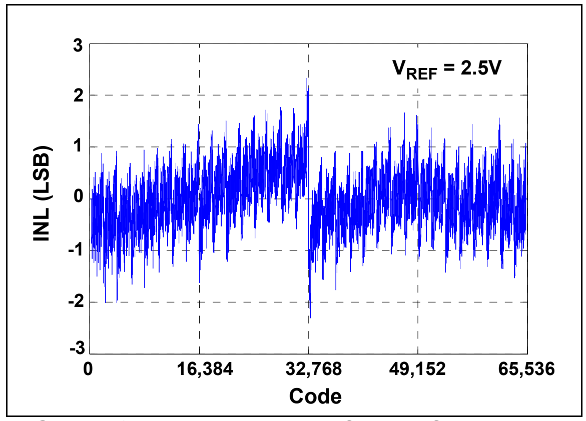


FIGURE 2-4: *INL vs. Output Code.*

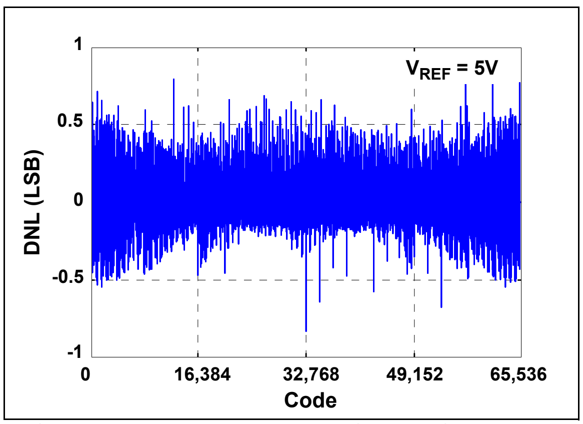


FIGURE 2-2: *DNL vs. Output Code.*

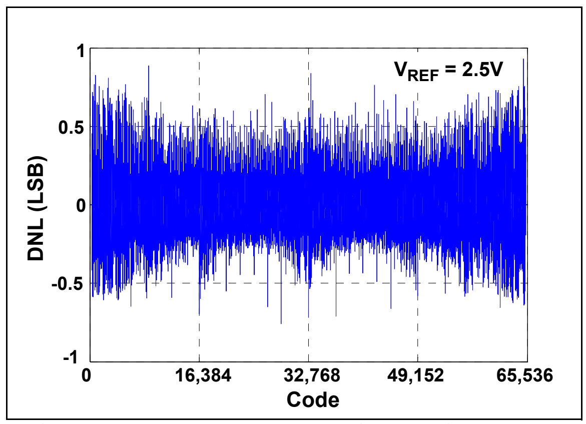


FIGURE 2-5: *DNL vs. Output Code.*

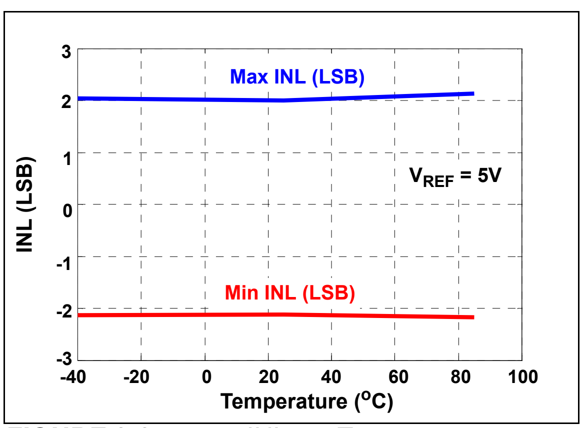


FIGURE 2-3: *INL vs. Temperature.*

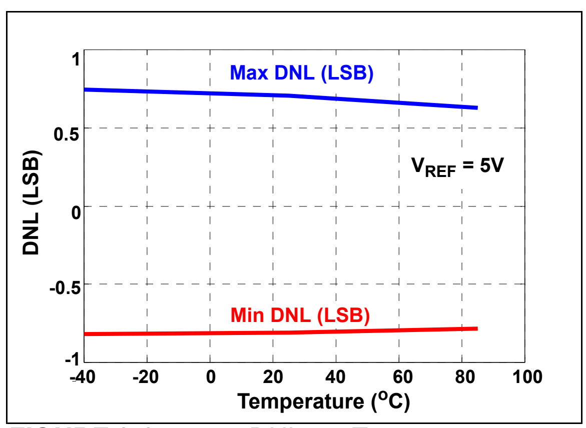


FIGURE 2-6: *DNL vs. Temperature.*

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (VIN) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33131D-10**.

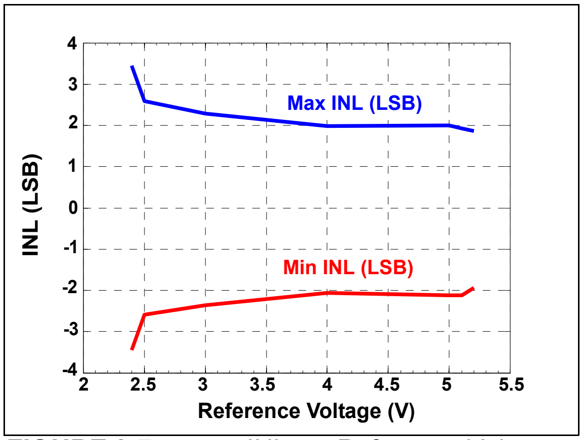


FIGURE 2-7: *INL vs. Reference Voltage.*

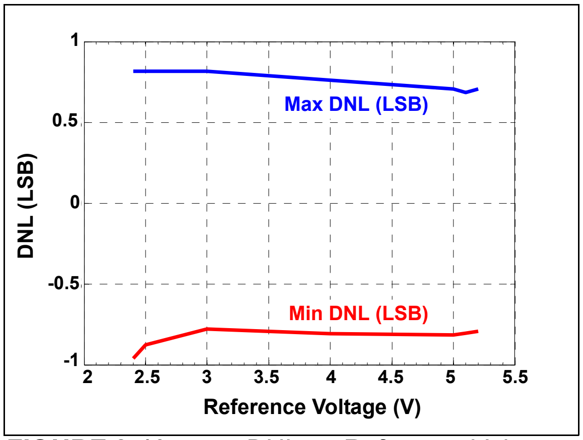


FIGURE 2-10: *DNL vs. Reference Voltage.*

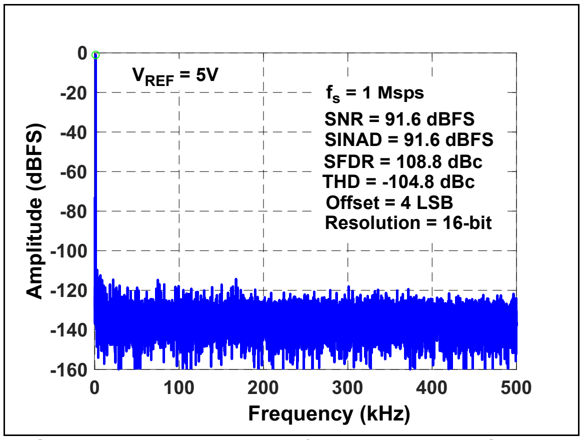


FIGURE 2-8: *FFT for 1 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 5V.*

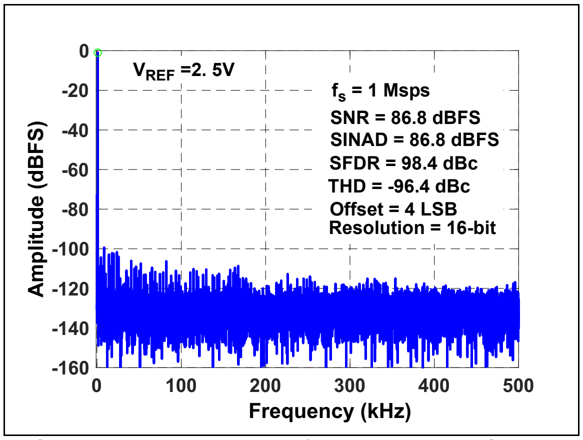


FIGURE 2-11: *FFT for 1 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 2.5V.*

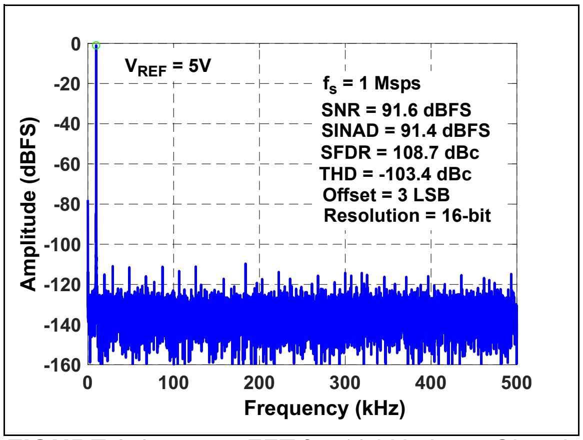


FIGURE 2-9: *FFT for 10 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 5V.*

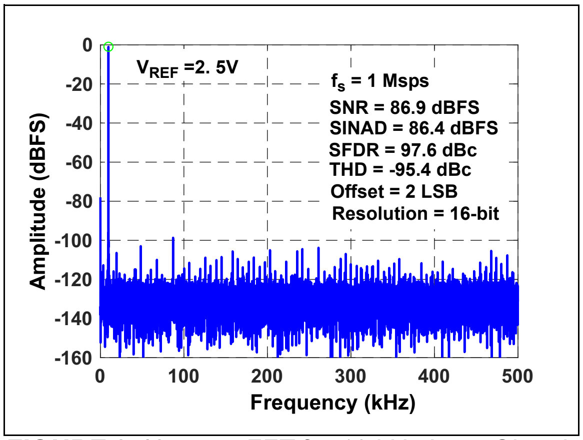


FIGURE 2-12: *FFT for 10 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 2.5V.*

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (VIN) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33131D-10**.

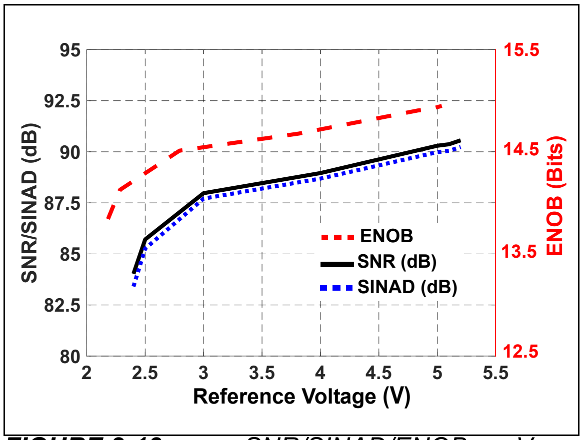


FIGURE 2-13: SNR/SINAD/ENOB vs. V_{REF}

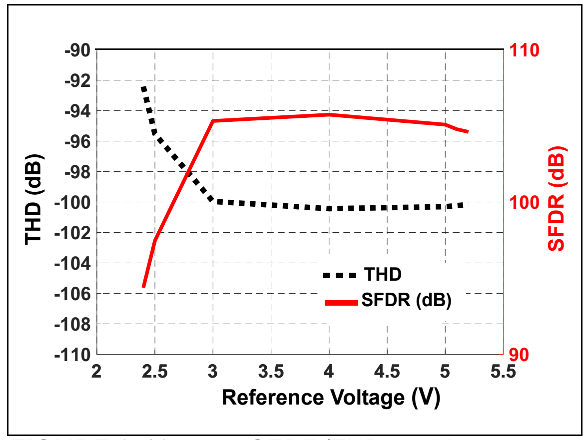


FIGURE 2-16: SFDR/THD vs. V_{REF}

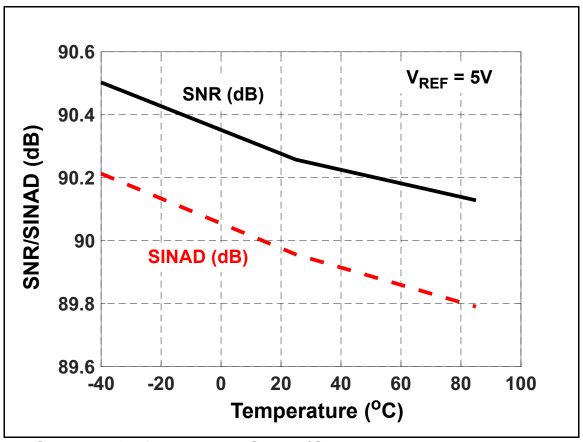


FIGURE 2-14: SNR/SINAD vs. Temperature: V_{REF} = 5V.

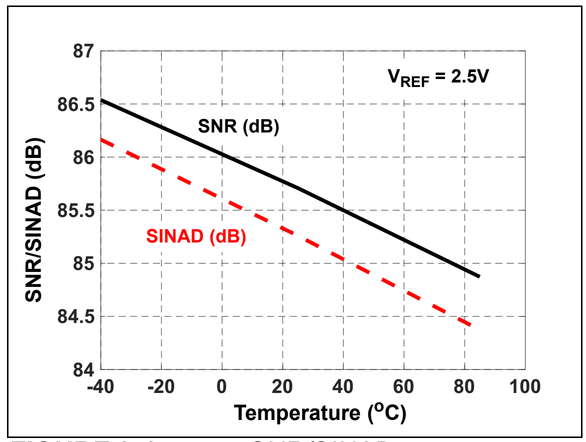


FIGURE 2-17: SNR/SINAD vs. Temperature: V_{REF} = 2.5V.

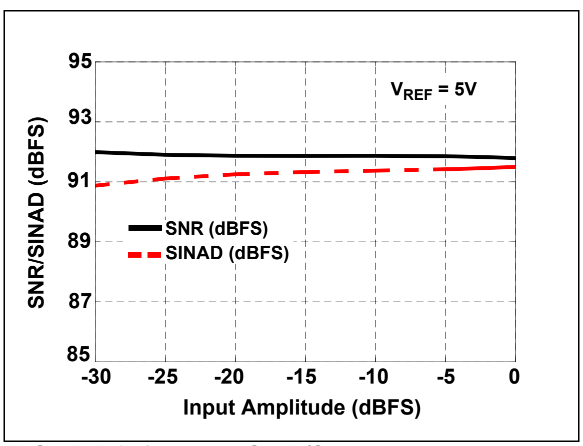


FIGURE 2-15: SNR/SINAD vs. Input Amplitude: F_{IN} = 10 kHz.

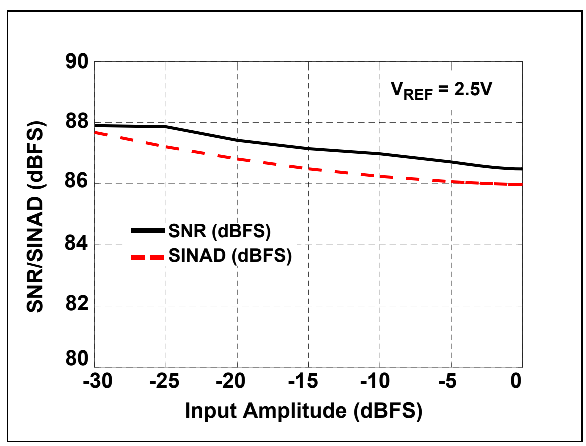


FIGURE 2-18: SNR/SINAD vs. Input Amplitude: F_{IN} = 10 kHz.

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (VIN) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33131D-10.**

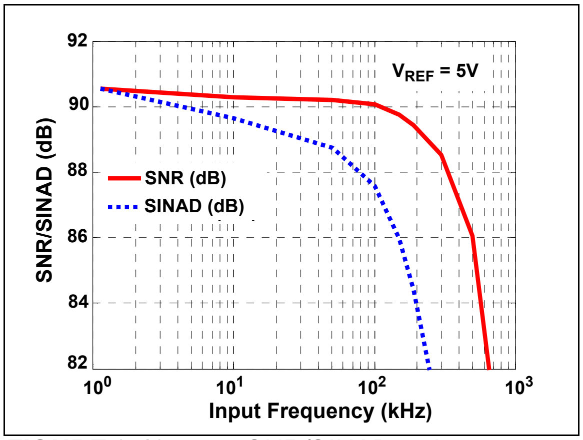


FIGURE 2-19: *SNR/SINAD vs.Input Frequency: V_{IN} = -1 dBFS.*

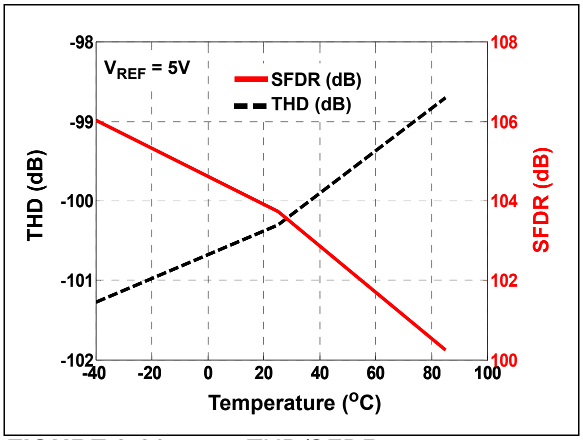


FIGURE 2-20: *THD/SFDR vs. Temperature: V_{REF} = 5V.*

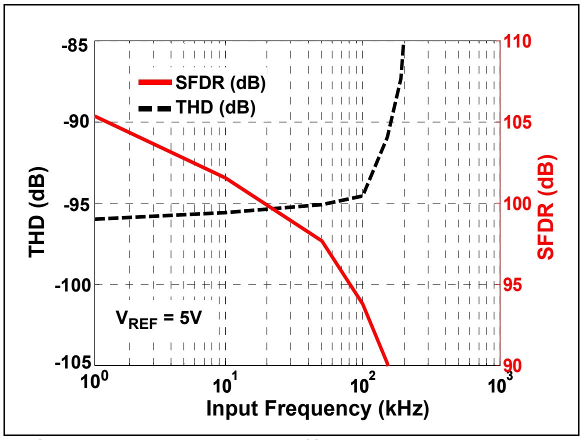


FIGURE 2-21: *THD/SFDR vs. Input Frequency: V_{REF} = 5V.*

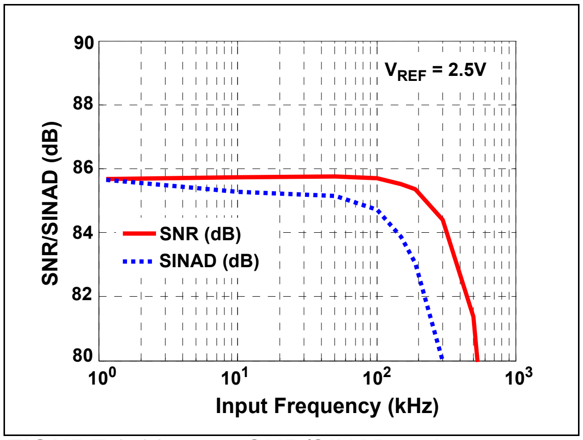


FIGURE 2-22: *SNR/SINAD vs.Input Frequency: V_{IN} = -1 dBFS.*

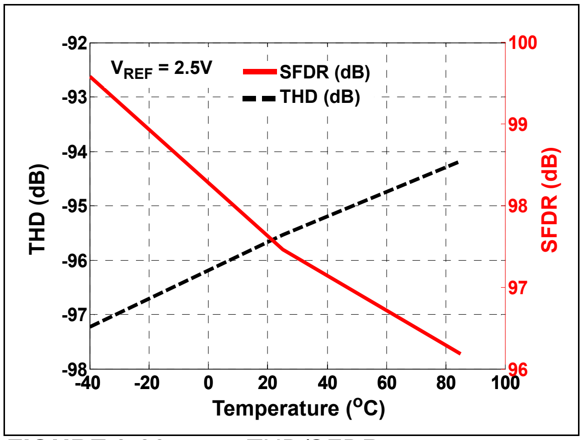


FIGURE 2-23: *THD/SFDR vs. Temperature: V_{REF} = 2.5V.*

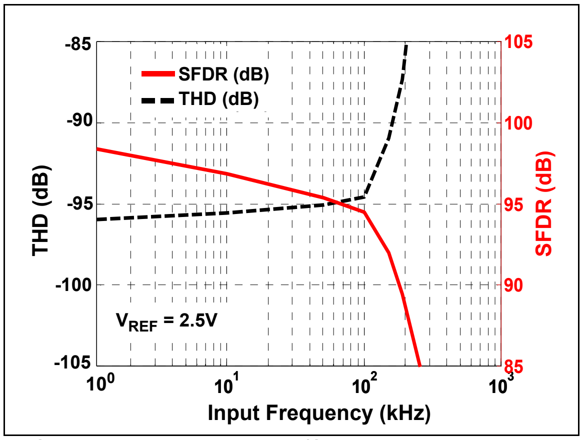


FIGURE 2-24: *THD/SFDR vs. Input Frequency: V_{REF} = 2.5V.*

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33131D-10**.

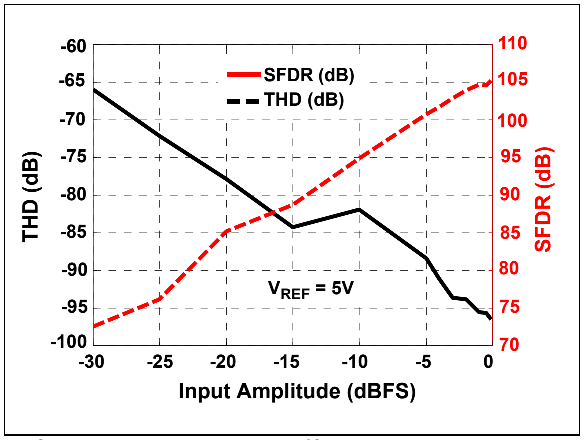


FIGURE 2-25: *THD/SFDR vs. Input Amplitude: V_{REF} = 5V.*

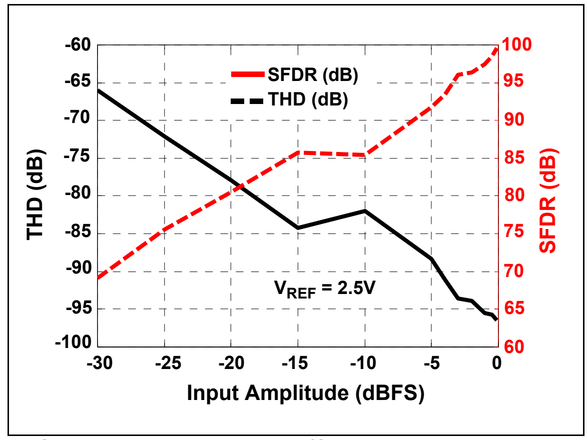


FIGURE 2-28: *THD/SFDR vs. Input Amplitude: V_{REF} = 2.5V.*

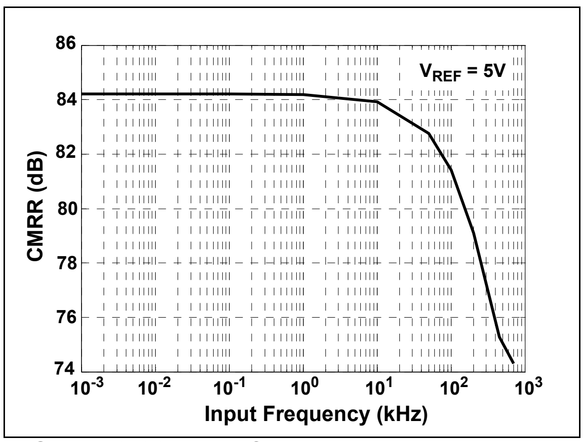


FIGURE 2-26: *CMRR vs. Input Frequency: V_{REF} = 5V.*

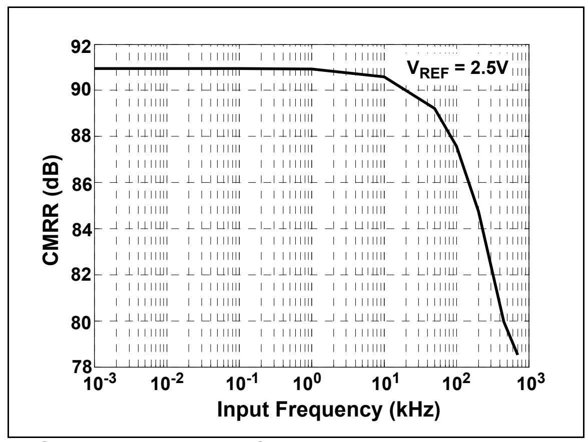


FIGURE 2-29: *CMRR vs. Input Frequency: V_{REF} = 2.5V.*

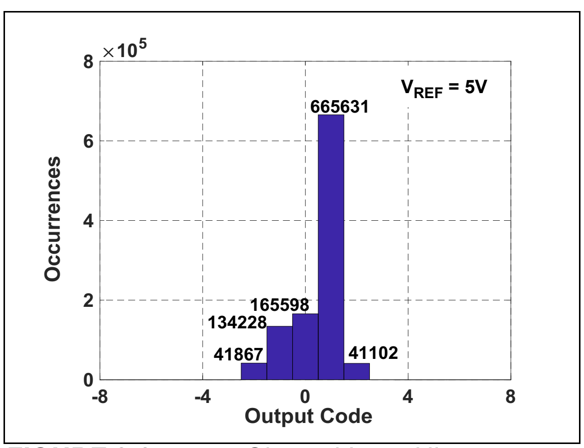


FIGURE 2-27: *Shorted Input Histogram: V_{REF} = 5V.*

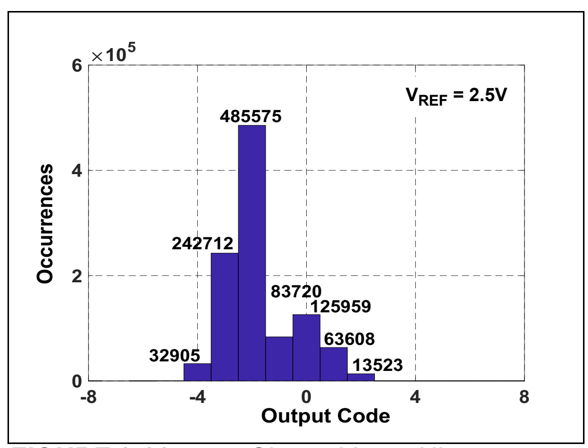


FIGURE 2-30: *Shorted Input Histogram: V_{REF} = 2.5V.*

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (VIN) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33131D-10.**

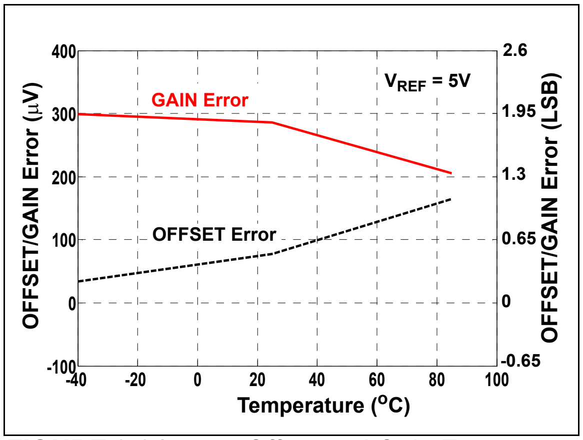


FIGURE 2-31: *Offset and Gain Error vs. Temperature: V_{REF} = 5V.*

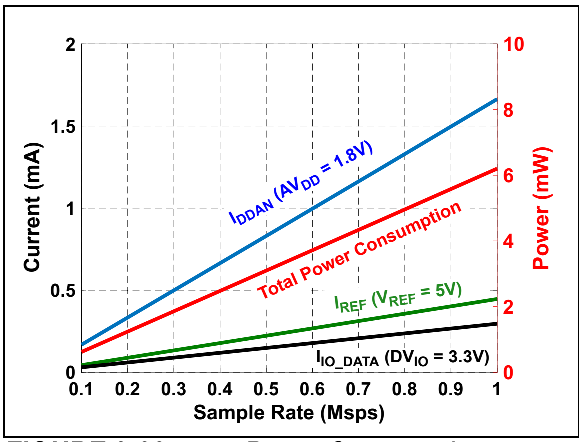


FIGURE 2-32: *Power Consumption vs. Sample Rate (Throughput): C_{LOAD_SDO} = 20 pF.*

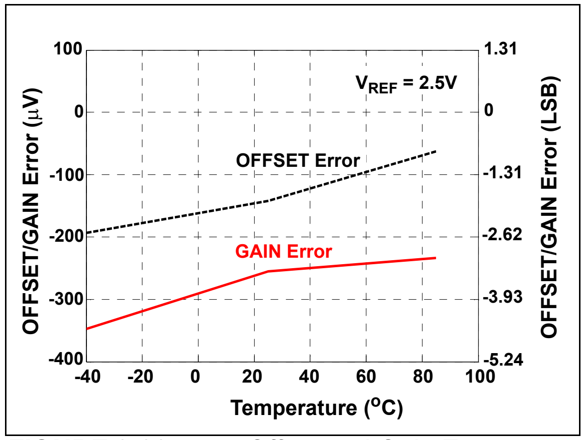


FIGURE 2-33: *Offset and Gain Error vs. Temperature: V_{REF} = 2.5V.*

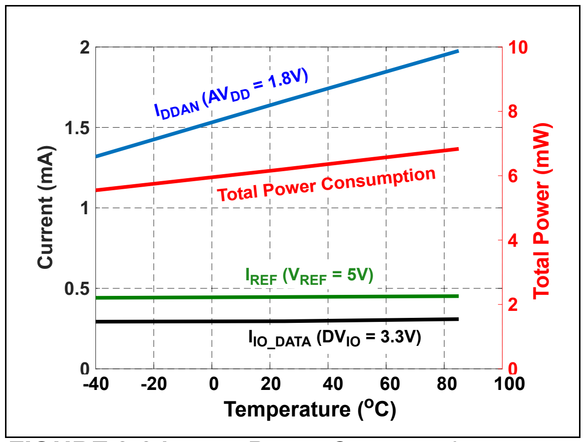


FIGURE 2-34: *Power Consumption vs. Temperature: C_{LOAD_SDO} = 20 pF.*

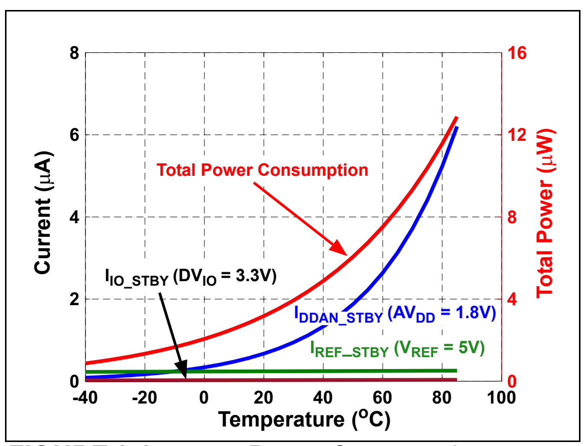


FIGURE 2-35: *Power Consumption vs. Temperature during Shutdown.*

3.0 TYPICAL PERFORMANCE CURVES FOR MCP33121D-10

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

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33121D-10**.

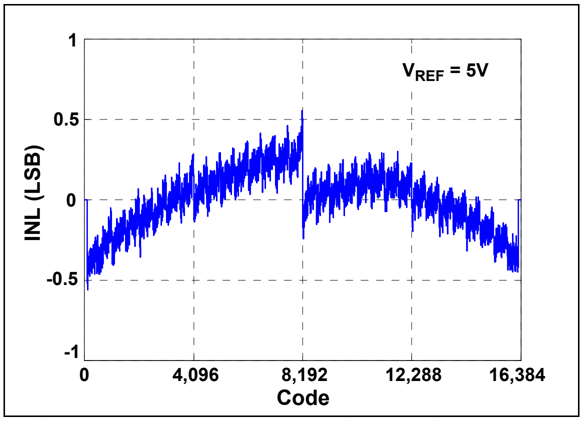


FIGURE 3-1: *INL vs. Output Code.*

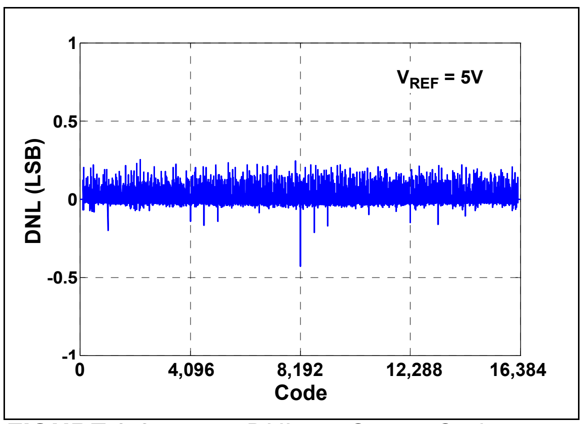


FIGURE 3-2: *DNL vs. Output Code.*

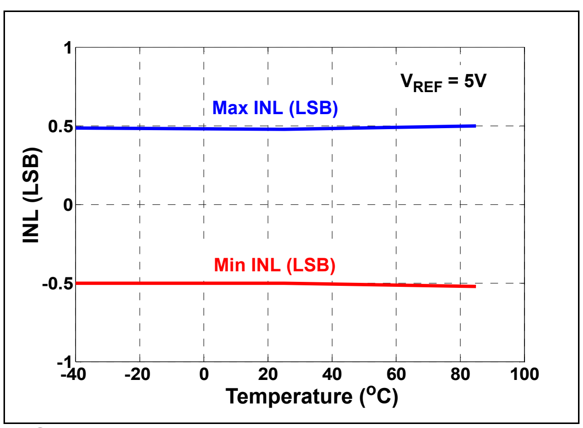


FIGURE 3-3: *INL vs. Temperature.*

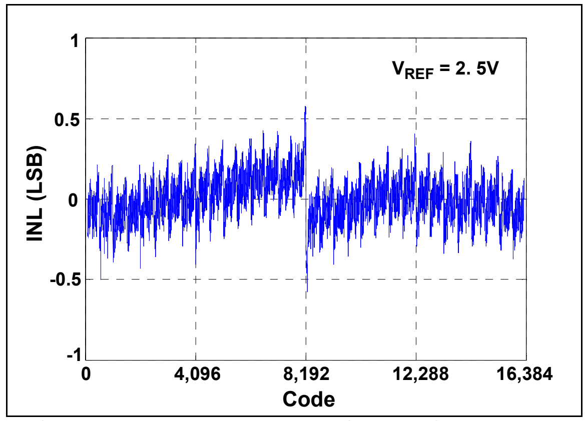


FIGURE 3-4: *INL vs. Output Code.*

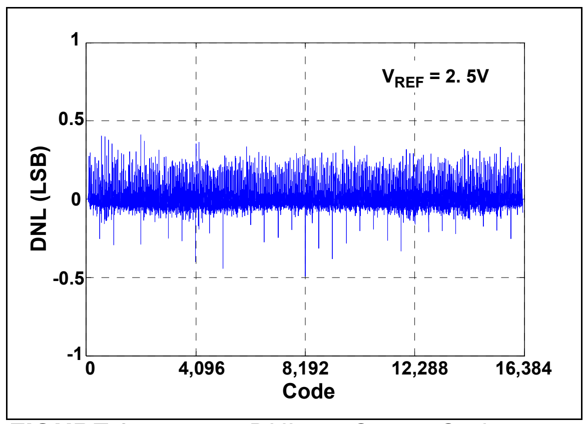


FIGURE 3-5: *DNL vs. Output Code.*

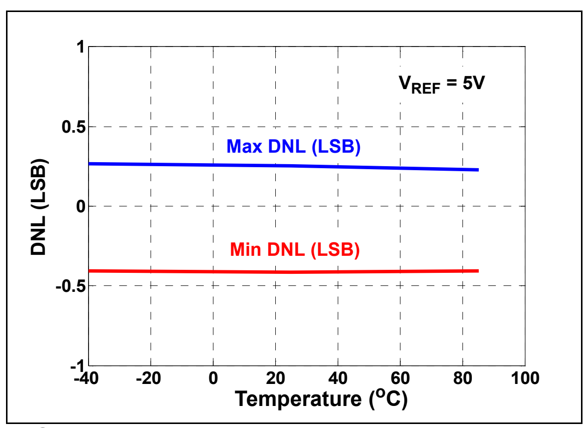


FIGURE 3-6: *DNL vs. Temperature.*

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33121D-10**.

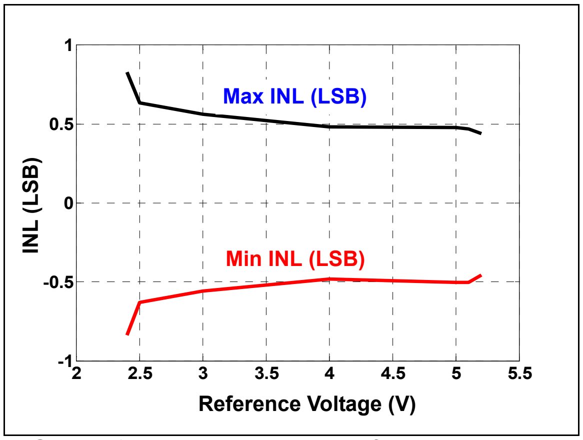


FIGURE 3-7: *INL vs. Reference Voltage.*

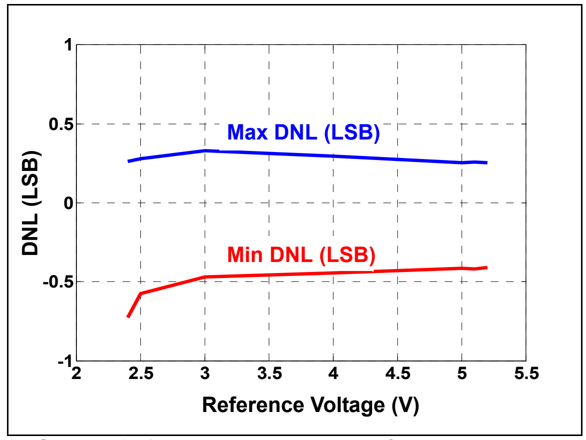


FIGURE 3-10: *DNL vs. Reference Voltage.*

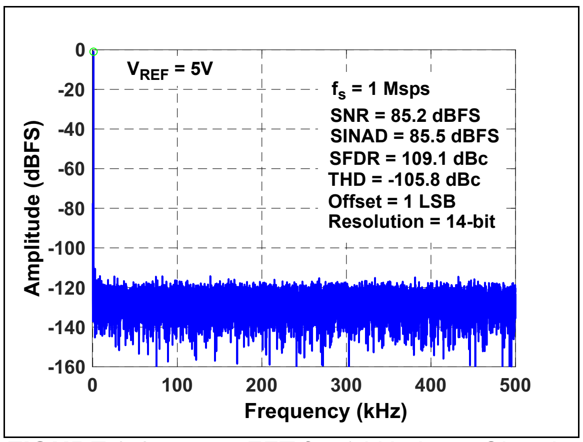


FIGURE 3-8: *FFT for 1 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 5V.*

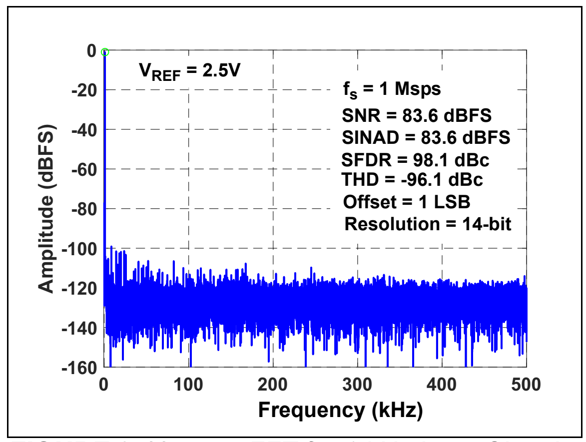


FIGURE 3-11: *FFT for 1 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 2.5V.*

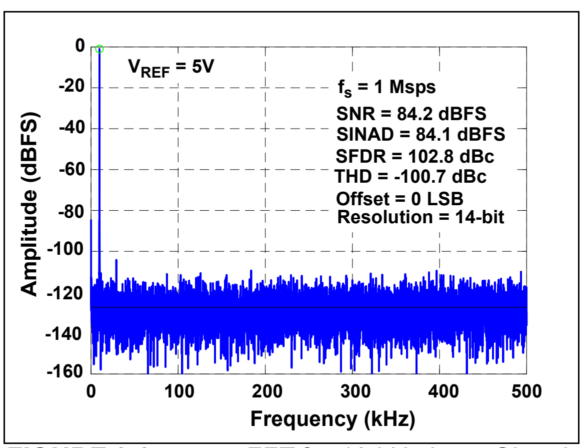


FIGURE 3-9: *FFT for 10 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 5V.*

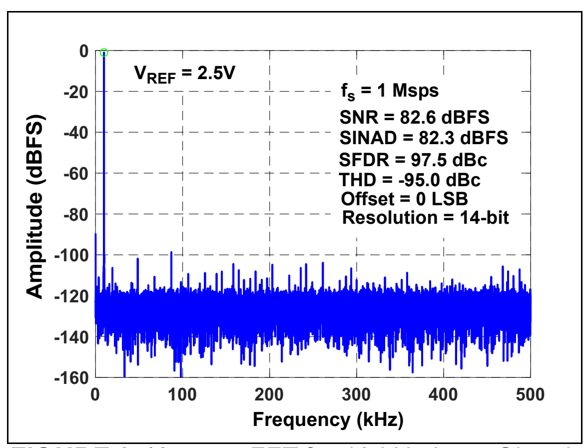


FIGURE 3-12: *FFT for 10 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 2.5V.*

Note: Unless otherwise specified, all parameters apply for T_A = -40°C to +85°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33121D-10**.

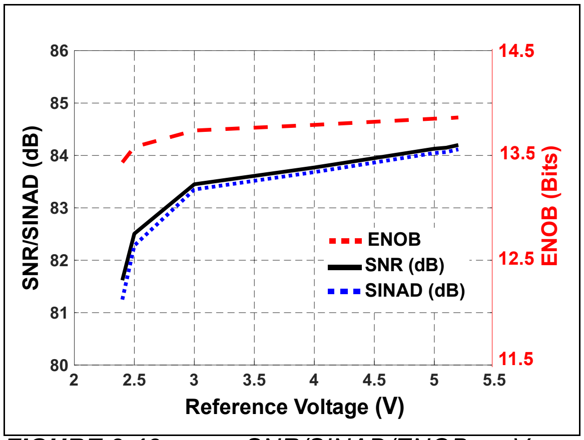


FIGURE 3-13: SNR/SINAD/ENOB vs. V_{REF}

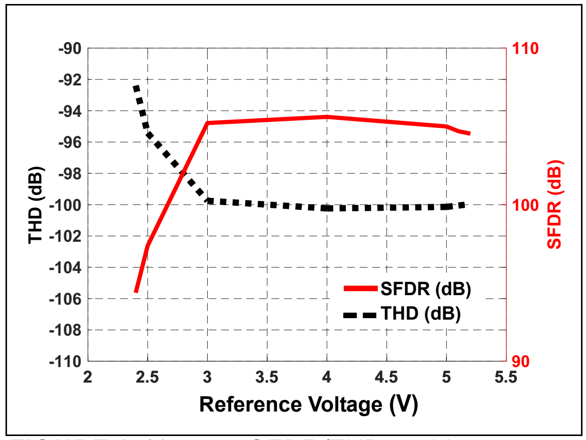


FIGURE 3-16: SFDR/THD vs. V_{REF}

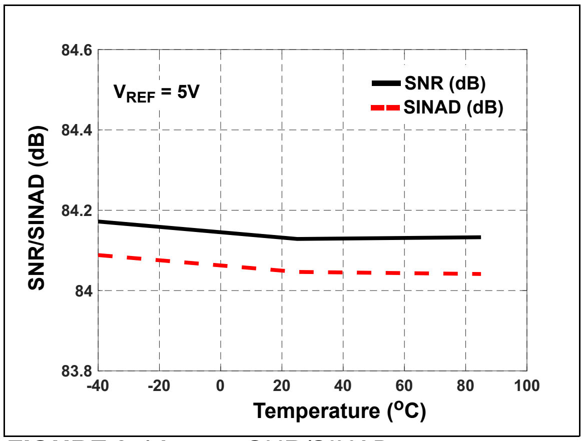


FIGURE 3-14: SNR/SINAD vs. Temperature: V_{REF} = 5V.

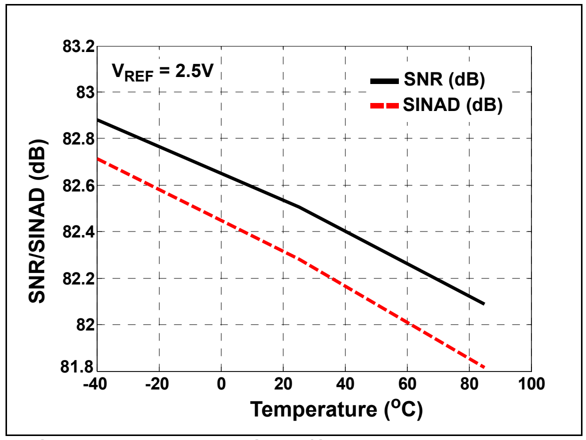


FIGURE 3-17: SNR/SINAD vs. Temperature: V_{REF} = 2.5V.

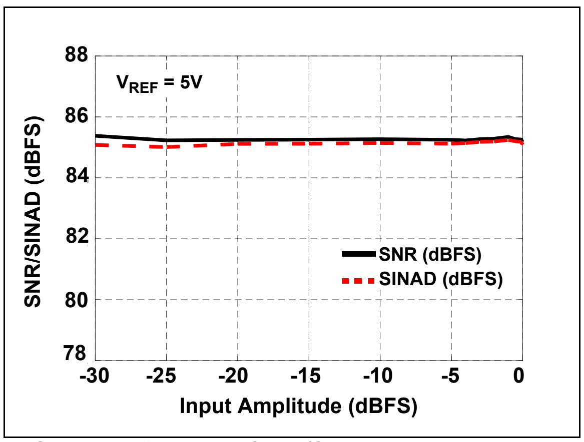


FIGURE 3-15: SNR/SINAD vs. Input Amplitude: F_{IN} = 10 kHz.

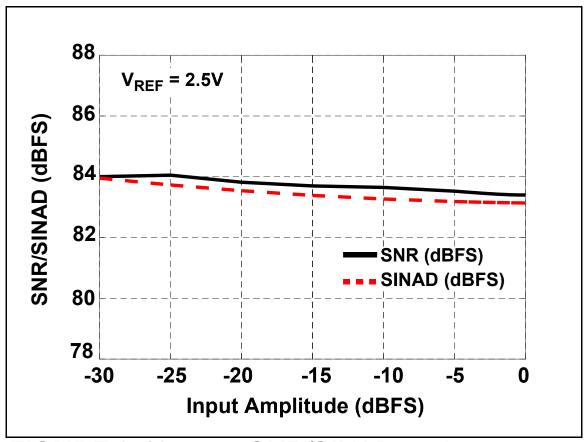


FIGURE 3-18: SNR/SINAD vs. Input Amplitude: F_{IN} = 10 kHz.

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33121D-10**.

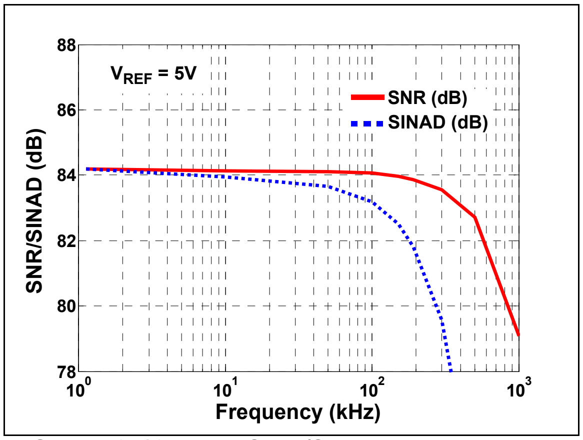


FIGURE 3-19: *SNR/SINAD vs.Input Frequency: V_{IN} = -1 dBFS.*

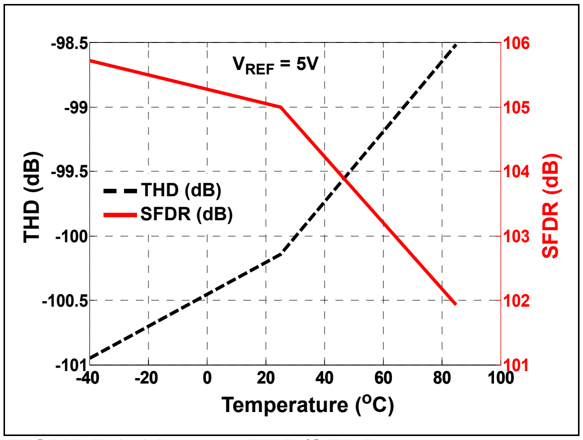


FIGURE 3-20: *THD/SFDR vs. Temperature: V_{REF} = 5V.*

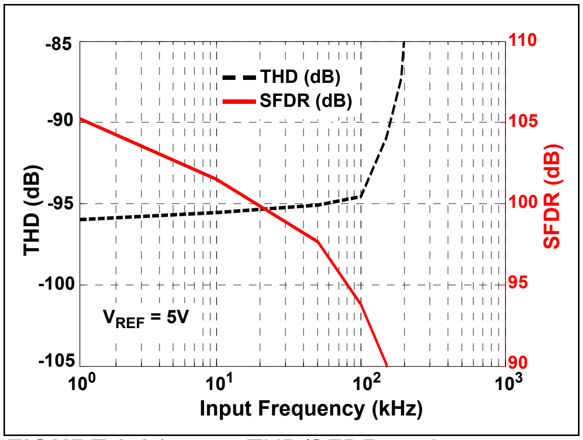


FIGURE 3-21: *THD/SFDR vs. Input Frequency: V_{REF} = 5V.*

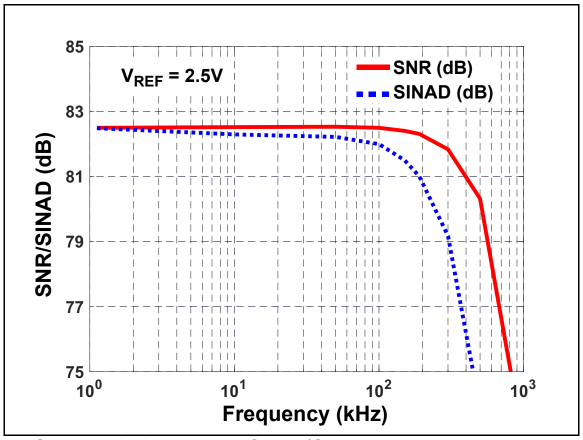


FIGURE 3-22: *SNR/SINAD vs.Input Frequency: V_{IN} = -1 dBFS.*

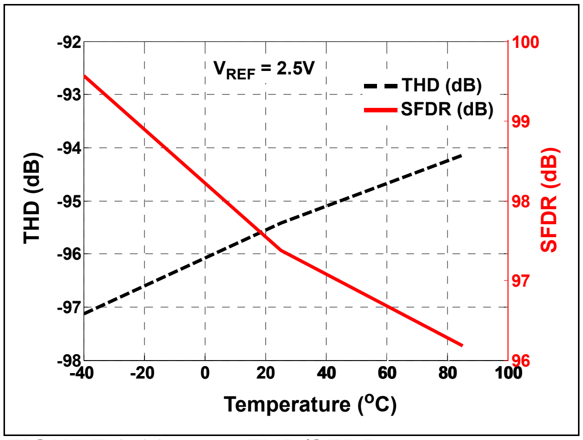


FIGURE 3-23: *THD/SFDR vs. Temperature: V_{REF} = 2.5V.*

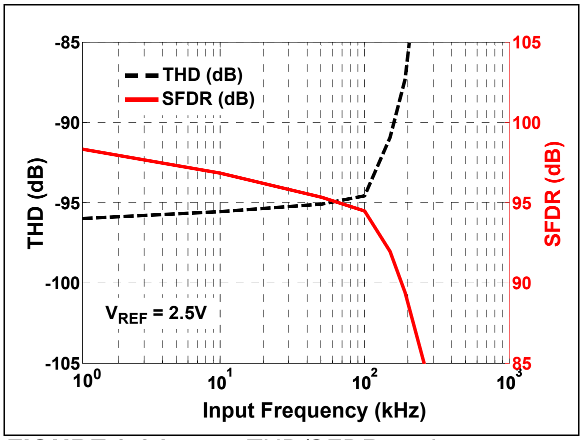


FIGURE 3-24: *THD/SFDR vs. Input Frequency: V_{REF} = 2.5V.*

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33121D-10**.

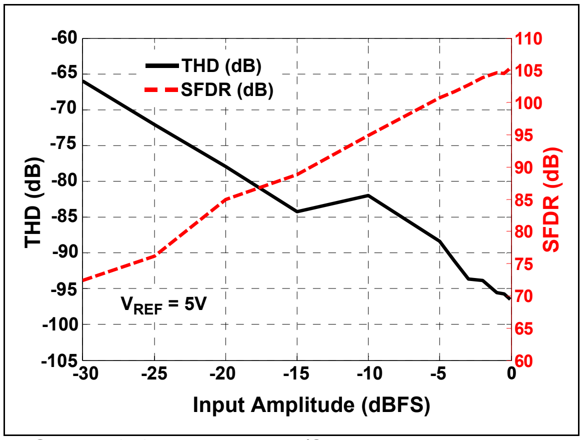


FIGURE 3-25: THD/SFDR vs. Input Amplitude: V_{REF} = 5V.

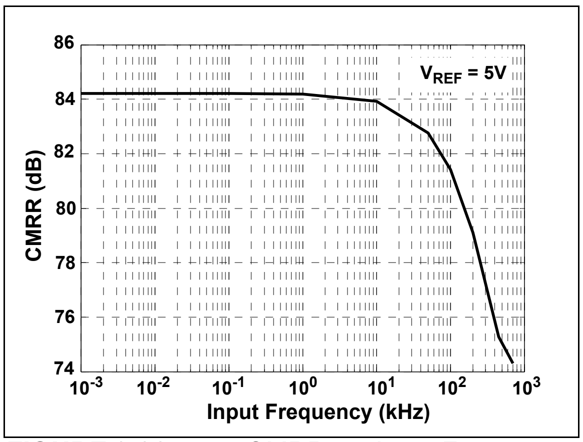


FIGURE 3-26: CMRR vs. Input Frequency: V_{REF} = 5V.

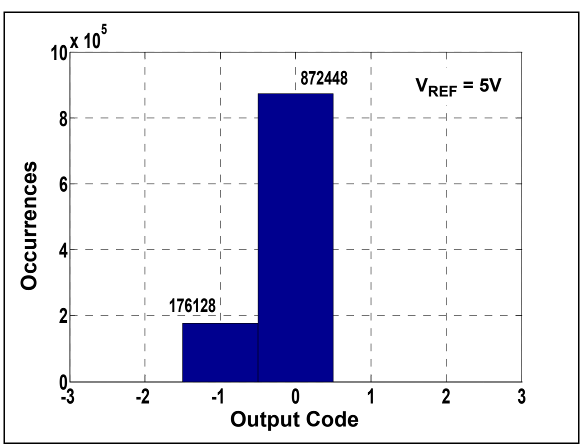


FIGURE 3-27: Shorted Input Histogram: V_{REF} = 5V.

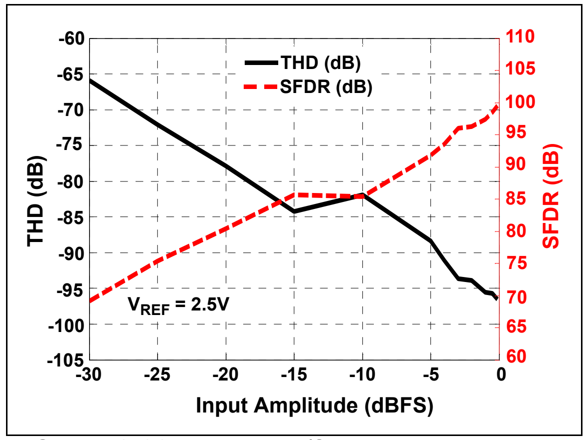


FIGURE 3-28: THD/SFDR vs. Input Amplitude: V_{REF} = 2.5V.

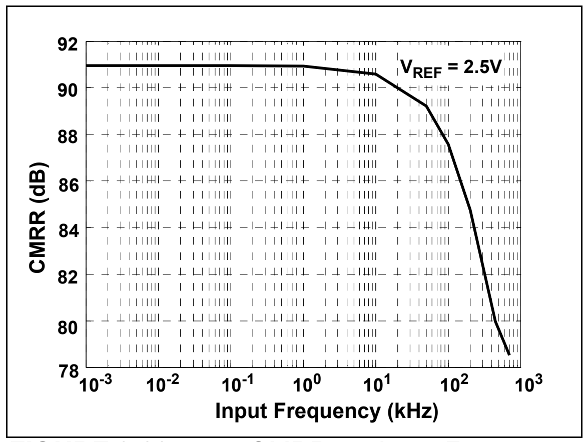


FIGURE 3-29: CMRR vs. Input Frequency: V_{REF} = 2.5V.

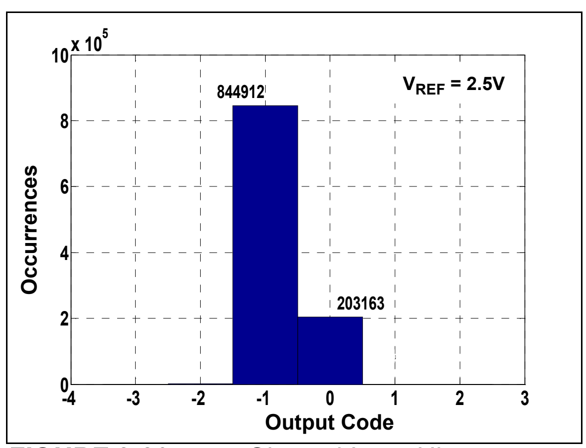


FIGURE 3-30: Shorted Input Histogram: V_{REF} = 2.5V.

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33121D-10.**

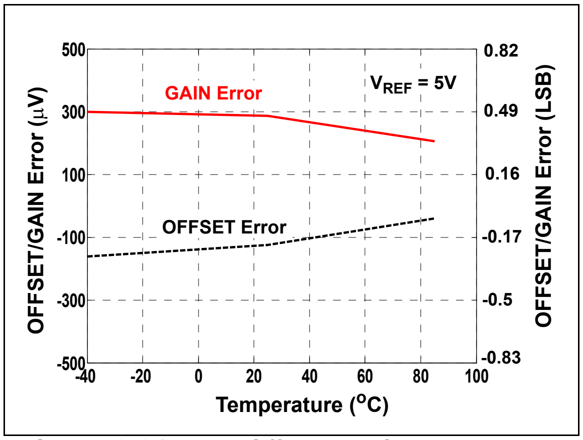


FIGURE 3-31: *Offset and Gain Error vs. Temperature: V_{REF} = 5V.*

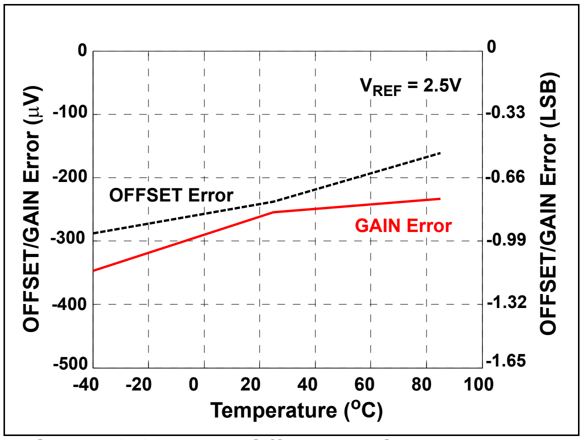


FIGURE 3-33: *Offset and Gain Error vs. Temperature: V_{REF} = 2.5V.*

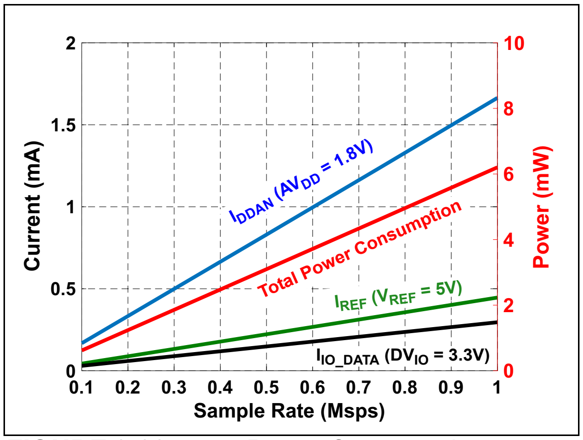


FIGURE 3-32: *Power Consumption vs. Sample Rate (Throughput): C_{LOAD_SDO} = 20 pF.*

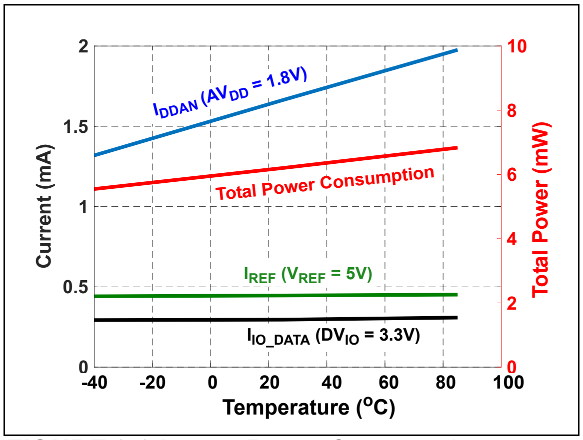


FIGURE 3-34: *Power Consumption vs. Temperature: C_{LOAD_SDO} = 20 pF.*

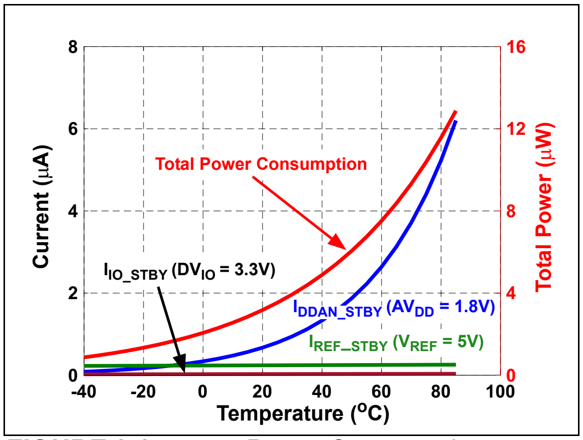


FIGURE 3-35: *Power Consumption vs. Temperature during Shutdown.*

4.0 TYPICAL PERFORMANCE CURVES FOR MCP33111D-10

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

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33111D-10**.

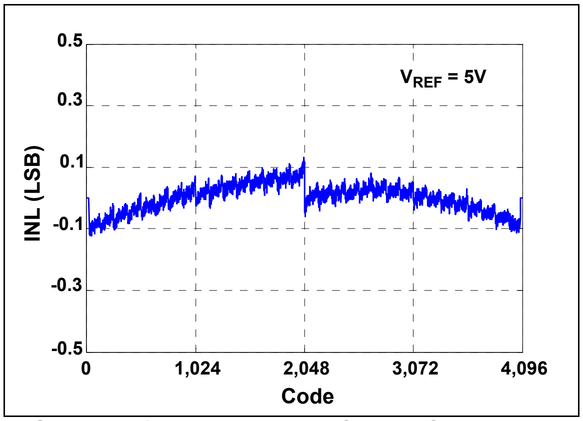


FIGURE 4-1: *INL vs. Output Code.*

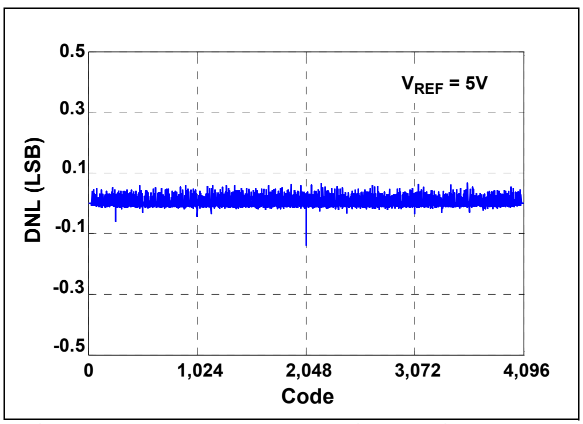


FIGURE 4-2: *DNL vs. Output Code.*

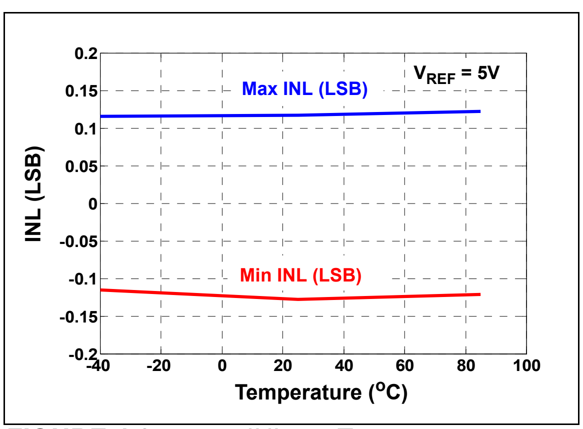


FIGURE 4-3: *INL vs. Temperature.*

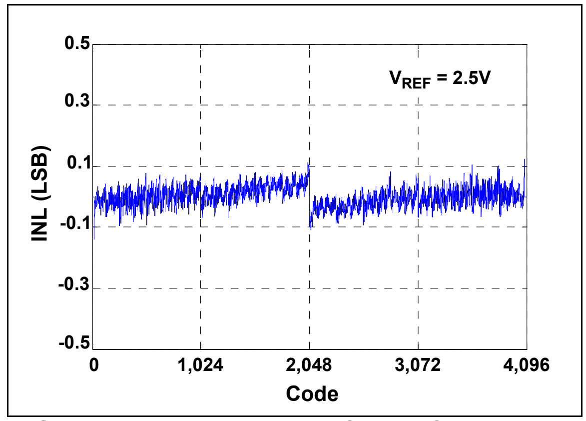


FIGURE 4-4: *INL vs. Output Code.*

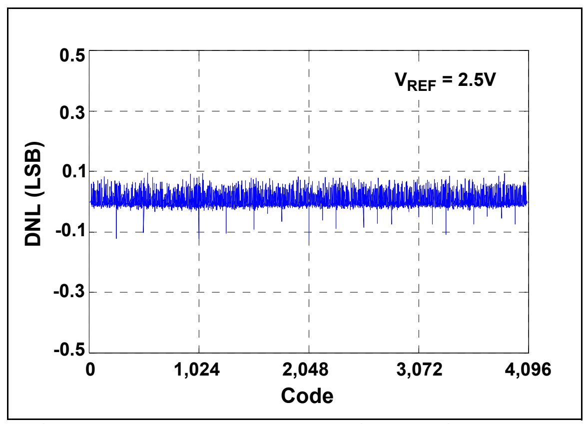


FIGURE 4-5: *DNL vs. Output Code.*

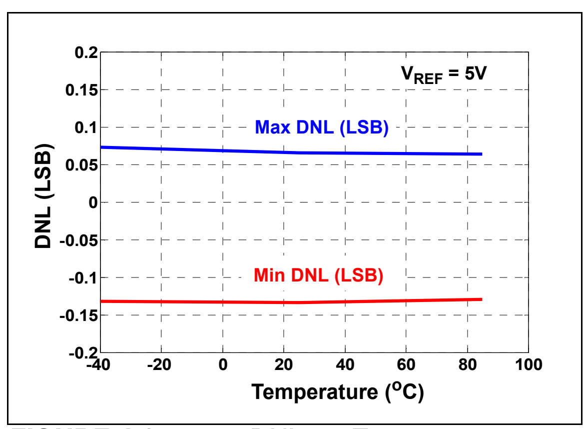


FIGURE 4-6: *DNL vs. Temperature.*

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33111D-10**.

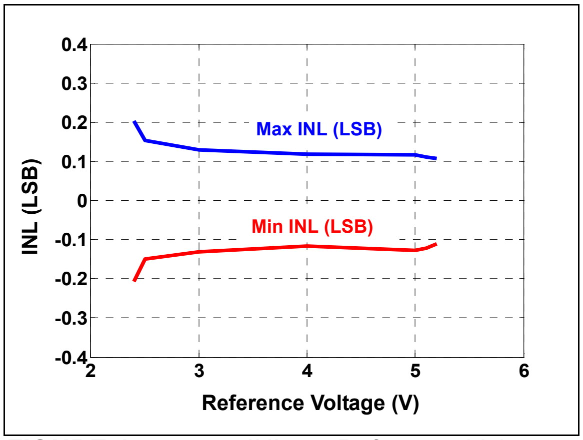


FIGURE 4-7: *INL vs. Reference Voltage.*

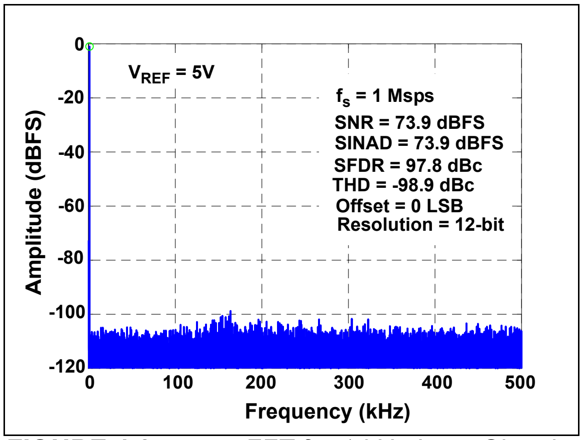


FIGURE 4-8: *FFT for 1 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 5V.*

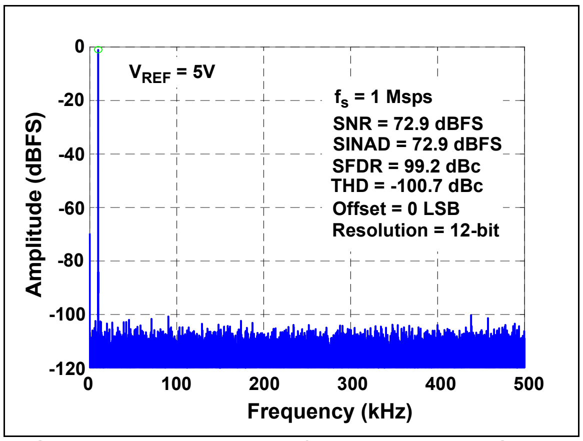


FIGURE 4-9: *FFT for 10 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 5V.*

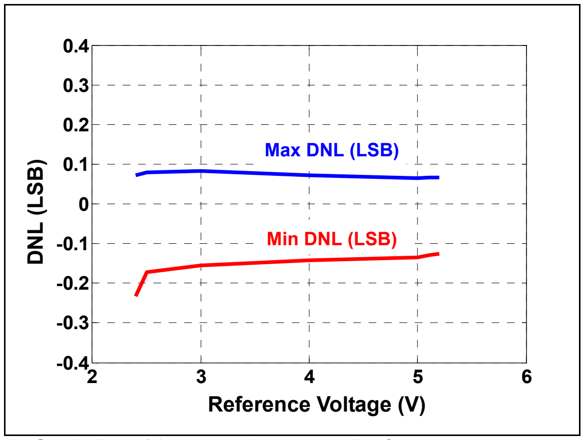


FIGURE 4-10: *DNL vs. Reference Voltage.*

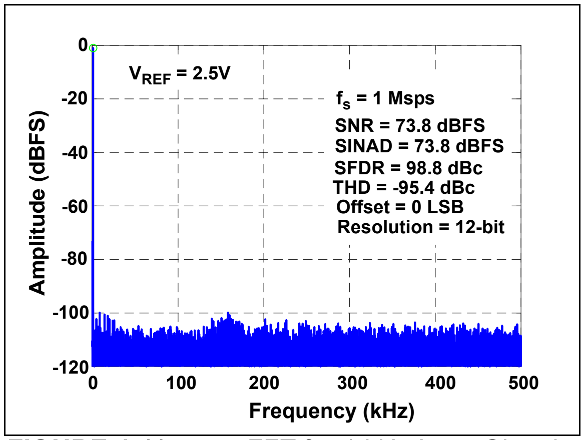


FIGURE 4-11: *FFT for 1 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 2.5V.*

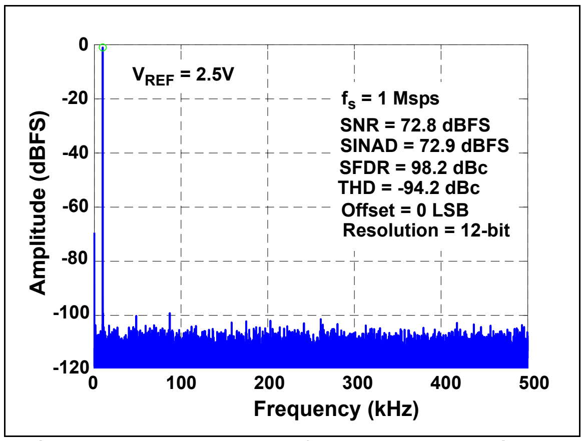


FIGURE 4-12: *FFT for 10 kHz Input Signal: f_S = 1 Msps, V_{IN} = -1 dBFS, V_{REF} = 2.5V.*

Note: Unless otherwise specified, all parameters apply for T_A = +25°C, AV_{DD} = 1.8V, DV_{IO} = 3.3V, V_{REF} = 5V, GND = 0V, Differential Analog Input (V_{IN}) = -1 dBFS, f_{IN} = 10 kHz, SPI Clock Input = 60 MHz, Sample Rate (f_S) = 1 Msps. Device = **MCP33111D-10**.

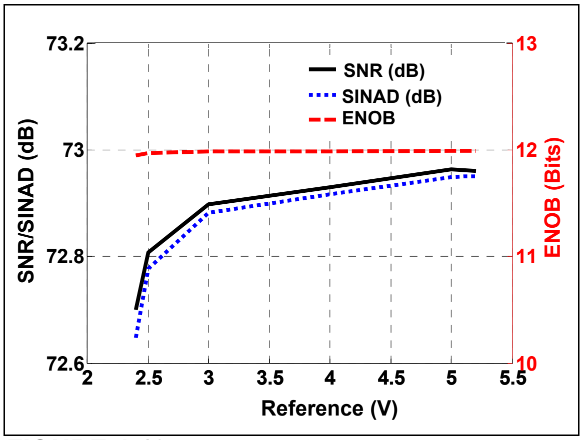


FIGURE 4-13: *SNR/SINAD/ENOB vs.* V_{REF}

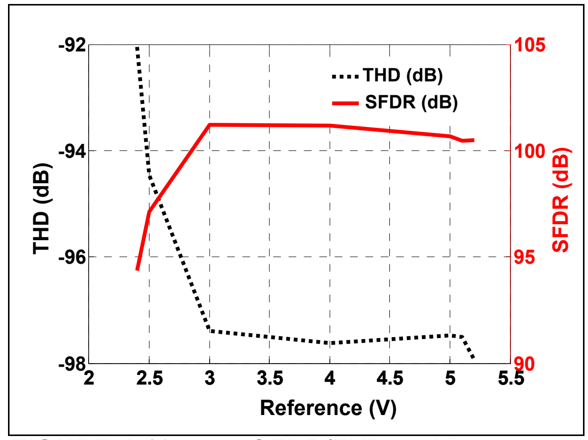


FIGURE 4-16: *SFDR/THD vs.* V_{REF}

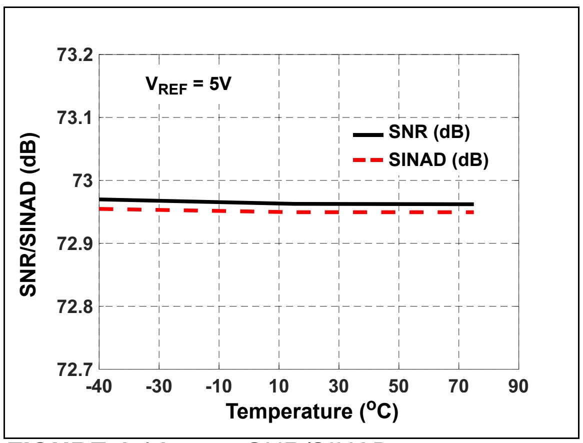


FIGURE 4-14: *SNR/SINAD vs. Temperature:* V_{REF} *= 5V.*

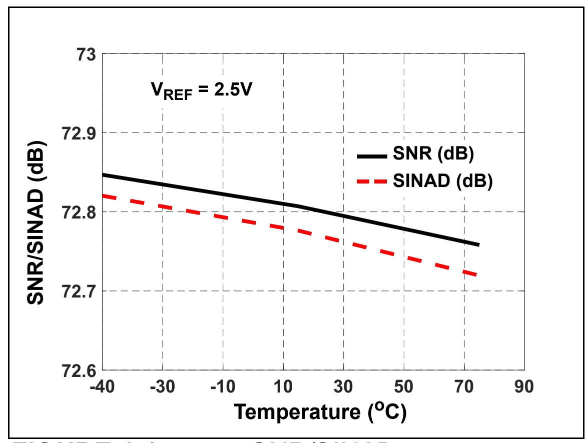


FIGURE 4-17: *SNR/SINAD vs. Temperature:* V_{REF} *= 2.5V.*

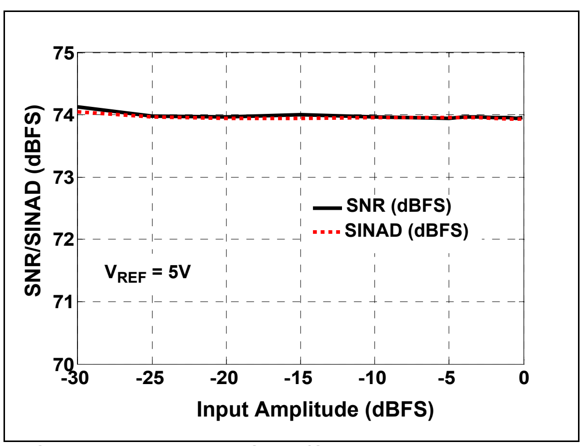


FIGURE 4-15: *SNR/SINAD vs. Input Amplitude:* F_{IN} *= 10 kHz.*

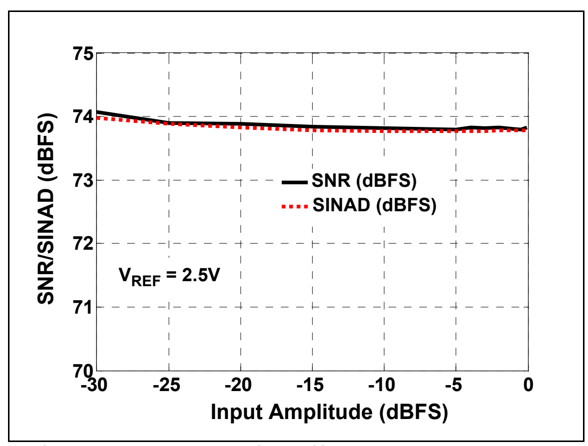


FIGURE 4-18: *SNR/SINAD vs. Input Amplitude:* F_{IN} *= 10 kHz.*

