HARRIS SEMICONDUCTOR
A DIVISION OF HARRIS CORPORATION

Preliminary

HI-5610

10 Bit High Speed Monolithic Digital-to-Analog Converter

FEATURES

- MONOLITHIC CONSTRUCTION
- EXTREMELY FAST SETTLING . . . . 85ns TO ½LSB TYP.
- LOW GAIN DRIFT . . . . ±5ppm/°C TYP.
- EXCELLENT LINEARITY OVER TEMPERATURE . . . . ± ½LSB MAX.
- DESIGNED FOR MINIMUM GLITCHES
- MONOTONIC OVER TEMPERATURE

APPLICATIONS

- CRT DISPLAY GENERATION
- HIGH SPEED A/D CONVERTERS
- VIDEO SIGNAL RECONSTRUCTION
- WAVEFORM SYNTHESIZERS
- HIGH SPEED DATA ACQUISITION
- HIGH RELIABILITY APPLICATIONS
- PRECISION INSTRUMENTS

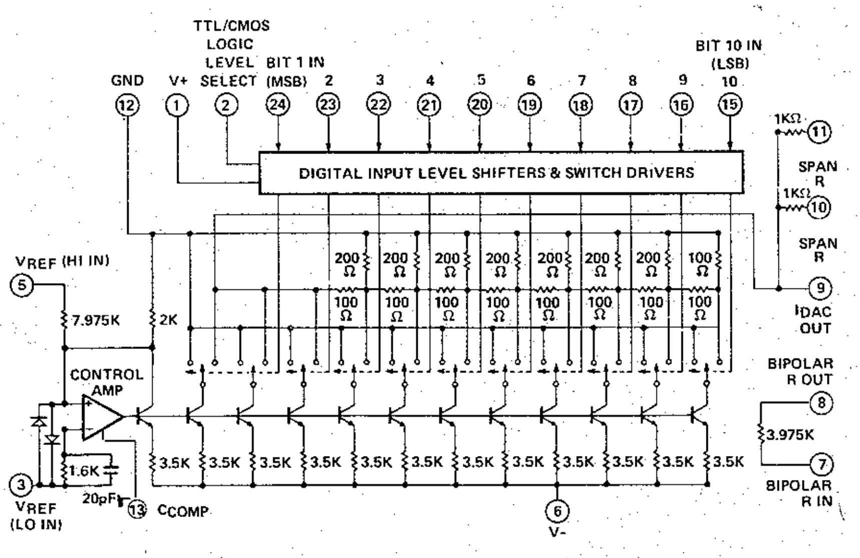
DESCRIPTION

The HI-5610 is an ultra-high speed 10 bit monolithic current output digital-to-analog converter. The fast output current settling of 85ns to ½LSB of its final value is achieved using dielectric isolation processing to reduce internal parasitics for fast rise and fall times during switching. Output glitches are minimized in the HI-5610 by incorporating equally weighted current sources switched into an R-2R ladder network for symmetrical turn-on and turn-off switching times. This creates within the chip a very uniform and constant thermal distribution for excellent linearity and also eliminates thermal transients during switching. High stability thin film resistor processing, together with laser trimming provide the HI-5610 with true 10 bit linearity to within ± ½LSB maximum over operating temperature range. The HI-5610's low offset and gain drift over the operating temperature range assures that its absolute accuracy when referred to a fixed 10V reference will not deviate more than ± 1LSB for both unipolar and bipolar operation.

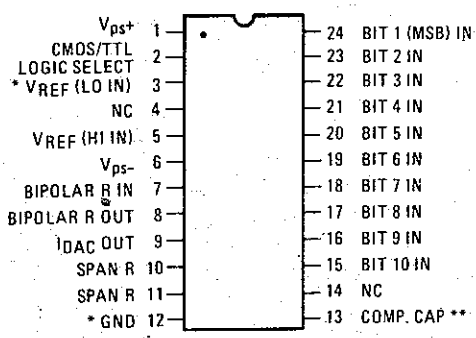
The HI-5610 is recommended as a replacement for high cost hybrid and modular units for increased reliability and accuracy in applications such as CRT Displays, precision instruments and data acquisition system requiring through-put rates as high as 12mHz for full range transitions. Its small size makes it an ideal choice as the essential part of high speed A/D converter designs or as a building block in high speed or high resolution industrial process control systems. The HI-5610 is also ideally suited for aircraft and space instrumentation where operation over a wide temperature range is required.

The HI-5610-5 is specified for operation over 0°C to +75°C, the HI-5610-2 and HI-5610-8 over -55°C to +125°C. Processing to MIL-STD-883A class B screening is available by selecting the HI-5610-8. All are available in a hermetically sealed 24 lead dual-in-line package.

FUNCTIONAL DIAGRAM



PINOUT



* Pin 3 connected to bottom case for high frequency shielding.

** For high speed operation, connect 0.01μF between Pin 13 and GND. Otherwise, leave Pin 13 open.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS (Referred to Ground)[1]

Power Supply Inputs	$V_{ps}+$	+20V
	$V_{ps}-$	-20V
Reference Inputs	VREF (Hi)	$\pm V_{ps}$
	VREF(Lo)	0V
Digital Inputs	Bits 1 - 12	-1V, +12V
	CMOS/TTL Logic Select	-1V, +12V
Outputs	Pins 7, 8, 10, 11	$\pm V_{ps}$
	Pin 9	$+V_{ps}$, -5V

Power Dissipation	Pd, Package	1000mW
Operating Temperature Range		
	HI-5610-2	-55°C to +125°C
	HI-5610-5	0°C to +75°C
	HI-5610-8	-55°C to +125°C
Storage Temperature Range		-65°C to +150°C

ELECTRICAL CHARACTERISTICS (@ +25°C, $V_{ps}+$, = +5V, $V_{ps}-$ = -15V, V_{REF} = +10V, pin 2 ground unless otherwise noted)

		HI-5610-2 HI-5610-8			HI-5610-5			
PARAMETER	TEMP	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS								
Digital Inputs (2)								
TTL Logic Input Voltage (3)								
Logic "1"	Full	2.0			2.0			V
Logic "0"	Full			0.8			0.8	V
Input Current								
Logic "1"	Full		20	100		20	100	nA
Logic "0"	Full		-50	-100		-50	-100	μA
CMOS Logic Input Voltage (4)								
Logic "1"	Full	$0.7V_{ps}+$			$0.7V_{ps}+$			V
Logic "0"	Full			$0.3V_{ps}+$			$0.3V_{ps}+$	V
Input Current								
Logic "1"	Full		20	100		20	100	nA
Logic "0"	Full		-50	-100		-50	-100	μA
Reference Input								
Input Resistance			8K			8K		Ω
Input Voltage (I_{OUT} = 5mA + 20%)			+10			+10		V
TRANSFER CHARACTERISTICS								
Resolution	Full			10			10	Bits
Nonlinearity (5)	25°C			±½			±½	LSB
Differential Nonlinearity (5)	25°C			±½			±½	LSB
Relative Accuracy (6)								
Gain Error								(9)
(Input Code 11....1)			±0.05			±0.05		% FSR
Unipolar Offset Error								
(Input Code 00....0)			±0.05			±0.05		% FSR
Bipolar Offset Error								
(Input Code 00....0)			±0.05			±0.05		% FSR
(Adjustable to zero, see Figure 4, 5)								
Adjustment Range								
Gain			±0.25			±0.25		% FSR
Bipolar Offset			±0.25			±0.25		% FSR
Temperature Stability								
Gain Drift	Full		±5			±5		ppm/°C
Unipolar Offset Drift	Full		±3			±3		ppm/°C
Bipolar Offset Drift	Full		±3			±3		ppm/°C
Differential Nonlinearity	Full		±2			±2		ppm/°C
MONOTONICITY - GUARANTEED OVER FULL OPERATING TEMPERATURE RANGE								
Settling Time to ½LSB (5)								
From all 0's to all 1's			85			85		ns
From all 1's to all 0's			85			85		ns
Major Carry Switching to 90% Complete			40			40		ns

SPECIFICATIONS (continued)

PARAMETER	TEMP	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Power Supply Sensitivity (5)								
V_{ps+} = +5V, V_{ps-} = -13.5V to -16.5V								
Gain								
(Input Code 11....1)				±2			±2	
Unipolar Offset								
(Input Code 00....0)			±0.5			±0.5		
Bipolar Offset								ppm of
(Input Code 00....0)			±1.5			±1.5		FSR/%V_{ps}
V_{ps-} = -15V, V_{ps+} = 4.5V to 5.5V								
Gain								
(Input Code 11....1)				±1			±1	
Unipolar Offset								
(Input Code 00....0)			±0.5			±0.5		
Bipolar Offset								
(Input Code 00....0)			±1.5			±1.5		
OUTPUT CHARACTERISTICS								
Output Current								
Unipolar			-5.0			-5.0		mA
Bipolar			±2.5			±2.5		mA
Output Resistance			200			200		Ω
Output Capacitance			20			20		pF
Output Voltage Range (7)								
Unipolar			+5			+5		V
			+2.5			+2.5		V
Bipolar			±2.5			±2.5		V
			±1.25			±1.25		V
Output Compliance Limit (5)		-3		+10	-3		+10	V
Output Compliance Voltage (5)	Full		±1.5			±1.5		V
Output Noise Voltage (8)								
0.1Hz to 100Hz			10			10		μVp-p
0.1Hz to 1MHz			100			100		μVp-p
POWER REQUIREMENTS								
V_{ps+} (4)	Full	4.5	5	15	4.75	5	15	V
V_{ps-}	Full	13.5	15	16.5	13.5	15	16.5	V
I_{ps+} (All 1's or all 0's in	25°C		9			9		mA
(10) either TTL or CMOS Mode)	Full		20			20		mA
I_{ps-} (Same as above)	25°C		25			25		mA
(10)	Full		30			30		mA

NOTES

1. Absolute maximum ratings are limiting values, applied individually, beyond which the serviceability of the circuit may be impaired. Functional operation under any of these conditions is not necessarily implied.

2. The HI-5610 accepts digital input codes in binary format and may be user connected for any one of three binary codes. Straight binary, offset binary, or two's complement binary. (See operating instructions)

3. For TTL and DTL compatibility connect +5V to pin 1 and ground pin 2. The $V_{ps}+$ tolerance is ±10% for HI-5610-2, -8. And ± 5% for HI-5610-5.

4. For CMOS compatibility connect digital power supply ($+4.5V \leq V_{DD} \leq +10V$) to pin 1 and short pin 2 to pin 1.

5. See definitions.

6. Using an external op amp with internal span resistors and 24.9 Ω ± 1% external trim resistors in place of potentiometers R1 and R2. These errors are adjustable to zero using R1 and R2. (See operating instructions)

7. Using an external op amp and internal span resistors. (See operating instructions for connections)

8. Specified for digital input in all '1's or all '0's.

9. FSR is "Full Scale Range" and is 5V for ± 2.5V range, 2.5V for ± 1.25V range, etc., or 5mA (± 20%) for current output.

10. After 30 seconds warm-up.

DEFINITIONS OF SPECIFICATIONS

ACCURACY

NONLINEARITY - Nonlinearity of a D/A converter is an important measure of its accuracy. It describes the deviation from an ideal straight line transfer curve drawn between zero (all bits OFF) and full scale (all bits ON).

DIFFERENTIAL NONLINEARITY - For a D/A converter, it is the difference between the actual output voltage change and the ideal (1LSB) voltage change for a one bit change in code. A Differential Nonlinearity of ± 1LSB or less guarantees monotonicitiy; i.e., the output always increases and never decreases for and increasing input.

SETTLING TIME

Settling time is the time required for the output to settle to within the specified error band for any input code transition. It is usually specified for a full scale or major carry transition (01.........1 to 10.........0 or vice versa)

DRIFT

GAIN DRIFT - The change in full scale analog output over the specified temperature range expressed in parts per million of full scale range per °C (ppm of FSR/°C). Gain error is measured with respect to +25°C at high (T_H) and low (T_L) temperatures. Gain drift is calculated for both high (T_H -25°C) and low ranges (+25°C - T_L) by dividing the gain error by the respective change in temperature. The specification is the larger of the two representing worst case drift.

OFFSET DRIFT - The change in analog output with all bits OFF over the specified temperature range expressed in parts per million of full scale range per °C (ppm of FSR/°C). Offset error is measured with respect to +25°C at high (T_H) and low (T_L) temperatures. Offset Drift is calculated for both high (T_H -25°C) and low (+25°C -T_L) ranges by dividing the offset error by the respective change in temperature. The specification given is the larger of the two, representing worst case drift.

POWER SUPPLY SENSITIVITY

Power Supply Sensitivity is a measure of the change in gain and offset of the D/A converter resulting from a change in -15V, +5V or +15V supplies. It is specified under DC conditions and expressed as parts per million of full scale range per percent of change in power supply (ppm of FSR/%).

COMPLIANCE

Compliance voltage is the maximum output voltage range that can be tolerated and still maintain its specified accuracy. Compliance limit implies functional operation only and makes no claims to accuracy.

GLITCH

A glitch on the output of a D/A converter is a large transient spike resulting from unequal internal ON-OFF switching times. Worst case glitches usually occur at half-scale or the major carry code transition from 011.....1 to 100.....0 or vice versa. For example, if turn ON is greater than turn OFF for 011.....1 to 100.....0, an intermediate state of 000.....0 exists, such that, the output momentarily glitches to zero output. Matched switching times and fast switching will reduce glitches considerably.

OPERATING INSTRUCTIONS

DECOUPLING AND GROUNDING

For best accuracy and high speed performance, the grounding and decoupling scheme shown in Figure 1 should be used. Decoupling capacitors should be connected close to the HI-5610 (preferrably to the device pin) and should be tantalum or electrolytic bypassed with ceramic types for best high frequency noise rejection.

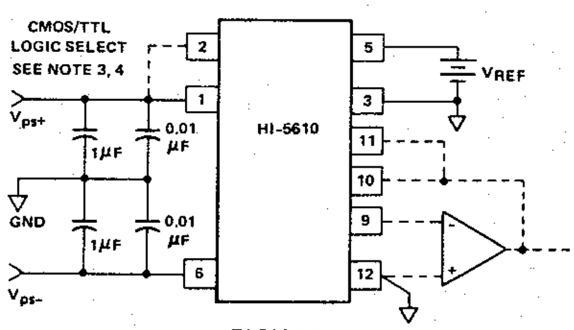


FIGURE 1

HIGH PERCISION PERFORMANCE

The output accuracy of the HI-5610 depends mainly on the accuracy of the voltage applied to the VREF input of HI-5610 and it can be described roughly as VREF/8KΩ = ¼ full scale output current. This means the output of HI-5610 will change whenever VREF varies. For high precision performance a precision +10V voltage reference with reasonably low temperature coefficient such as HA-1600 is highly recommended. For voltage output operation use an external op amp as current-to-voltage converter and the HI-5610 internal scaling resistors as feedback elements for optimum accuracy and temperature coefficient. The selected op amp should have a good front-end temperature coefficient such as HA-2600/2605 with offset voltage and offset current tempco's of 5μV/°C and 1nA/°C, respectively. The input reference resistor (7.975K Ω) and bipolar offset resistor (3.975K Ω) are both intentionally set low by 25 Ω to allow the user to externally trim-out initial errors to a very high degree of precision. For high speed voltage output applications where fast settling is required, the HA-2510/2515 is recommended for better than 1 μs settling to ½LSB.

UNIPOLAR VOLTAGE OUTPUT CONNECTIONS AND CALIBRATION

The connections for unipolar +5V and +2.5V voltage output using an external op amp and the internal span resistors are shown in Figure 2 and Figure 3, respectively.

CALIBRATION - UNIPOLAR

Step 1 Offset
- Turn all bits off (all 0's)
- Adjust R3 for zero volts output

Step 2 Gain
- Turn all bits on (all 1's)
- Adjust R1 for an output of FS-1LSB
  That is, adjust for:
  4.99512V for 0V to +5V range
  2.49756V for 0V to +2.5V range

UNIPOLAR - STRAIGHT BINARY
0V TO +5V OUTPUT RANGE

DIGITAL INPUT	ANALOG OUTPUT	
11 1	FS - 1LSB	= 4.99512V
10 0	½FS	= 2.50000V
01 1	½FS -1LSB	= 2.49512V
00 0	Zero	= 0.00000V

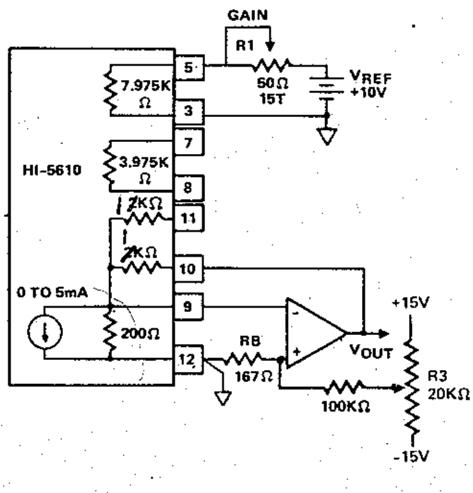


FIGURE 2

UNIPOLAR - STRAIGHT BINARY
0V TO +2.5V OUTPUT RANGE

DIGITAL INPUT	ANALOG OUTPUT	
11 1	FS - 1LSB	= 2.49756V
10 0	½FS	= 1.25000V
01 1	½FS -1LSB	= 1.24756V
00 0	Zero	= 0.00000V

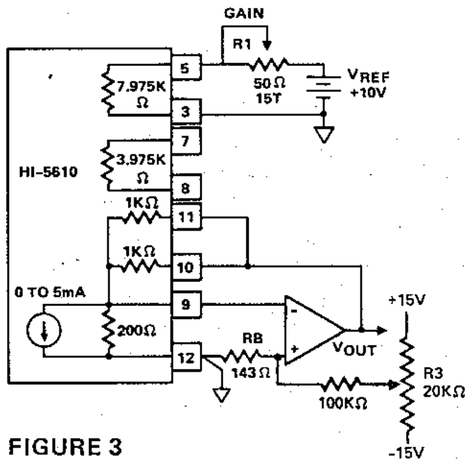


FIGURE 3

BIPOLAR VOLTAGE OUTPUT CONNECTIONS AND CALIBRATION

The connections for Bipolar ± 2.5V and ± 1.25V voltage output using an external op amp and the internal span resistors are shown in Figure 4 and Figure 5, respectively.

CALIBRATION - BIPOLAR

Step 1 Op Amp Null
- Short op amp output to op amp -input
- Adjust R3 for zero volts output

Step 2 Gain
- Turn all bits on (all 1's) record output voltage
- Turn all bits off (all 0's) record output voltage
- Adjust R1 till the difference between the readings is equal to:
  4.99512V for ± 2.5V range
  2.49756V for ±1.25V range.

Step 3 Offset
- Turn bit 1 (MSB) on, all other bits off (10....0)
- Adjust R2 for zero volts output

BIPOLAR - OFFSET BINARY
± 2.5V OUTPUT VOLTAGE RANGE

DIGITAL INPUT	ANALOG OUTPUT	
11 1	+FS - 1 LSB	= +2.49512V
10 0	ZERO	= +0.00000V
01 1	Zero - 1 LSB	= -0.00488V
00 0	-FS	= -2.50000V

BIPOLAR TWO'S COMPLEMENT **
± 2.5V OUTPUT VOLTAGE RANGE

DIGITAL INPUT	ANALOG OUTPUT	
01 1	+FS - 1LSB	= +2.49512V
00 0	Zero	= +0.00000V
11 1	Zero - 1LSB	= -0.00488V
10 0	-FS	= -2.50000V

** Invert MSB with external inverter to obtain two's complement coding.

BIPOLAR - OFFSET BINARY
± 1.25V OUTPUT VOLTAGE RANGE

DIGITAL INPUT	ANALOG OUTPUT	
11 1	+FS - 1LSB	= +1.24756V
10 0	Zero	= +0.00000V
01 1	Zero - 1LSB	= -0.00244V
00 0	-FS	= -1.25000V

BIPOLAR - TWO'S COMPLEMENT **
± 1.25V OUTPUT VOLTAGE RANGE

DIGITAL INPUT	ANALOG OUTPUT	
01 1	+FS - 1LSB	= +1.24756V
00 0	Zero	= +0.00000V
11 1	Zero - 1LSB	= -0.00244V
10	-FS	= -1.25000V

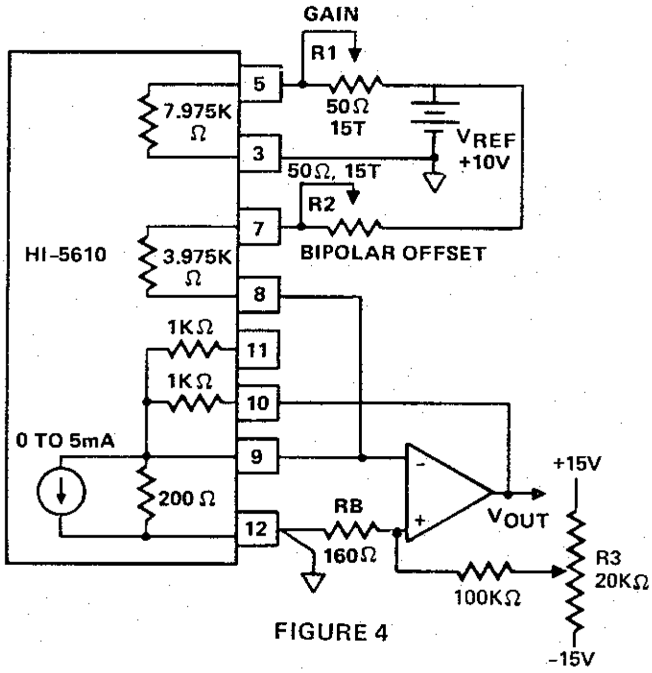


FIGURE 4

FIGURE 5