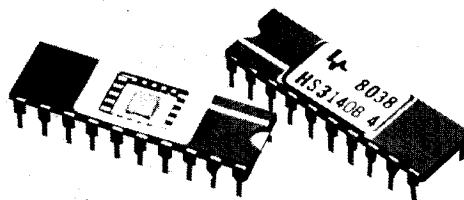


# MONOLITHIC 14-BIT MDAC

## FEATURES

- Monolithic CMOS circuit
- On-chip resistors
- Linearity  $\pm 0.004\%$
- Monotonic over temperature
- Latch-up protected
- Small size, 20 pin DIP
- Pin compatible to DAC-HA14B
- Commercial and MIL-STD-883 processing



## DESCRIPTION

The HS3140 is a 14-bit CMOS multiplying D/A converter integrated in a single monolithic chip. It represents a major advance in the field of monolithic converter technology, extending resolution and linearity to 14 bits and 0.003%. The HS3140 accepts AC or DC reference voltages, multiplies in all four quadrants, has latch-up protection, and is packaged in a hermetic 20 pin DIP. Outstanding features of the HS3140 include:

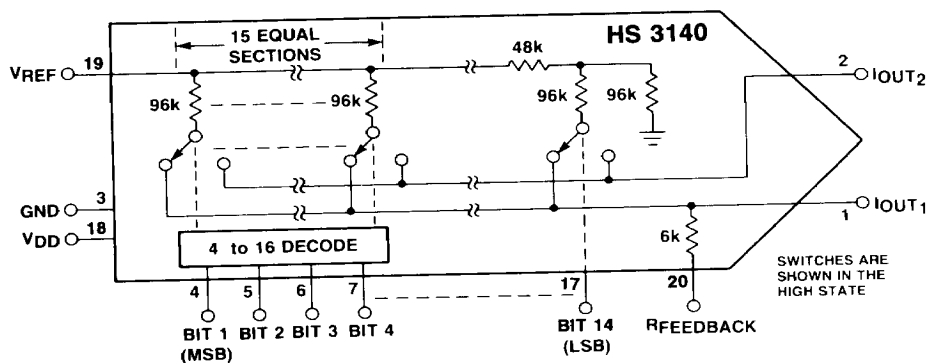
**14-Bit Performance** — HS3140 offers a 0.003% integral linearity and a 0.003% differential linearity and is monotonic over the entire specified operating temperature range. The excellent differential linearity is achieved by using a unique bit decoding technique. The transfer function is actually divided into 16 segments (determined by bits 1 to 4), each consisting of 1024 discrete voltage levels (determined by bits 5 to 14). Bits 1 to 4 are digitally decoded into 15 control signals, driving 15 equal

current sources, rather than 4 binarily weighted sources; thus, reducing the matching accuracy requirement on the resistors and CMOS switches.

**Monolithic Construction** — HS3140 is a single chip CMOS circuit using advanced design and manufacturing techniques. It is the industry's first monolithic digital-to-analog converter offering 14-bit resolution and a linearity of 0.003%.

**Processing** — The HS3140 is offered in two versions. The -C version is commercially processed for applications in the 0°C to 70°C range. The -B version operates in the -55°C to +125°C temperature range and is processed and screened to the requirements of MIL-M-38510 and MIL-STD-883C.

## FUNCTIONAL DIAGRAM



# SPECIFICATIONS

(Typical @ +25°C, nominal power supply,  $V_{REF} = +10V$ , unipolar unless otherwise noted)

<b>MODEL</b>	<b>HS 3140</b>
<b>TYPE</b>	<b>4 QUADRANT MULTIPLYING</b>

## DIGITAL INPUTS

Resolution	14-Bits
2-Quad. Unipolar Coding	Binary
4-Quad. Bipolar Coding	Offset Binary
Logic Compatibility <sup>1</sup>	CMOS, TTL
Input Current	<1µA

## REFERENCE INPUT<sup>2</sup>

Voltage Range	±25V (max), AC or DC
Input Impedance	6.5kΩ ± 50%

## ANALOG OUTPUT

Scale Factor	150µA/V <sub>REF</sub> ± 50%
Scale Factor Accuracy <sup>3, 4</sup>	±1% max
Output Leakage	
@ +25°C	10nA (max)
@ +125°C	200nA (max)
Output Capacitance	
C <sub>out</sub> 1, all inputs high	100 pF
C <sub>out</sub> 1, all inputs low	50 pF
C <sub>out</sub> 2, all inputs high	50 pF
C <sub>out</sub> 2, all inputs low	100 pF

## STATIC PERFORMANCE

Integral Linearity <sup>5</sup>	
HS 3140-3	±0.007% F.S.R. (typ)
	±0.012% F.S.R. (max)
HS 3140-4	±0.003% F.S.R. (typ)
	±0.006% F.S.R. (max)
Differential Linearity <sup>6</sup>	
HS 3140-3	±0.006% F.S.R. (typ)
	±0.012% F.S.R. (max)
HS 3140-4	±0.003% F.S.R. (typ)
	±0.006% F.S.R. (max)
Monotonicity	
HS 3140-3	Guaranteed to 13-Bits
HS 3140-4	Guaranteed to 14-Bits

## DYNAMIC PERFORMANCE

Digital Small Signal Settling	1µS
Digital Full Scale	
Transition Settling	2µS
Reference Feedthrough	
Error (V <sub>REF</sub> = 20Vpp)	
@ 1kHz	200µV
@ 10kHz	2mV

## STABILITY (Over specified Temp. Range)

Scale Factor <sup>3</sup>	4ppm/°C (typ)
Integral Linearity	0.5ppm F.S.R./°C (typ)
	1ppm F.S.R./°C (max)
Differential Linearity	0.5ppm F.S.R./°C (typ)
	1ppm F.S.R./°C (max)
Monotonicity Temp. Range	
HS 3140C-3/4	0°C to +70°C
HS 3140B-3/4	-25°C to +85°C

## POWER SUPPLY (V<sub>DD</sub>)<sup>7</sup>

Nominal Voltage	+15V ±5%
Maximum Voltage Range	+11V to +18V
Current	2mA
Rejection Ratio	.005%/%

## TEMPERATURE RANGE

Operating HS 3140C-3/4	0°C to +70°C
Operating HS 3140B-3/4	-55°C to +125°C
Storage	-65°C to +150°C

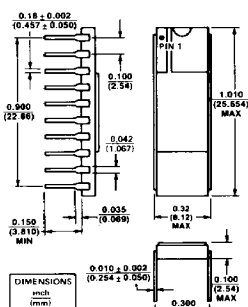
## MECHANICAL

Case Style	20 pin DIP, ceramic
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## NOTES

- 0.5V < "0" < +0.8V, 2.4V < "1" ≤ V<sub>DD</sub>, Worst Case.
- We recommend our HS REF 01 or R675B-1 for fixed reference application.
- Using the internal feedback resistor and an external Opamp.
- The Scale Factor can be adjusted externally by variable resistors in series with the reference input and/or in series to the internal feedback resistor (See APPLICATIONS INFORMATION).
- Integral Linearity is measured as the arithmetic mean value of the magnitudes of the greatest positive deviation and the greatest negative deviation from the theoretical value for any given input combination.
- Differential Linearity is the deviation of an output step from the theoretical value of 1 LSB for any two adjacent digital input codes.
- A 400Ω resistor should be added in series with V<sub>DD</sub> and by-passed by a 0.1µF capacitor.

## Case Dimensions

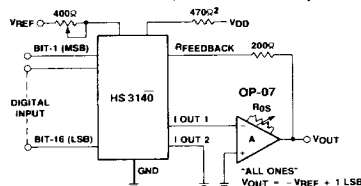


## Pin Assignments

PIN	FUNCTION	PIN	FUNCTION
1	OUTPUT 1, IOUT 1	20	R FEEDBACK
2	OUTPUT 2, IOUT 2	19	V <sub>REF</sub>
3	GND	18	+V <sub>DD</sub>
4	BIT 1 (MSB)	17	BIT 14
5	BIT 2	16	BIT 13
6	BIT 3	15	BIT 12
7	BIT 4	14	BIT 11
8	BIT 5	13	BIT 10
9	BIT 6	12	BIT 9
10	BIT 7	11	BIT 8

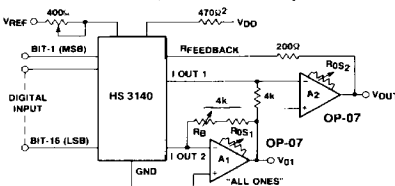
# APPLICATIONS INFORMATION

## UNIPOLAR OPERATION (2-Quadrant Multiplication)



NOTES:  
1. To maintain specified HS 3140 linearity, the external amplifier (A) must be zeroed. With a digital input of 10, 0 and V<sub>REF</sub> set to zero.  
2. Apply an ALL "ZEROS" digital input and adjust R<sub>FB</sub> for V<sub>OUT</sub> = 0 ± 1mV.  
3. Series resistor recommended to limit current during turn-on.

## BIPOLAR OPERATION (4-Quadrant Multiplication)



NOTES:  
1. To maintain specified HS 3140 linearity, external amplifiers (A<sub>1</sub> and A<sub>2</sub>) must be zeroed. With a digital input of 10, 0 and V<sub>REF</sub> set to zero.  
a) Set R<sub>FB1</sub> for V<sub>OUT1</sub> = 0  
b) Set R<sub>FB2</sub> for V<sub>OUT2</sub> = 0  
c) Set V<sub>DD</sub> to +10V and adjust R<sub>FB</sub> for V<sub>OUT</sub> to be 0 Volts  
2. Series resistor recommended to limit current during turn-on.

## UNIPOLAR OPERATION

### Transfer Characteristics

BINARY INPUT	ANALOG OUTPUT
111...111	-V <sub>REF</sub> (1-2 <sup>-N</sup> )
100...001	-V <sub>REF</sub> (1/2 + 2 <sup>-N</sup> )
100...000	-V <sub>REF</sub> /2
011...111	-V <sub>REF</sub> (1/2 - 2 <sup>-N</sup> )
000...001	-V <sub>REF</sub> (2 <sup>-N</sup> )
000...000	0

## BIPOLAR OPERATION

### Transfer Characteristics

OFFSET BINARY INPUT	ANALOG OUTPUT
111...111	-V <sub>REF</sub> (1-2 <sup>-N</sup> )
100...001	-V <sub>REF</sub> (2 <sup>-N</sup> -1)
100...000	0
011...001	V <sub>REF</sub> (2 <sup>-N</sup> -1)
000...001	V <sub>REF</sub> (1-2 <sup>-N</sup> )
000...000	V <sub>REF</sub>

**CAUTION:** ESD (Electro-Static Discharge) sensitive device. Permanent damage may occur when unconnected devices are subjected to high energy electrostatic fields. Unless otherwise noted, the voltage at any digital input should never exceed the supply voltage by more than 0.5 volts or go below -0.5 volts.

# ORDERING INFORMATION

MODEL	DESCRIPTION
HS 3140C-3	14-Bit MDAC, 0.006% Lin. Commercial
HS 3140C-4	14-Bit MDAC, 0.003% Lin. Commercial
HS 3140B-3	14-Bit MDAC, 0.006% Lin. MIL-STD-883C
HS 3140B-4	14-Bit MDAC, 0.003% Lin. MIL-STD-883C

Specifications subject to change without notice.