IH5140 thru IH5145

High-Level CMOS Analog Switch

December 1993

Features

- **Super Fast Break-Before-Make Switching**
- **t_{ON} 80ns Typ, t_{OFF} 50ns Typ (SPST Switches)**
- **Power Supply Currents Less Than 1μA**
- **OFF Leakages Less Than 100pA at +25°C Typical**
- **Non-Latching with Supply Turn-Off**
- **Single Monolithic CMOS Chip**
- **Plug-In Replacements for IH5040 Family and Part of the DG180 Family to Upgrade Speed and Leakage**
- **Greater Than 1MHz Toggle Rate**
- **Switches Greater Than 20Vp-p Signals with ±15V Supplies**
- **TTL, CMOS Direct Compatibility**
- **Internal Diode in Series with V+ for Fault Protection**

Description

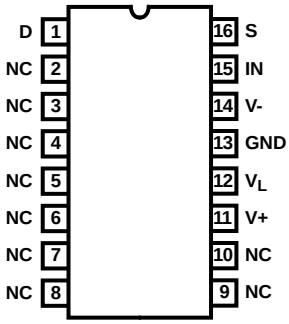
The IH5140 Family of CMOS switches utilizes Harris' latch-free junction isolated processing to build the fastest switches currently available. These switches can be toggled at a rate of greater than 1MHz with fast t_{ON} times (80ns typical) and faster t_{OFF} times (50ns typical), guaranteeing break before make switching. This family of switches combines the speed of the hybrid FET DG180 family with the reliability and low power consumption of a monolithic CMOS construction.

Very low quiescent power is dissipated in either the ON or the OFF state of the switch. Maximum power supply current is 10μA (at +25°C) from any supply and typical quiescent currents are in the 10nA which makes these devices ideal for portable equipment and military applications.

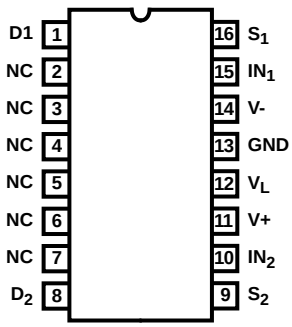
The IH5140 Family is completely compatible with TTL (5V) logic, TTL open collector logic and CMOS logic. It is pin compatible with Harris' IH5040 family and part of the DG180/DG190 family as shown in the switching state diagrams.

Pinouts

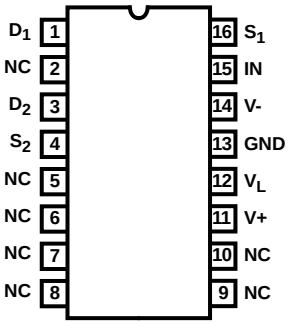
IH5140
(PDIP, CDIP)
TOP VIEW



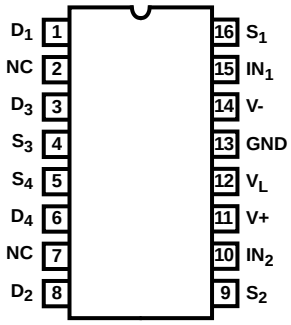
IH5141
(PDIP, CDIP)
TOP VIEW



IH5142
(PDIP, CDIP)
TOP VIEW



IH5143
(PDIP, CDIP)
TOP VIEW

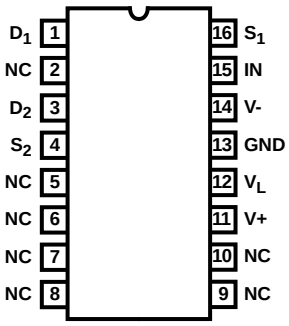


CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper I.C. Handling Procedures.

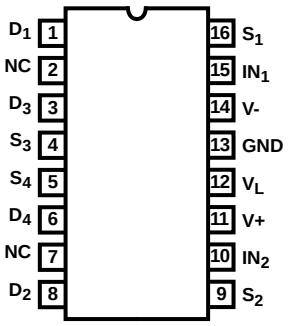
File Number **3132**

Pinouts (Continued)

IH5144
(PDIP, CDIP)
TOP VIEW



IH5145
(PDIP, CDIP)
TOP VIEW



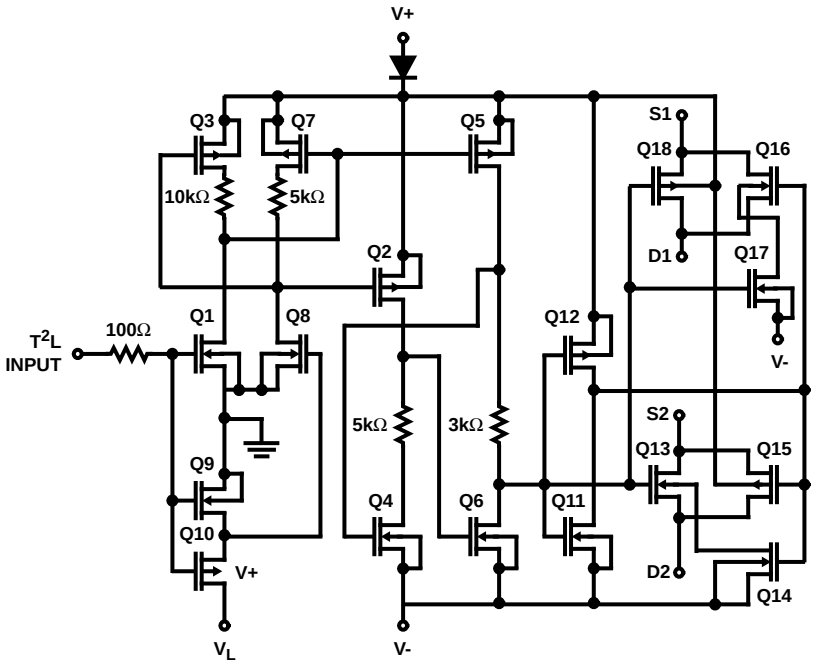
Ordering Information

PART NUMBER	FUNCTION	TEMPERATURE RANGE	PACKAGE
IH5140MJE	SPST	-55°C to +125°C	16 Lead Ceramic DIP
IH5140CJE	SPST	0°C to +70°C	16 Lead Ceramic DIP
IH5140CPE	SPST	0°C to +70°C	16 Lead Plastic DIP
IH5141MJE	Dual SPST	-55°C to +125°C	16 Lead Ceramic DIP
IH5141CJE	Dual SPST	0°C to +70°C	16 Lead Ceramic DIP
IH5141CPE	Dual SPST	0°C to +70°C	16 Lead Plastic DIP
IH5142MJE	SPDT	-55°C to +125°C	16 Lead Ceramic DIP
IH5142CJE	SPDT	0°C to +70°C	16 Lead Ceramic DIP
IH5142CPE	SPDT	0°C to +70°C	16 Lead Plastic DIP
IH5143MJE	Dual SPDT	-55°C to +125°C	16 Lead Ceramic DIP
IH5143CJE	Dual SPDT	0°C to +70°C	16 Lead Ceramic DIP
IH5143CPE	Dual SPDT	0°C to +70°C	16 Lead Plastic DIP
IH5144MJE	DPST	-55°C to +125°C	16 Lead Ceramic DIP
IH5144CJE	DPST	0°C to +70°C	16 Lead Ceramic DIP
IH5144CPE	DPST	0°C to +70°C	16 Lead Plastic DIP
IH5145MJE	Dual DPST	-55°C to +125°C	16 Lead Ceramic DIP
IH5145CJE	Dual DPST	0°C to +70°C	16 Lead Ceramic DIP
IH5145CPE	Dual DPST	0°C to +70°C	16 Lead Plastic DIP
IH5140MJE/883B	SPST	-55°C to +125°C	16 Lead Ceramic DIP
IH5141MJE/883B	Dual SPST	-55°C to +125°C	16 Lead Ceramic DIP
IH5142MJE/883B	SPDT	-55°C to +125°C	16 Lead Ceramic DIP
IH5143MJE/883B	Dual SPDT	-55°C to +125°C	16 Lead Ceramic DIP
IH5144MJE/883B	DPST	-55°C to +125°C	16 Lead Ceramic DIP
IH5145MJE/883B	Dual DPST	-55°C to +125°C	16 Lead Ceramic DIP

NOTES:

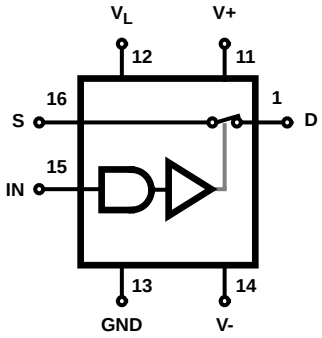
1. For MIL-STD-883 compliant parts, request the /883 datasheet on the above products.

Functional Block Diagram

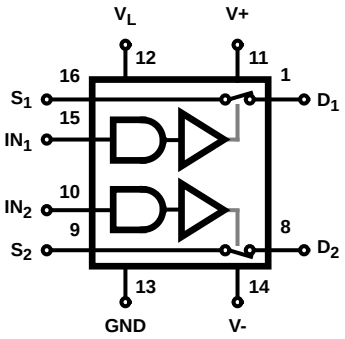


TYPICAL DRIVER/GATE - IH5142

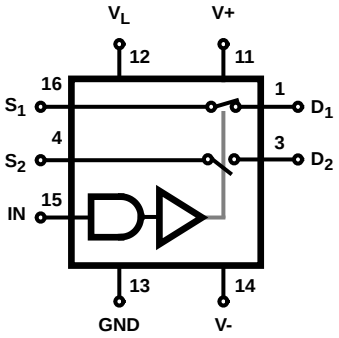
Switching State Diagrams



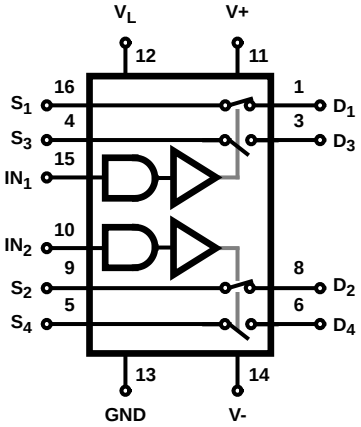
DIP (JE, PE)
SPST IH5140



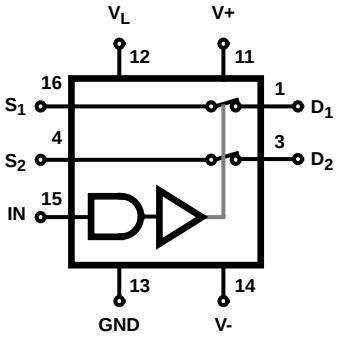
DIP (JE, PE)
DUAL SPST IH5141



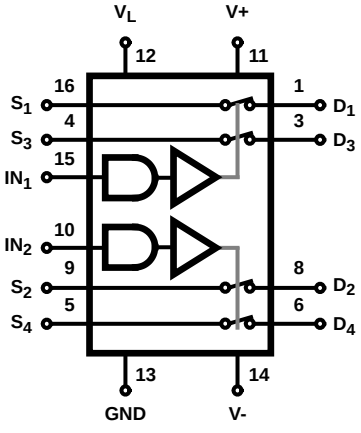
DIP(JE, PE)
SPDT IH5142



DIP (JE, PE)
DUAL SPDT IH5143



DIP (JE, PE)
DPST IH5144



DIP (JE, PE)
DUAL DPST IH5145

Absolute Maximum Ratings

V+ to V- . . . . . <36V
V+ to V_D . . . . . <30V
V_D to V- . . . . . <30V
V_D to V_S . . . . . <±22V
V_L to V- . . . . . <33V
V_L to V_{IN} . . . . . <30V
V_L to GND . . . . . <20V
V_{IN} to GND . . . . . <20V
Current (Any Terminal) 30mA
Storage Temperature . . . . . -65°C to +150°C
Lead Temperature (Soldering 10s) . . . . . +300°C

Thermal Information

Thermal Resistance	θ_{JA}	θ_{JC}
Ceramic DIP Package	80°C/W	24°C/W
Plastic DIP Package	100°C/W	-

Operating Temperature
M . . . . . -55°C to +125°C
C . . . . . 0°C to +70°C
Junction Temperature
Ceramic DIP Package . . . . . +175°C
Plastic DIP Package . . . . . +150°C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Electrical Specifications

+25°C, V+ = +15V, V- = -15V, V_L = +5V

PER CHANNEL PARAMETERS	TEST CONDITIONS	MILITARY			COMMERCIAL			UNITS
		-55°C	+25°C	+125°C	0°C	+25°C	+70°C	
LOGIC INPUT								
Input Logic Current, I_{INH}	V_{IN} = 2.4V, Note 1	±1	±1	10	–	±10	10	µA
Input Logic Current, I_{INL}	V_{IN} = 0.8V, Note 1	±1	±1	10	–	±10	10	µA
SWITCH								
Drain Source On Resistance, $R_{DS(ON)}$	I_S = -10mA, V_{ANALOG} = -10V to +10V	50	50	75	75	75	100	Ω
Channel to Channel $R_{DS(ON)}$ Match, $\Delta R_{DS(ON)}$		-	25 (Typ)	-	-	30 (Typ)	-	Ω
Minimum Analog Signal Handling Capability, V_{ANALOG}		-	±11 (Typ)	-	-	±10 (Typ)	-	V
Switch OFF Leakage Current, $I_{D(OFF)}+I_{S(OFF)}$	V_D = +10V, V_S = -10V	-	±0.5	100	-	±5	100	nA
	V_D = -10V, V_S = +10V	-	±0.5	100	-	±5	100	nA
Switch On Leakage Current, $I_{D(ON)}+I_{S(ON)}$	V_D = V_S = -10V to +10V	-	±1	200	-	±2	200	nA
Minimum Channel to Channel Cross Coupling Rejection Ratio, CCRR	One Channel Off; Any Other Channel Switches, See Performance Characteristics	-	54 (Typ)	-	-	50 (Typ)	-	dB
Switch "ON" Time, t_{ON}	See switching time specifications and timing diagrams							
Switch "OFF" Time, t_{OFF}	See switching time specifications and timing diagrams							
Charge Injection, $Q_{(INJ)}$	See Performance Characteristics	-	10 (Typ)	-	-	15 (Typ)	-	pC
Minimum Off Isolation Rejection Ratio, OIRR	f = 1MHz, R_L = 100Ω, $C_L \leq$ 5pF, See Performance Characteristics	-	54 (Typ)	-	-	50 (Typ)	-	dB
SUPPLY								
+ Power Supply Quiescent Current, I+	V+ = +15V, V- = -15V, V_L = +5V, See Performance Characteristics	1.0	1.0	10	10	10	100	µA
- Power Supply Quiescent Current, I-		1.0	1.0	10	10	10	100	µA
+5V Supply Quiescent Current, I_L		1.0	1.0	10	10	10	100	µA
Ground Supply Quiescent Current, I_{GND}		1.0	1.0	10	10	10	100	µA

NOTE:

1. Some channels are turned on by high (1) logic inputs and other channels are turned on by low (0) inputs; however 0.8V to 2.4V describes the minimum range for switching properly. Refer to logic diagrams to find logical value of logic input required to produce ON or OFF state.
2. Typical values are for design aid only, not guaranteed and not subject to production testing.

Switching Time Specifications (t_{ON}, t_{OFF} are Maximum Specifications and t_{ON} - t_{OFF} is Minimum Specification)

PART NUMBER	SPECIFICATIONS	TEST CONDITIONS	MILITARY			COMMERCIAL			UNITS
			-55°C	+25°C	+125°C	0°C	+25°C	+70°C	
IH5140, IH5141	Switch "ON" Time, t_{ON}	Figure 8, Note 2	-	100	-	-	150	-	ns
	Switch "OFF" Time, t_{OFF}		-	75	-	-	125	-	ns
	Break-Before-Make, t_{ON} - t_{OFF}		-	10	-	-	5	-	ns
	Switch "ON" Time, t_{ON}	Figure 7	-	150	-	-	175	-	ns
	Switch "OFF" Time, t_{OFF}		-	125	-	-	150	-	ns
IH5142, IH5143	Switch "ON" Time, t_{ON}	Figure 8, Note 2	-	175	-	-	250	-	ns
	Switch "OFF" Time, t_{OFF}		-	125	-	-	150	-	ns
	Break-Before-Make, t_{ON} - t_{OFF}		-	10	-	-	5	-	ns
	Switch "ON" Time, t_{ON}	Figure 7	-	200	-	-	300	-	ns
	Switch "OFF" Time, t_{OFF}		-	125	-	-	150	-	ns
	Switch "ON" Time, t_{ON}	Figure 2, Note 2	-	175	-	-	250	-	ns
	Switch "OFF" Time, t_{OFF}		-	125	-	-	150	-	ns
	Break-Before-Make, t_{ON} - t_{OFF}		-	10	-	-	5	-	ns
	Switch "ON" Time, t_{ON}	Figure 3, Note 2	-	200	-	-	300	-	ns
	Switch "OFF" Time, t_{OFF}		-	125	-	-	150	-	ns
	Break-Before-Make, t_{ON} - t_{OFF}		-	10	-	-	5	-	ns
IH5144, IH5145	Switch "ON" Time, t_{ON}	Figure 8, Note 2	-	175	-	-	250	-	ns
	Switch "OFF" Time, t_{OFF}		-	125	-	-	150	-	ns
	Break-Before-Make, t_{ON} - t_{OFF}		-	10	-	-	5	-	ns
	Switch "ON" Time, t_{ON}	Figure 7	-	200	-	-	300	-	ns
	Switch "OFF" Time, t_{OFF}		-	125	-	-	150	-	ns

NOTES:

1. Switching times are measured at 90% points.
2. Typical values are for design aid only, not guaranteed and not subject to production testing.

Typical Performance Curves

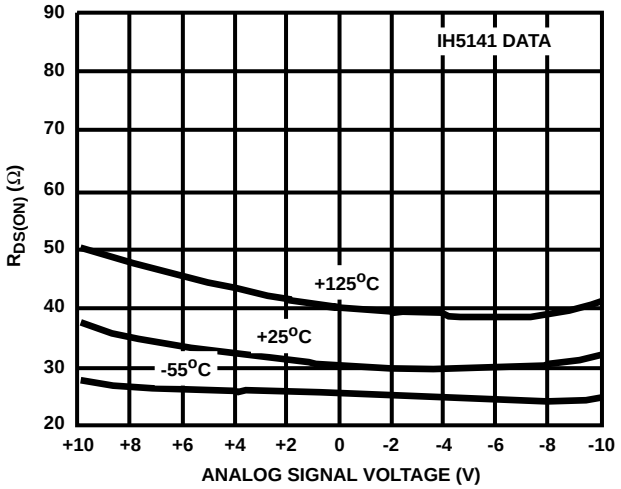


FIGURE 1. $R_{DS(ON)}$ vs TEMPERATURE AT ±15V, +5V SUPPLIES

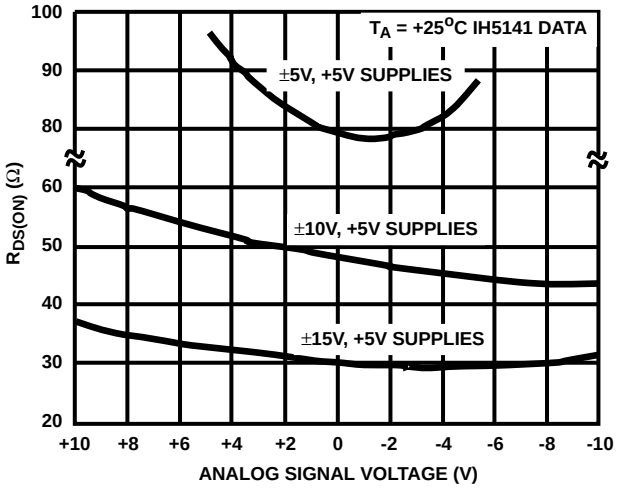
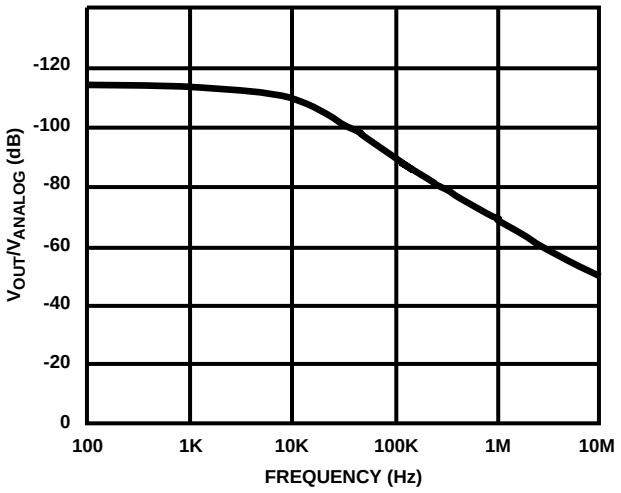
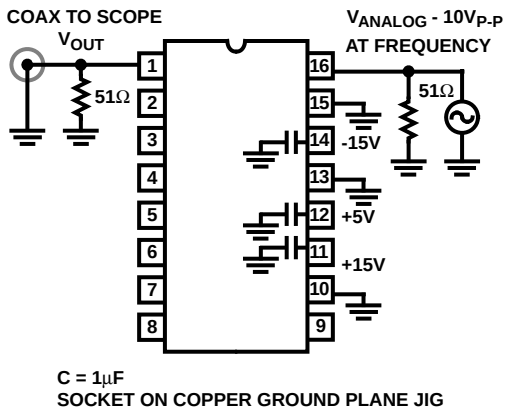


FIGURE 2. $R_{DS(ON)}$ vs POWER SUPPLIES

Typical Performance Curves (Continued)

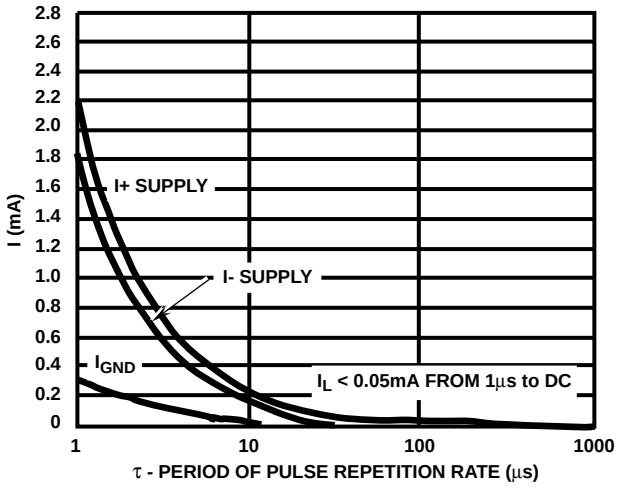


3A.

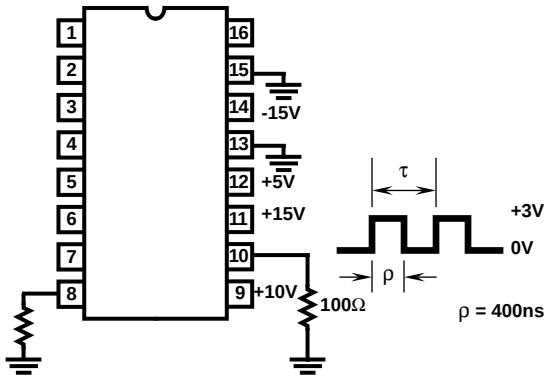


3B.

FIGURE 3. "OFF" ISOLATION vs FREQUENCY

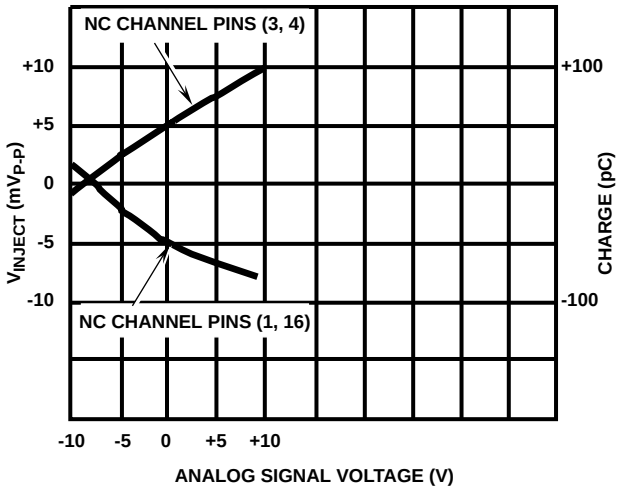


4A.

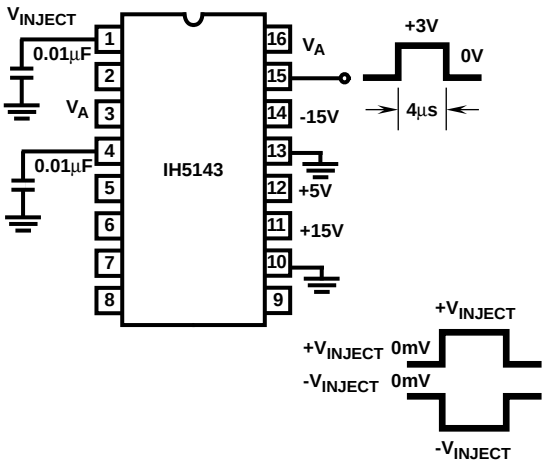


4B.

FIGURE 4. POWER SUPPLY CURRENTS vs LOGIC STROBE RATE



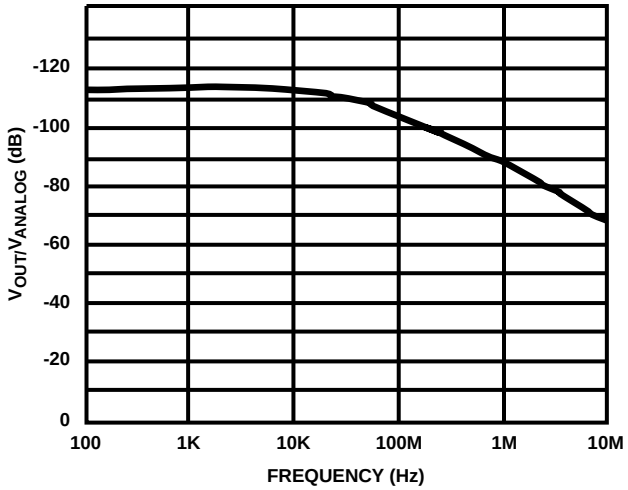
5A.



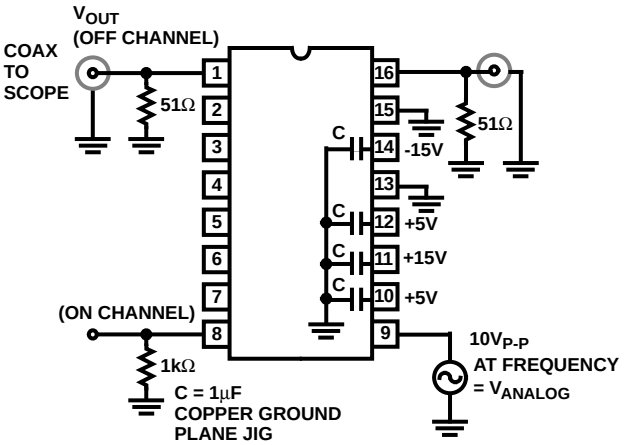
5B.

FIGURE 5. CHARGE INJECTION vs ANALOG SIGNAL

Typical Performance Curves (Continued)



6A.



6B.

FIGURE 6. CHANNEL TO CHANNEL CROSS COUPLING REJECTION vs FREQUENCY

Test Circuits

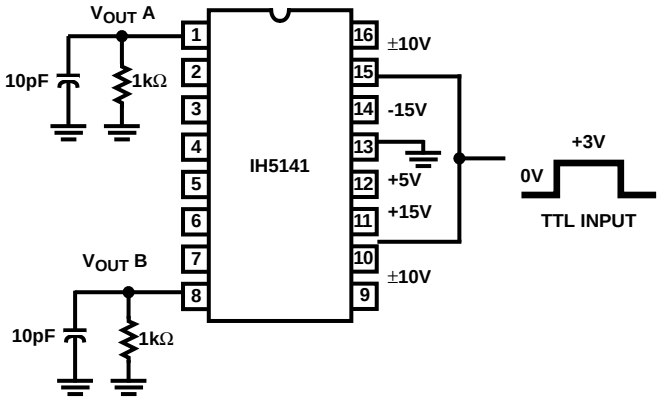
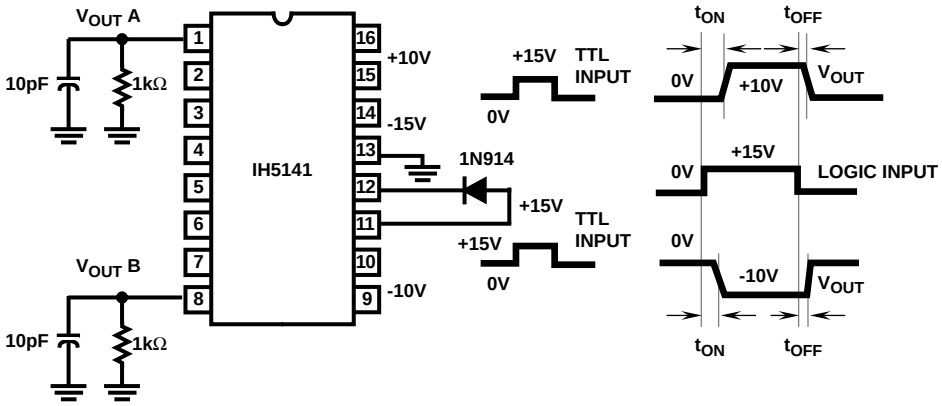


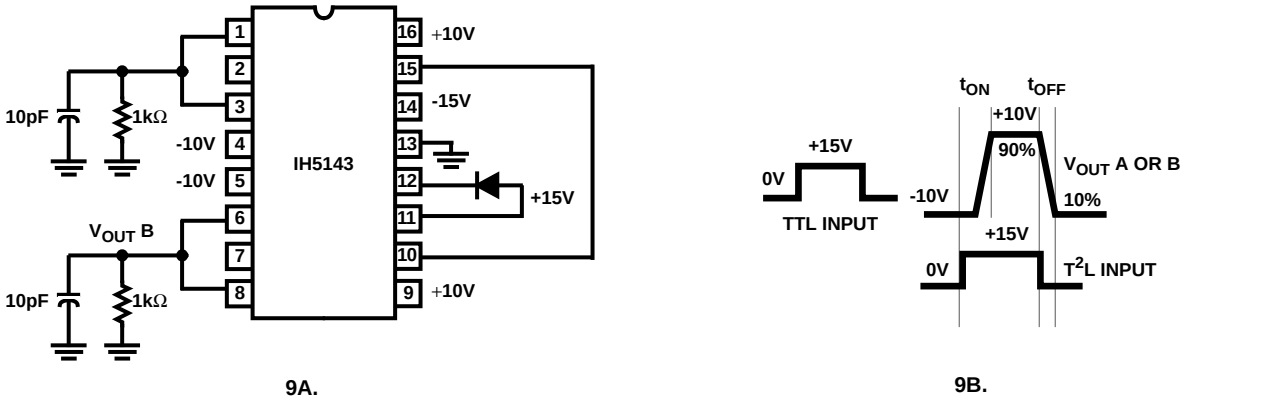
FIGURE 7. IH5141 t_{ON} AND t_{OFF} (3V DIGITAL INPUT)



NOTE: SWITCHING TIMES ARE MEASURED AT 90% POINTS

FIGURE 8. IH5141 t_{ON} AND t_{OFF} (15V DIGITAL INPUT)

Test Circuits (Continued)



9A. 9B.

FIGURE 9. IH5143 t_{ON} AND t_{OFF} (15V DIGITAL INPUT)

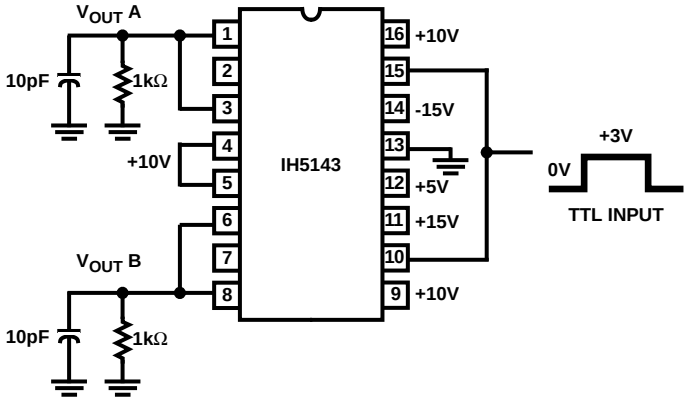


FIGURE 10. IH5143 t_{ON} AND t_{OFF} (3V DIGITAL INPUT)

Typical Applications

To maximize switching speed on the IH5140 family, TTL open collector logic (15V with a 1kΩ or less collector resistor) should be used. This configuration will result in (SPST) t_{ON} and t_{OFF} times of 80ns and 50ns, for signals between -10V and +10V. The SPDT and DPST switches are approximately 30ns slower in both t_{ON} and t_{OFF} with the same drive configuration. 15V CMOS logic levels can be used (0V to +15V), but propagation delays in the CMOS logic will slow down the switching (typical 50ns → 100ns delays).

When driving the IH5140 Family from either +5V TTL or CMOS logic, switching times run 20ns slower than if they were driven from +15V logic levels. Thus t_{ON} is about 105ns, and t_{OFF} 75ns for SPST switches, and 135ns and 105ns (t_{ON}, t_{OFF}) for SPDT or DPST switches. The low level drive can be made as fast as the high level drive if ±5V strobe levels are used instead of the usual 0V → +3.0V drive. Pin 13 is taken to -5V instead of the usual GND and strobe input is taken from +5V to -5V levels as shown in Figure 11.

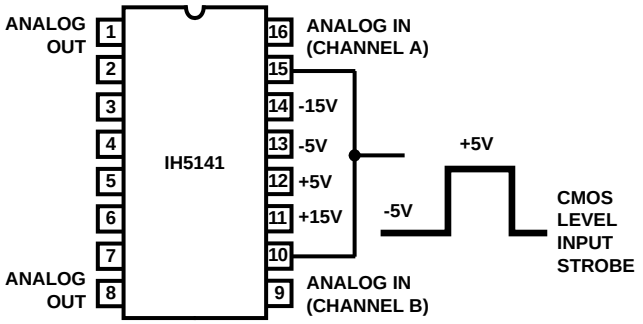


FIGURE 11.

The typical channel of the IH5140 family consists of both P and N-channel MOSFETs. The N-channel MOSFET uses a "Body Puller" FET to drive the body to -15V (±15V supplies) to get good breakdown voltages when the switch is in the off state (see Figure 12). This "Body Puller" FET also allows the N-channel body to electrically float when the switch is in the

on state producing a fairly constant $R_{DS(ON)}$ with different signal voltages. While this “Body Puller” FET improves switch performance, it can cause a problem when analog input signals are present (negative signals only) and power supplies are off. This fault condition is shown in Figure 13.

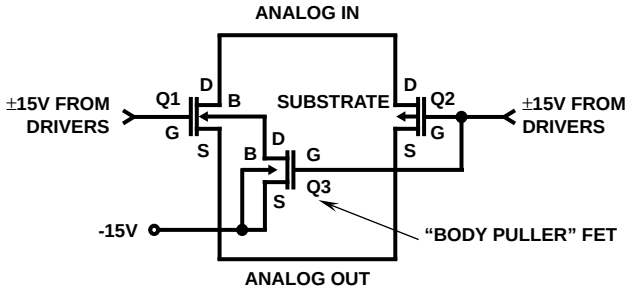


FIGURE 12.

Current will flow from -10V analog voltage through the drain to body junction of Q1, then through the drain to body junction of Q3 to GND. This means that there is 10V across two forward-biased silicon diodes and current will go to whatever value the input signal source is capable of supplying. If the analog input signal is derived from the same supplies as the switch this fault condition cannot occur. Turning off the supplies would turn off the analog signal at the same time.

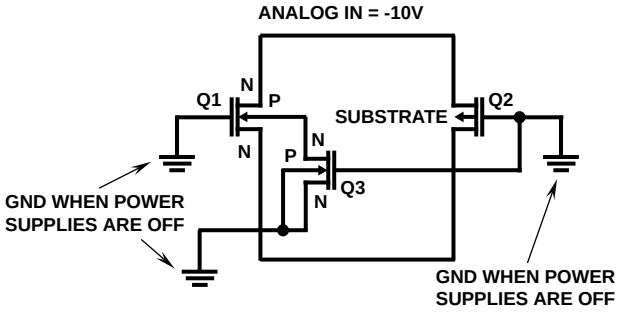


FIGURE 13.

This fault situation can also be eliminated by placing a diode in series with the negative supply line (pin 14) as shown in Figure 14. Now when the power supplies are off and a negative input signal is present this diode is reverse biased and no current can flow.

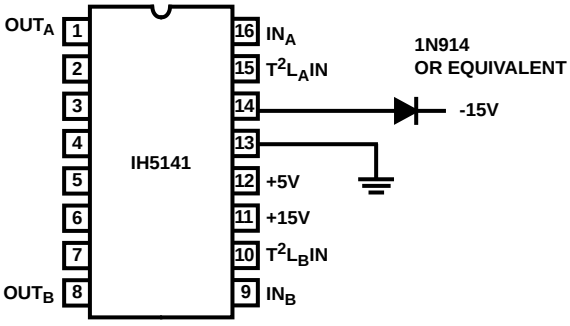
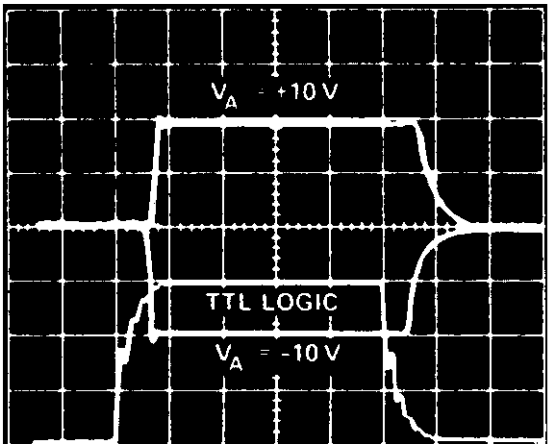
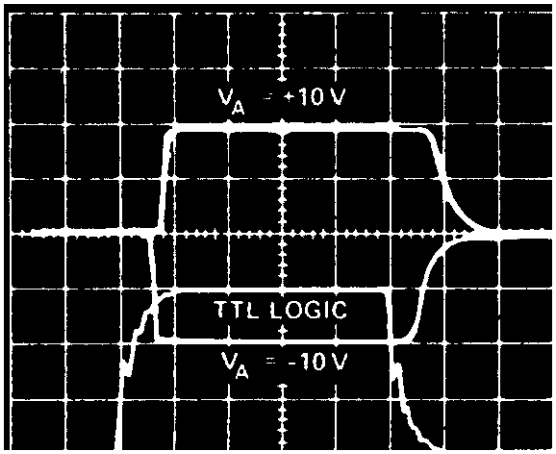


FIGURE 14.

Typical Switching Waveforms (Scale: Vertical = 5V/DIV., Horizontal = 100ns/DIV.)

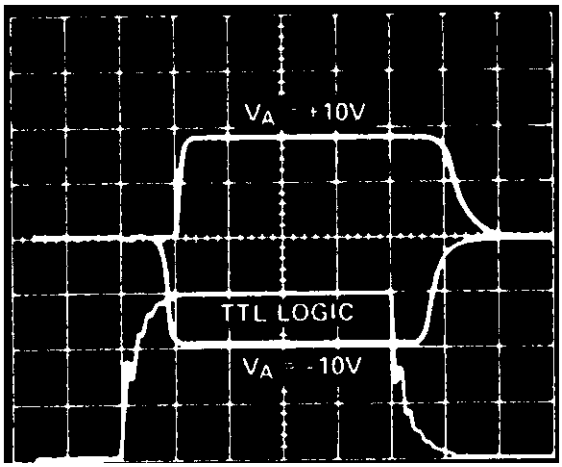


15A. -55°C



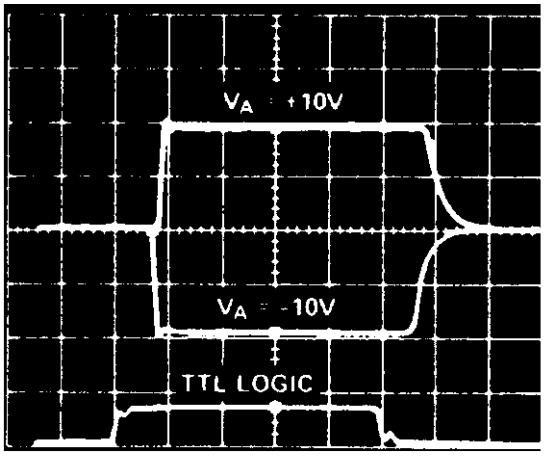
15B. +25°C

Typical Switching Waveforms (Scale: Vertical = 5V/DIV., Horizontal = 100ns/DIV.) (Continued)

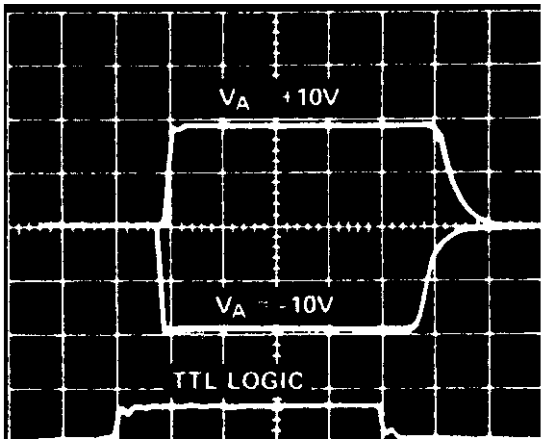


15C. +125°C

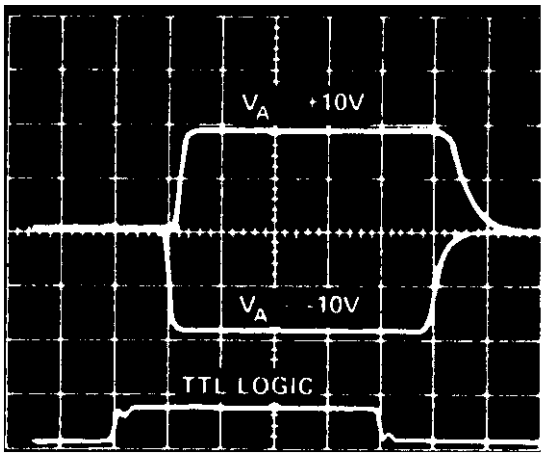
FIGURE 15. TTL OPEN COLLECTOR LOGIC DRIVE
(Corresponds to Figure 12)



16A. -55°C



16B. +25°C



16C. +125°C

FIGURE 16. TTL OPEN COLLECTOR LOGIC DRIVE
(Corresponds to Figure 13)

Typical Switching Waveforms (Scale: Vertical = 5V/DIV., Horizontal = 100ns/DIV.) (Continued)

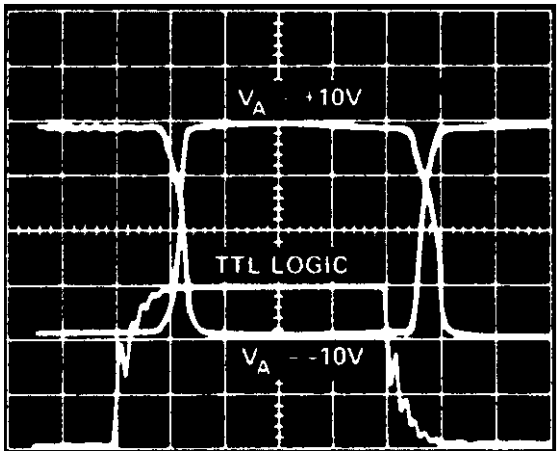


FIGURE 17. +25°C TTL OPEN COLLECTOR LOGIC DRIVE
(Corresponds to Figure 14)

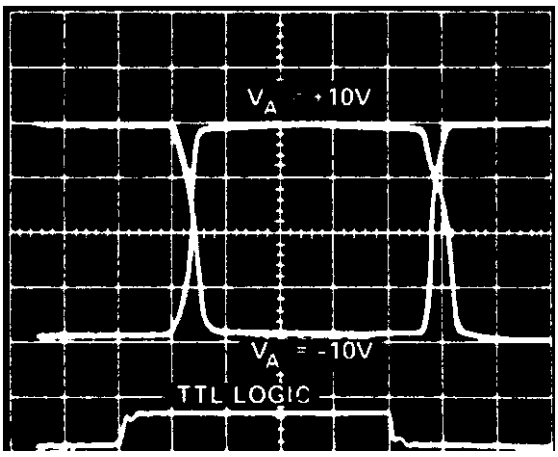


FIGURE 18. +25°C TTL OPEN COLLECTOR LOGIC DRIVE
(Corresponds to Figure 19)

Typical Applications

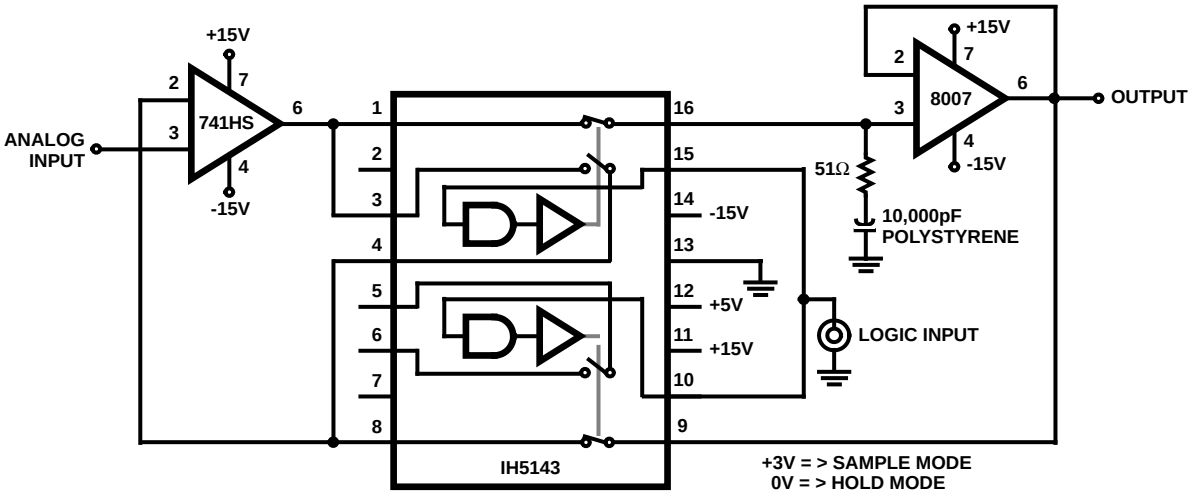


FIGURE 19. IMPROVED SAMPLE AND HOLD USING IH5143

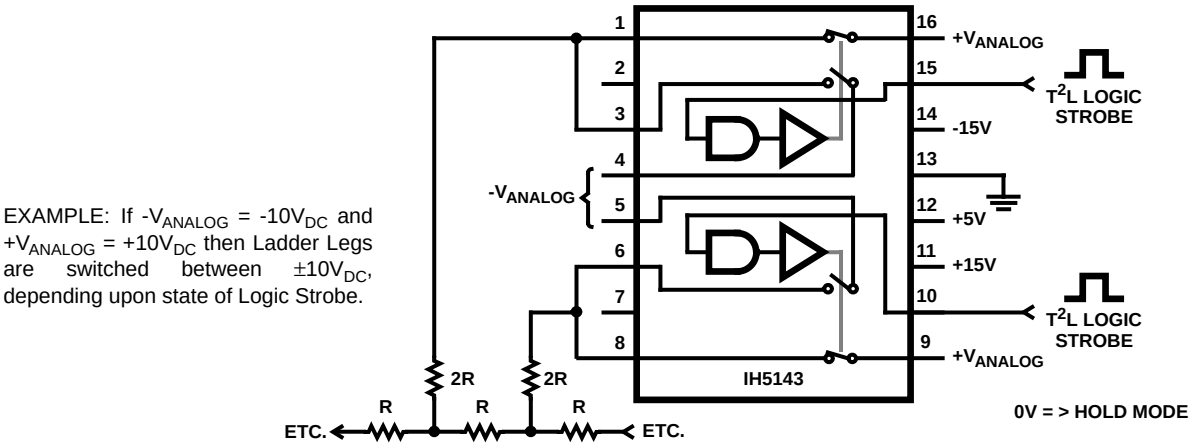
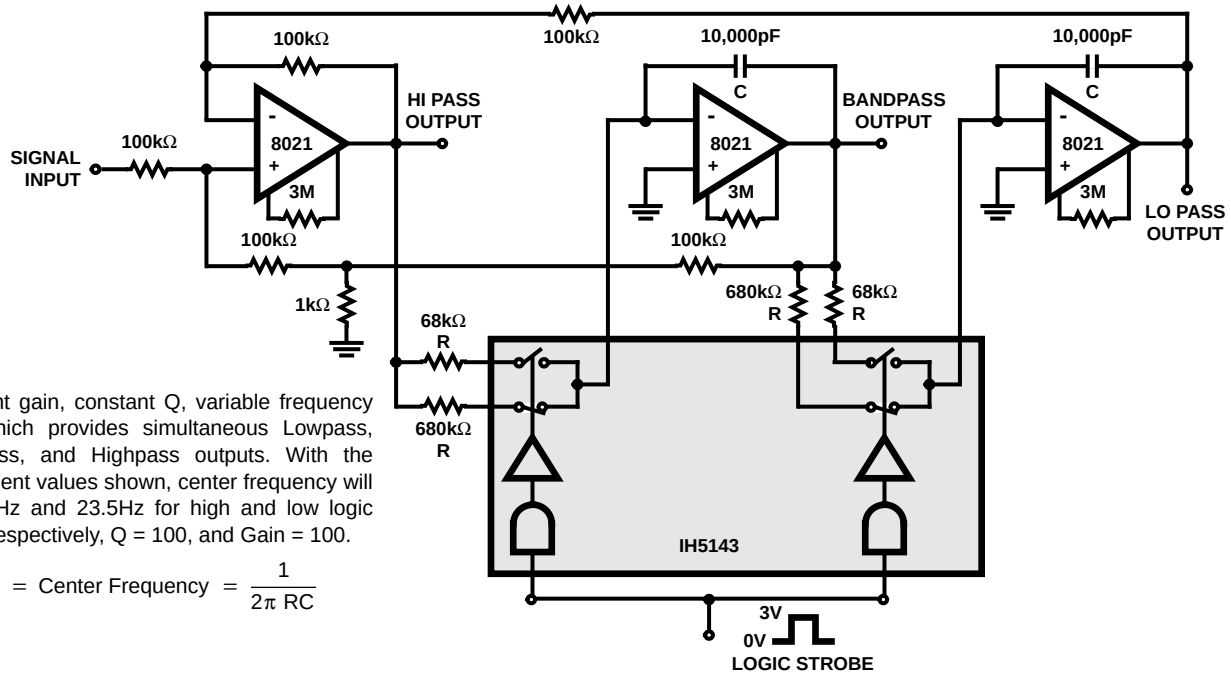


FIGURE 20. USING THE CMOS SWITCH TO DRIVE AN R/2R LADDER NETWORK (2 LEGS)

Typical Applications (Continued)



Constant gain, constant Q, variable frequency filter which provides simultaneous Lowpass, Bandpass, and Highpass outputs. With the component values shown, center frequency will be 235Hz and 23.5Hz for high and low logic inputs respectively, Q = 100, and Gain = 100.

$$f_N = \text{Center Frequency} = \frac{1}{2\pi RC}$$

FIGURE 21. DIGITALLY TUNED LOW POWER ACTIVE FILTER