

Numerically Controlled Oscillator/Modulator

The Intersil HSP45116/883 combines a high performance quadrature numerically controlled oscillator (NCO) and a high speed 16-bit Complex Multiplier/Accumulator (CMAC) on a single IC. This combination of functions allows a complex vector to be multiplied by the internally generated (cos, sin) vector for quadrature modulation and demodulation. As shown in the Block Diagram, the HSP45116/883 is divided into three main sections. The Phase/Frequency Control Section (PFCS) and the Sine/Cosine Section together form a complex NCO. The CMAC multiplies the output of the Sine/Cosine Section with an external complex vector.

The inputs to the Phase/Frequency Control Section consist of a microprocessor interface and individual control lines. The phase resolution of the PFCS is 32 bits, which results in frequency resolution better than 0.006Hz at 25.6MHz. The output of the PFCS is the argument of the sine and cosine. The spurious free dynamic range of the complex sinusoid is greater than 90dBc.

The output vector from the Sine/Cosine Section is one of the inputs to the Complex Multiplier/Accumulator. The CMAC multiplies this (cos, sin) vector by an external complex vector and can accumulate the result. The resulting complex vectors are available through two 20-bit output ports which maintain the 90dB spectral purity. This result can be accumulated internally to implement an accumulate and dump filter.

A quadrature down converter can be implemented by loading a center frequency into the Phase/Frequency Control Section. The signal to be downconverted is the Vector Input of the CMAC, which multiplies the data by the rotating vector from the Sine/Cosine Section. The resulting complex output is the down converted signal.

Features

- This Circuit is Processed in Accordance to MIL-STD-883 and is Fully Conformant Under the Provisions of Paragraph 1.2.1.
- NCO and CMAC on One Chip
- 15MHz and 25.6MHz Versions
- 32-Bit Frequency Control
- 16-Bit Phase Modulation
- 16-Bit CMAC
- 0.006Hz Tuning Resolution at 25.6MHz
- Spurious Frequency Components < -90dBc
- Fully Static CMOS

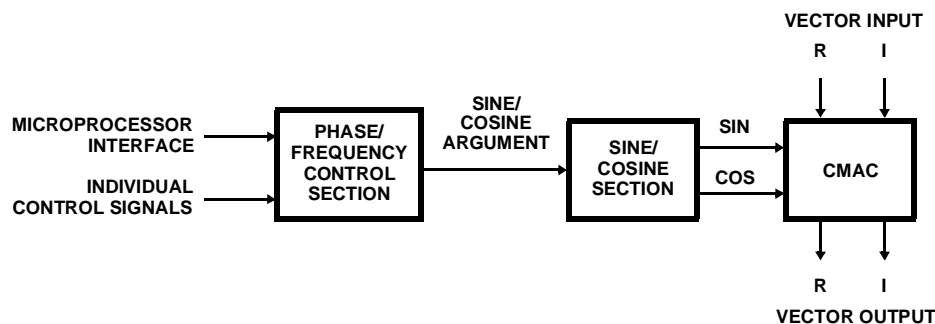
Applications

- Frequency Synthesis
- Modulation - AM, FM, PSK, FSK, QAM
- Demodulation, PLL
- Phase Shifter
- Polar to Cartesian Conversions

Ordering Information

PART NUMBER	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
HSP45116GM-15/883	-55 to 125	145 Ld PGA	G145.A
HS45116GM-25/883	-55 to 125	145 Ld PGA	G145.A

Block Diagram



Absolute Maximum Ratings

Supply Voltage +8.0V
 Input or Output Voltage Applied GND -0.5V to V_{CC} +0.5V
 ESD Rating Classification Class 1

Operating Conditions

Temperature Range -55°C to 125°C
 Supply Range +4.5V to +5.5V

Thermal Information

Thermal Resistance (Typical, Note 1) θ_{JA} (°C/W) θ_{JC} (°C/W)
 PGA Package 30.0 5.0
 Maximum Package Power Dissipation at 125°C
 PGA Package 2.16W
 Maximum Junction Temperature 175°C
 Maximum Storage Temperature Range -65°C to 150°C
 Maximum Lead Temperature (Soldering 10s) 300°C
 Number of Transistors or Gates 103,000 Transistors

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.

NOTE:

1. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

TABLE 1. DC ELECTRICAL PERFORMANCE SPECIFICATIONS

Device Guaranteed and 100% Tested

PARAMETER	SYMBOL	TEST CONDITIONS	GROUP A SUBGROUPS	TEMPERATURE (°C)	MIN	MAX	UNITS
Logical One Input Voltage	V _{IH}	V _{CC} = 5.5V	1, 2, 3	55 ≤ T _A ≤ 125	2.2	-	V
Logical Zero Input Voltage	V _{IL}	V _{CC} = 4.5V	1, 2, 3	55 ≤ T _A ≤ 125	-	0.8	V
Logical One Input Voltage Clock	V _{IHC}	V _{CC} = 5.5V	1, 2, 3	55 ≤ T _A ≤ 125	3.0	-	V
Logical Zero Input Voltage Clock	V _{ILC}	V _{CC} = 4.5V	1, 2, 3	55 ≤ T _A ≤ 125	-	0.8	V
Output HIGH Voltage	V _{OH}	I _{OH} = -400µA V _{CC} = 4.5V (Note 2)	1, 2, 3	55 ≤ T _A ≤ 125	2.6	-	V
Output LOW Voltage	V _{OL}	I _{OL} = +2.0mA V _{CC} = 4.5V (Note 2)	1, 2, 3	55 ≤ T _A ≤ 125	-	0.4	V
Input Leakage Current	I _I	V _{IN} = V _{CC} or GND V _{CC} = 5.5V	1, 2, 3	55 ≤ T _A ≤ 125	-10	+10	µA
Output or I/O Leakage Current	I _O	V _{OUT} = V _{CC} or GND V _{CC} = 5.5V	1, 2, 3	55 ≤ T _A ≤ 125	-10	+10	µA
Standby Power Supply Current	I _{CCSB}	V _{IN} = V _{CC} or GND, V _{CC} = 5.5V, (Note 5)	1, 2, 3	55 ≤ T _A ≤ 125	-	500	µA
Operating Power Supply Current	I _{CCOP}	f = 15MHz, V _{IN} = V _{CC} or GND V _{CC} = 5.5V (Notes 3, 5)	1, 2, 3	55 ≤ T _A ≤ 125	-	150	mA
Functional Test	FT	(Note 4)	7, 8	55 ≤ T _A ≤ 125	-	-	

NOTES:

2. Interchanging of force and sense conditions is permitted.
3. Operating Supply Current is proportional to frequency, typical rating is 10mA/MHz.
4. Tested as follows: f = 1MHz, V_{IH} (clock inputs) = 3.4V, V_{IH} (all other inputs) = 2.6V, V_{IL} = 0.4V, V_{OH} ≥ 1.5V, and V_{OL} ≤ 1.5V.
5. Output per test load circuit with switch open and C_L = 40pF.

TABLE 2. ELECTRICAL PERFORMANCE SPECIFICATIONS

Device Guaranteed and 100% Tested

PARAMETER	SYMBOL	NOTES	GROUP A SUBGROUPS	TEMPERATURE (°C)	-15 (15MHz)		-25 (25.6MHz)		UNITS
					MIN	MAX	MIN	MAX	
CLK Period	t _{CP}		9, 10, 11	-55 ≤ T _A ≤ 125	66	-	39	-	ns
CLK High	t _{CH}		9, 10, 11	-55 ≤ T _A ≤ 125	26	-	15	-	ns
CLK Low	t _{CL}		9, 10, 11	-55 ≤ T _A ≤ 125	26	-	-15	-	ns
$\overline{\text{WR}}$ Low	t _{WL}		9, 10, 11	-55 ≤ T _A ≤ 125	26	-	15	-	ns
$\overline{\text{WR}}$ High	t _{WH}		9, 10, 11	-55 ≤ T _A ≤ 125	26	-	15	-	ns
Setup Time; ADO-1, $\overline{\text{CS}}$ to $\overline{\text{WR}}$ Going High	t _{AWS}		9, 10, 11	-55 ≤ T _A ≤ 125	20	-	18	-	ns
Hold Time; AD0, AD1, $\overline{\text{CS}}$ from $\overline{\text{WR}}$ Going High	t _{AWH}		9, 10, 11	-55 ≤ T _A ≤ 125	0	-	0	-	ns
Setup Time CO-15 from $\overline{\text{WR}}$ Go- ing High	t _{CWS}		9, 10, 11	-55 ≤ T _A ≤ 125	20	-	18	-	ns
Hold Time CO-15 from $\overline{\text{WR}}$ Go- ing High	t _{CWA}		9, 10, 11	-55 ≤ T _A ≤ 125	0	-	0	-	ns
Setup Time $\overline{\text{WR}}$ to CLK High	t _{WC}	(Note 7)	9, 10, 11	-55 ≤ T _A ≤ 125	20	-	16	-	ns
Setup Time MODO-1 to CLK Going High	t _{MCS}		9, 10, 11	-55 ≤ T _A ≤ 125	20	-	18	-	ns
Hold Time MODO-1 from CLK Going High	t _{MCH}		9, 10, 11	-55 ≤ T _A ≤ 125	0	-	0	-	ns
Setup Time $\overline{\text{PACI}}$ to CLK Going High	t _{PCS}		9, 10, 11	-55 ≤ T _A ≤ 125	25	-	18	-	ns
Hold Time $\overline{\text{PACI}}$ from CLK Going High	t _{PCH}		9, 10, 11	-55 ≤ T _A ≤ 125	0	-	0	-	ns
Setup Time $\overline{\text{ENPHREG}}$, $\overline{\text{ENCFRCTL}}$, $\overline{\text{ENPHAC}}$, $\overline{\text{ENTICTL}}$, $\overline{\text{CLROFR}}$, $\overline{\text{PMSEL}}$, $\overline{\text{LOAD}}$, $\overline{\text{ENI}}$, $\overline{\text{ACC}}$, $\overline{\text{BINFMT}}$, $\overline{\text{PEAK}}$, $\overline{\text{MODPI/2PI}}$, $\overline{\text{SHO-1}}$, $\overline{\text{RBYTILD}}$ from CLK Going High	t _{ECS}		9, 10, 11	-55 ≤ T _A ≤ 125	20	-	15	-	ns
Hold Time $\overline{\text{ENPHREG}}$, $\overline{\text{ENCFRCTL}}$, $\overline{\text{ENPHAC}}$, $\overline{\text{ENTICTL}}$, $\overline{\text{CLROFR}}$, $\overline{\text{PMSEL}}$, $\overline{\text{LOAD}}$, $\overline{\text{ENI}}$, $\overline{\text{ACC}}$, $\overline{\text{BINFMT}}$, $\overline{\text{PEAK}}$, $\overline{\text{MODPI/2PI}}$, $\overline{\text{SHO-1}}$, $\overline{\text{RBYTILD}}$ from CLK Going High	t _{ECH}		9, 10, 11	-55 ≤ T _A ≤ 125	0	-	0	-	ns
Setup Time RINO-18, IMINO-18 to CLK Going High	t _{DS}		9, 10, 11	-55 ≤ T _A ≤ 125	20	-	15	-	ns
Hold Time RINO-18, IMINO-18, to CLK Going High	t _{DH}		9, 10, 11	-55 ≤ T _A ≤ 125	0	-	0	-	ns
CLK to Output Delay R0O-19, I0O-19	t _{DO}		9, 10, 11	-55 ≤ T _A ≤ 125	40	-	25	-	ns

TABLE 2. ELECTRICAL PERFORMANCE SPECIFICATIONS (Continued)

Device Guaranteed and 100% Tested

PARAMETER	SYMBOL	NOTES	GROUP A SUBGROUPS	TEMPERATURE (°C)	-15 (15MHz)		-25 (25.6MHz)		UNITS
					MIN	MAX	MIN	MAX	
CLK to Output Delay DETO-1	t _{DEO}		9, 10, 11	-55 ≤ T _A ≤ 125	40	-	27	-	ns
CLK to Output Delay $\overline{\text{PAC}}\overline{\text{O}}$	t _{PO}		9, 10, 11	-55 ≤ T _A ≤ 125	-	30	-	20	ns
CLK to Output Delay $\overline{\text{TIC}}\overline{\text{O}}$	t _{TO}		9, 10, 11	-55 ≤ T _A ≤ 125	-	30	-	20	ns
Output Enable Time $\overline{\text{OER}}$, $\overline{\text{OEI}}$, $\overline{\text{OEREXT}}$, $\overline{\text{OEIEXT}}$	t _{OE}	(Note 8)	9, 10, 11	-55 ≤ T _A ≤ 125	-	25	-	20	ns
OUTMUXO-1 to Output Delay	t _{MD}		9, 10, 11	-55 ≤ T _A ≤ 125	-	40	-	28	ns

NOTES:

- AC testing is performed as follows: V_{CC} = 4.5V and 5.5V. Input levels (CLK Input) 4.0V and 0V; input levels (all other inputs) 3.0V and 0V; timing reference levels (CLK) 2.0V; all others 1.5V. Output load per test load circuit with switch closed and C_L = 40pF. Output transition is measured at V_{OH} ≥ 1.5V and V_{OL} ≤ 1.5V.
- Applicable only when outputs are being monitored and $\overline{\text{ENCFREG}}$, $\overline{\text{ENPHREG}}$, or $\overline{\text{ENTIREG}}$ is active.
- Transition is measured at ±200mV from steady state voltage, output loading per test load circuit, with switch closed and C_L = 40pF.

TABLE 3. ELECTRICAL PERFORMANCE SPECIFICATIONS

PARAMETER	SYMBOL	TEST CONDITIONS	NOTES	TEMPERATURE (°C)	-15		-25		UNITS
					MIN	MAX	MIN	MAX	
Input Capacitance	C _{IN}	V _{CC} = Open, f = 1MHz All measurements are referenced to device GND	9	T _A - +25	-	15	-	15	pF
Output Capacitance	C _{OUT}		9	T _A - +25	-	15	-	15	pF
Output Disable Time	t _{OD}		9, 10	-55 ≤ T _A ≤ 125	-	20	-	15	ns
Output Rise Time	t _R	From 0.8V to 2.0V	9, 10	-55 ≤ T _A ≤ 125	-	8	-	8	ns
Output Fall Time	t _F	From 2.0V to 0.8V	9, 10	-55 ≤ T _A ≤ 125	-	8	-	8	ns

NOTES:

- The parameters in Table 3 are controlled via design or process parameters and not directly tested. Characterized upon initial design and after major process and/or design changes.
- Loading is as specified in the test load circuit with C_L = 40pF.

TABLE 4. APPLICABLE SUBGROUPS

CONFORMANCE GROUPS	METHOD	SUBGROUPS
Initial Tess	100%/5004	-
Interim Test	100%/5004	-
PDA	100%	1
Final Test	100%	2, 3, 8A, 8B, 10, 11
Group A	-	1, 2, 3, 7, 8A, 8B, 9, 10, 11
Groups C & D	Samples	1, 7, 9

Burn-In Circuit

**145 PIN PGA
TOP VIEW**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
A	V _{CC}	IMIN4	IMIN8	IMIN9	IMIN11	IMIN15	IMIN16	GND	V _{CC}	IO18	IO15	IO12	IO10	GND	V _{CC}	A
B	GND	IMIN 1	IMIN5	IMIN7	IMIN10	IMIN13	IMIN14	IO19	IO16	IO14	IO11	IO8	IO7	IO5	IO2	B
C	RIN15	RIN18	IMIN2	IMIN3	IMIN6	IMIN12	IMIN17	IMIN18	IO17	IO13	IO9	IO6	IO4	IO1	RO18	C
D	RIN13	RIN17	IMIN0	INDEX									IO3	RO19	RO17	D
E	RIN10	RIN14	RIN16									IO0	RO16	RO15	E	
F	RIN7	RIN11	RIN12									RO14	RO13	RO11	F	
G	V _{CC}	RIN9	RIN8									RO9	RO12	RO10	G	
H	GND	RIN6	RIN5									RO8	RO7	GND	H	
J	RIN3	RIN1	RIN4									RO5	RO4	V _{CC}	J	
K	RIN2	RIN0	SH1									RO1	RO2	RO6	K	
L	SH0	ACC	RBYTILD									PACO	DET1	RO3	L	
M	ENPH REG	PEAK	MOD1									OEREXT	OEI	RO0	M	
N	ENOF REG	BINFMT	MOD0	LOAD	ENCF REG	MODPI /2PI	AD0	C14	C13	C8	C2	OUT- MUX1	OUT- MUX0	OEIEXT	DET0	N
P	TICO	PACI	PMSSEL	CLROFR	ENTIREG	CS	AD1	C15	C10	C9	C6	C3	C1	OER	GND	P
Q	V _{CC}	GND	ENPHAC	ENI	CLK	WR	V _{CC}	GND	C12	C11	C7	C5	C4	C0	V _{CC}	Q

All Intersil U.S. products are manufactured, assembled and tested utilizing ISO9000 quality systems.
Intersil Corporation's quality certifications can be viewed at www.intersil.com/design/quality

Intersil products are sold by description only. Intersil Corporation reserves the right to make changes in circuit design, software and/or specifications at any time without notice. Accordingly, the reader is cautioned to verify that data sheets are current before placing orders. Information furnished by Intersil is believed to be accurate and reliable. However, no responsibility is assumed by Intersil or its subsidiaries for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Intersil or its subsidiaries.

For information regarding Intersil Corporation and its products, see www.intersil.com

Burn-in Circuit

PGA PIN	PIN NAME	BURN-IN-SIGNAL	PGA PIN	PIN NAME	BURN-IN SIGNAL	PGA PIN	PIN NAME	BURN-IN SIGNAL	PGA PIN	PIN NAME	BURN-IN SIGNAL
D3	IMIN(0)	F4	Q3	ENPHAC	F1	K14	RO(2)	V _{CC} /2	A10	IO(18)	V _{CC} /2
C2	RIN(18)	F9	P5	ENTIREG	F4	L15	RO(3)	V _{CC} /2	B8	IO(19)	V _{CC} /2
D2	RIN(17)	F8	Q4	ENI	F1	J14	RO(4)	V _{CC} /2	C8	IMIN(18)	F9
E3	RIN(16)	F7	N6	MODPI/2PI	F16	J13	RO(5)	V _{CC} /2	C7	IMIN(17)	F8
C1	RIN(15)	F6	P6	CS	F2	K15	RO(6)	V _{CC} /2	A7	IMIN(16)	F7
E2	RIN(14)	F5	Q5	CLK	F0	H14	RO(7)	V _{CC} /2	A6	IMIN(15)	F6
D1	RIN(13)	F4	P7	AD(1)	F4	H13	RO(8)	V _{CC} /2	B7	IMIN(14)	F5
F3	RIN(12)	F16	N7	AD(0)	F3	G13	RO(9)	V _{CC} /2	B6	IMIN(13)	F4
F2	RIN(11)	F15	Q6	WR	F1	G15	RO(10)	V _{CC} /2	C6	IMIN(12)	F16
E1	RIN(10)	F14	P8	C(15)	GND	F15	RO(11)	V _{CC} /2	A5	IMIN(11)	F15
G2	RIN(9)	F13	N8	C(14)	GND	G14	RO(12)	V _{CC} /2	B5	IMIN(10)	F14
G3	RIN(8)	F12	N9	C(13)	GND	F14	RO(13)	V _{CC} /2	A4	IMIN(9)	F13
F1	RIN(7)	F11	Q9	C(12)	GND	F13	RO(14)	V _{CC} /2	A3	IMIN(8)	F12
H2	RIN(6)	F10	Q10	C(11)	GND	E15	RO(15)	V _{CC} /2	B4	IMIN(7)	F11
H3	RIN(5)	F9	P9	C(10)	GND	E14	RO(16)	V _{CC} /2	C5	IMIN(6)	F10
J3	RIN(4)	F8	P10	C(9)	GND	D15	RO(17)	V _{CC} /2	B3	IMIN(5)	F9
J1	RIN(3)	F7	N10	C(8)	GND	C15	RO(18)	V _{CC} /2	A2	IMIN(4)	F8
K1	RIN(2)	F6	Q11	C(7)	GND	D14	RO(19)	V _{CC} /2	C4	IMIN(3)	F7
J2	RIN(1)	F5	P11	C(6)	GND	E13	IO(0)	V _{CC} /2	C3	IMIN(2)	F6
K2	RIN(0)	F4	Q12	C(5)	GND	C14	IO(1)	V _{CC} /2	B2	IMIN(1)	F5
K3	SH(1)	F3	Q13	C(4)	GND	B15	IO(2)	V _{CC} /2	A1	VC	None
L1	SH(0)	F2	P12	C(3)	GND	D13	IO(3)	V _{CC} /2	A9	V _{CC}	V _{CC}
L2	ACC	F4	N11	C(2)	GND	C13	IO(4)	V _{CC} /2	A15	V _{CC}	None
M1	ENPHREG	F16	P13	C(1)	GND	B14	IO(5)	V _{CC} /2	G1	V _{CC}	V _{CC}
N1	ENOFREG	F4	Q14	C(0)	V _{CC}	C12	IO(6)	V _{CC} /2	J15	V _{CC}	V _{CC}
M2	PEAK	F8	N12	OUT-MUX(1)	F11	B13	IO(7)	V _{CC} /2	Q1	V _{CC}	None
L3	RBYTILD	F16	N13	OUT-MUX(0)	F10	B12	IO(8)	V _{CC} /2	Q7	V _{CC}	V _{CC}
N2	BINFMT	F4	P14	OER	F0	C11	IO(9)	V _{CC} /2	Q15	V _{CC}	None
P1	TICO	V _{CC} /2	M13	OEREXT	F0	A13	IO(10)	V _{CC} /2	A8	GND	GND
M3	MOD(1)	GND	N14	OEIEXT	F0	B11	IO(11)	V _{CC} /2	A14	GND	None
N3	MOD(0)	GND	M14	OEI	F0	A12	IO(12)	V _{CC} /2	B1	GND	None
P2	PACI	F4	L13	PACO	V _{CC} /2	C10	IO(13)	V _{CC} /2	H1	GND	GND
N4	LOAD	F15	N15	DET0	V _{CC} /2	B10	IO(14)	V _{CC} /2	H15	GND	GND
P3	PMSSEL	F1	L14	DET1	V _{CC} /2	A11	IO(15)	V _{CC} /2	P15	GND	None
P4	CLROFR	F4	M15	RO(0)	V _{CC} /2	B9	IO(16)	V _{CC} /2	Q2	GND	None
N5	ENCFREG	F4	K13	RO(1)	V _{CC} /2	C9	IO(17)	V _{CC} /2	Q8	GND	GND

NOTE:

11. 47kΩ ±20%) resistor connected to all pins except V_{CC} and GND.
12. V_{CC} = 5.5V ±0.5V with 0.1μF (min) capacitor between V_{CC} and GND per position.
13. F0 = 100kHz ±10%, F1 = F0/2, F2 = F1/2 , F11 = F10/2, 40% to 60% duty cycle.
14. Input Voltage limits: V_{IL} = 0.8V max, V_{IH} = 4.5V ±10%.

Die Characteristics

DIE DIMENSIONS:

350 mils x 353 mils x 19 ± 1mils

METALLIZATION:

Type: Si-Al, or Si-Al-Cu
Thickness: 8kÅ

GLASSIVATION:

Type: Nitrox
Thickness: 10kÅ

WORST CASE DENSITY:

1.6 x 10⁵A/cm²