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S-Band 6-bit Digital Phase Shifter

GaAs Monolithic Microwave IC

Description

The CHP4012a98F is a 6-bit phase shifter monolithic circuit, which integrates a CMOS and TTL compatible interface.

It is designed for a wide range of applications, typically defence and space systems.

The circuit is manufactured with a pHEMT process, 0.25µm gate length, via holes through the substrate, air bridges and electron beam gate lithography.

It is supplied in chip form and RoHS compliant SMD package.
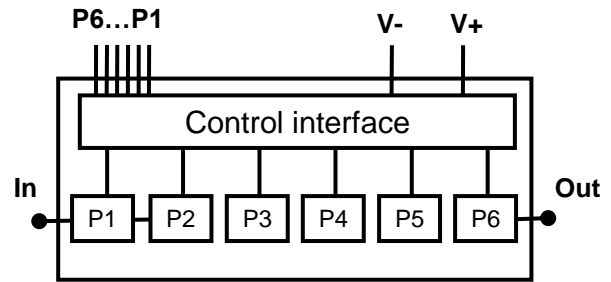
Main Features

- Frequency range: 2.7-3.5GHz
- 5.625° phase shifter step
- 0-360° phase shift range
- RMS phase error: 1°
- Digital interface
- Chip size: 3.61x1.84x0.1mm
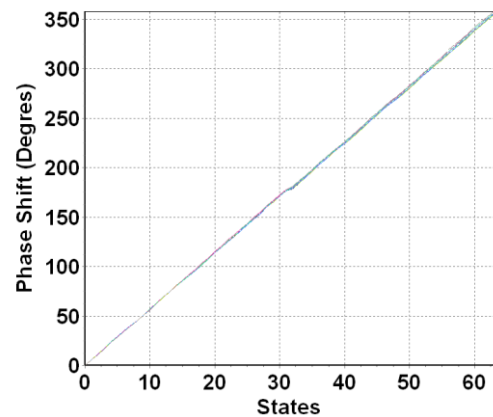
Main Electrical Characteristics

Tamb.= +25°C

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	2.7		3.5	GHz
IL	Insertion Loss		6		dB
RMS_PE	RMS Phase Error		1		°
P1dB	Input Power at 1dB gain compression		24.5		dBm

CHP4012a98F

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Electrical Characteristics

Tamb.= +25°C

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	2.7		3.5	GHz
PhS	Phase Shift Range	0		360	°
PhS_step	Phase Shift Step		5.625		°
PPE	Peak Phase Error		-2 / +4		°
RMS_PE	RMS Phase Error		1		°
IL	Insertion Loss (all states)		6.0		dB
Av	Amplitude Variation		+/-0.5		dB
RMS_Av	RMS Amplitude Variation		0.2		dB
S11	Input Reflection Coefficient (all states)		-15		dB
S22	Output Reflection Coefficient (all states)		-15		dB
P1dB	Input Power at 1dB gain compression		24.5		dBm
Vctrl_L	Control Input Voltage (P1-P6) – low level	0		0.4	V
Vctrl_H	Control Input Voltage (P1-P6) – high level	2.4	3.3	7	V
V+	Positive Supply Voltage		+5		V
V-	Negative Supply Voltage		-5		V
I+	Positive Supply Current		5		mA
I-	Negative Supply Current		5		mA
SwT	Switching Time		15		ns
Top	Operating Temperature	-40		+85	°C

Peak Phase Error (PPE) definition

PPE(i) = measured_Phase(S21)@state(i) - measured_Phase(S21)@state(0) – theoretical PhaseValue@State(i)

Amplitude Variation (Av) definition

Av(i) = Measured_dB(S21)@state(i) - Measured_dB(S21)@state(0)

RMS Phase Error (RMS_PE) definition

$$RMS\_PE = \sqrt{\frac{\sum_{i=0}^{63} PPE^2(i)}{64}}$$

RMS Amplitude variation (RMS_Av) definition

$$RMS\_AV = \overline{Av} = \frac{\sum_{i=0}^{63} Av(i)}{64}$$

where (i) is the state number (from 0 to 63)

Absolute Maximum Ratings

Tamb.= +25°C[(1)]

Symbol	Parameter	Values	Unit
V+	Maximum DC positive supply voltage	8	V
V-	Maximum DC negative supply voltage	-8	V
Vctrl	Phase shifter control voltage (Vlow, Vhigh)	-2 to +8	V
Pin	Maximum peak input power overdrive	30	dBm
Tj	Junction temperature	175	°C
Ta	Operating temperature range	-40 to +85	°C
Tstg	Storage temperature range	-55 to +150	°C

[(1)] Operation of this device above anyone of these parameters may cause permanent damage.

Typical Bias Conditions

Two options are possible for the bonding of biasing and control pads without impact on the RF performances.

Option 1

Pad name	Pad number	Parameter	Values	Unit
V+	3	Positive Supply Voltage	+5	V
V-	13	Negative Supply Voltage	-5	V
Vctrl	4, 7, 11, 14, 16, 18	Control Input Voltage	0 / +3.3	V

Option 2

Pad name	Pad number	Parameter	Values	Unit
V+	17	Positive Supply Voltage	+5	V
V-	15	Negative Supply Voltage	-5	V
Vctrl	5, 6, 8, 9, 10, 12	Control Input Voltage	0 / +3.3	V

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Phase shifter control table

Voltage to apply on the pads P1 to P6

| State	Phase (deg)	P6	P5	P4	P3	P2	P1	State	Phase (deg)	P6	P5	P4	P3	P2	P1
0	0	0	0	0	0	0	0	32	180	3.3	0	0	0	0	0
1	5.625	0	0	0	0	0	3.3	33	185.625	3.3	0	0	0	0	3.3
2	11.25	0	0	0	0	3.3	0	34	191.25	3.3	0	0	0	3.3	0
3	16.875	0	0	0	0	3.3	3.3	35	196.875	3.3	0	0	0	3.3	3.3
4	22.5	0	0	0	3.3	0	0	36	202.5	3.3	0	0	3.3	0	0
5	28.125	0	0	0	3.3	0	3.3	37	208.125	3.3	0	0	3.3	0	3.3
6	33.75	0	0	0	3.3	3.3	0	38	213.75	3.3	0	0	3.3	3.3	0
7	39.375	0	0	0	3.3	3.3	3.3	39	219.375	3.3	0	0	3.3	3.3	3.3
8	45	0	0	3.3	0	0	0	40	225	3.3	0	3.3	0	0	0
9	50.625	0	0	3.3	0	0	3.3	41	230.625	3.3	0	3.3	0	0	3.3
10	56.25	0	0	3.3	0	3.3	0	42	236.25	3.3	0	3.3	0	3.3	0
11	61.875	0	0	3.3	0	3.3	3.3	43	241.875	3.3	0	3.3	0	3.3	3.3
12	67.5	0	0	3.3	3.3	0	0	44	247.5	3.3	0	3.3	3.3	0	0
13	73.125	0	0	3.3	3.3	0	3.3	45	253.125	3.3	0	3.3	3.3	0	3.3
14	78.75	0	0	3.3	3.3	3.3	0	46	258.75	3.3	0	3.3	3.3	3.3	0
15	84.375	0	0	3.3	3.3	3.3	3.3	47	264.375	3.3	0	3.3	3.3	3.3	3.3
16	90	0	3.3	0	0	0	0	48	270	3.3	3.3	0	0	0	0
17	95.625	0	3.3	0	0	0	3.3	49	275.625	3.3	3.3	0	0	0	3.3
18	101.25	0	3.3	0	0	3.3	0	50	281.25	3.3	3.3	0	0	3.3	0
19	106.875	0	3.3	0	0	3.3	3.3	51	286.875	3.3	3.3	0	0	3.3	3.3
20	112.5	0	3.3	0	3.3	0	0	52	292.5	3.3	3.3	0	3.3	0	0
21	118.125	0	3.3	0	3.3	0	3.3	53	298.125	3.3	3.3	0	3.3	0	3.3
22	123.75	0	3.3	0	3.3	3.3	0	54	303.75	3.3	3.3	0	3.3	3.3	0
23	129.375	0	3.3	0	3.3	3.3	3.3	55	309.375	3.3	3.3	0	3.3	3.3	3.3
24	135	0	3.3	3.3	0	0	0	56	315	3.3	3.3	3.3	0	0	0
25	140.625	0	3.3	3.3	0	0	3.3	57	320.625	3.3	3.3	3.3	0	0	3.3
26	146.25	0	3.3	3.3	0	3.3	0	58	326.25	3.3	3.3	3.3	0	3.3	0
27	151.875	0	3.3	3.3	0	3.3	3.3	59	331.875	3.3	3.3	3.3	0	3.3	3.3
28	157.5	0	3.3	3.3	3.3	0	0	60	337.5	3.3	3.3	3.3	3.3	0	0
29	163.125	0	3.3	3.3	3.3	0	3.3	61	343.125	3.3	3.3	3.3	3.3	0	3.3
30	168.75	0	3.3	3.3	3.3	3.3	0	62	348.75	3.3	3.3	3.3	3.3	3.3	0
31	174.375	0	3.3	3.3	3.3	3.3	3.3	63	354.375	3.3	3.3	3.3	3.3	3.3	3.3

Typical on wafer Measurements
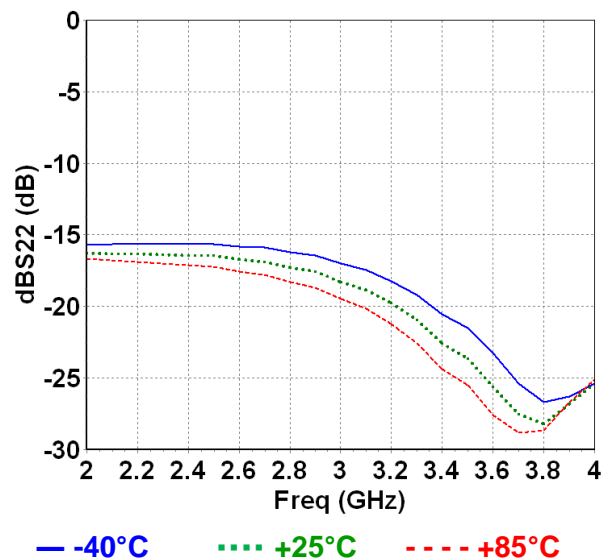
Temperature = -40°C, +25°C, +85°C, V+ = +5V, V- = -5V
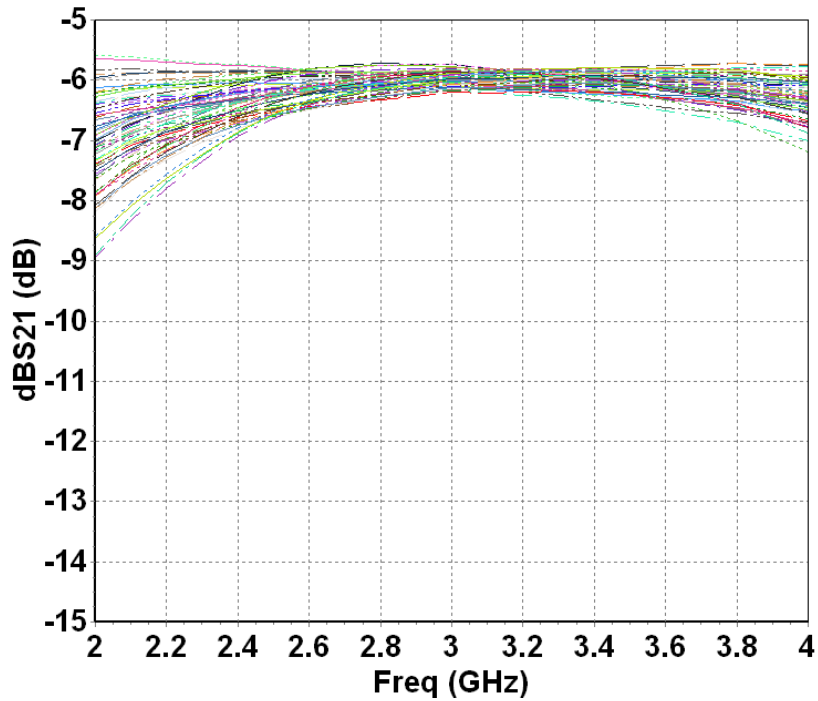
Insertion Losses versus Frequency @ States 0

— -40°C   ···· +25°C   - - - - +85°C
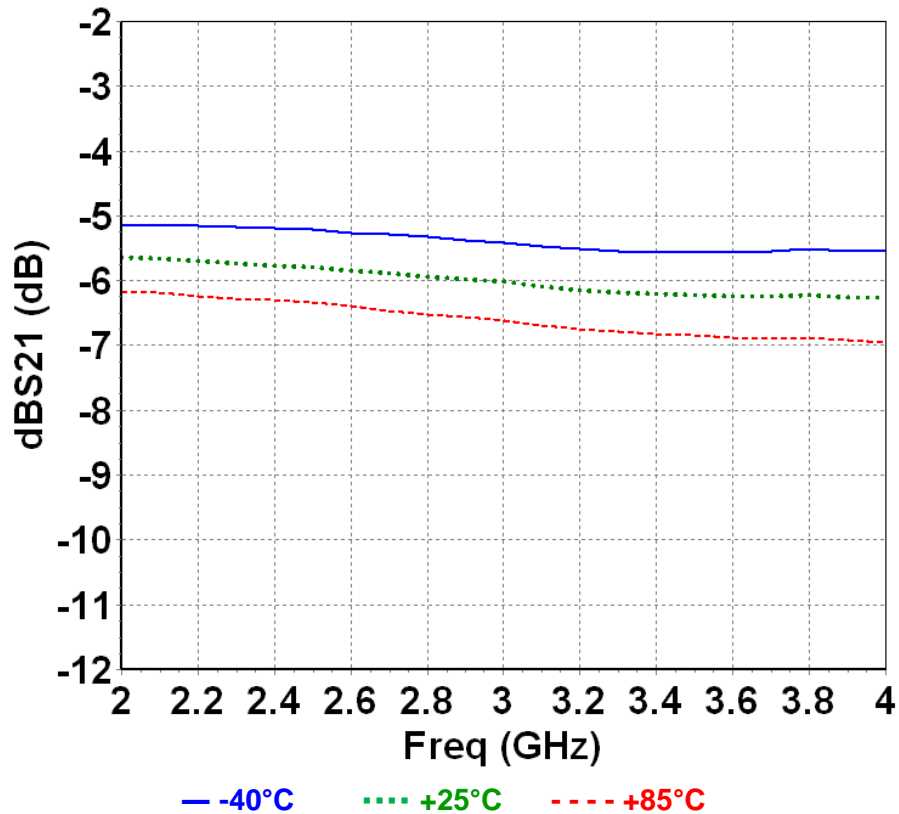
Input Return Loss @ States 0

— -40°C   ···· +25°C   - - - - +85°C
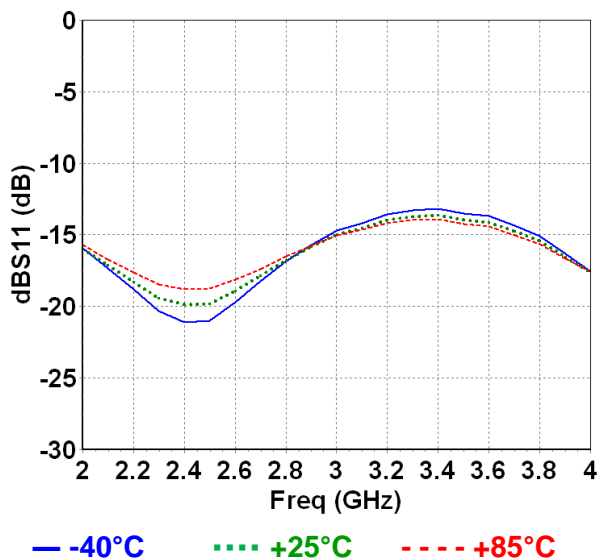
Output Return Loss @ States 0

— -40°C   ···· +25°C   - - - - +85°C

Typical on wafer Measurements

Temperature = +25°C, V+ = +5V, V- = -5V

Insertion Losses versus Frequency @ All States

Input Return Loss @ All States
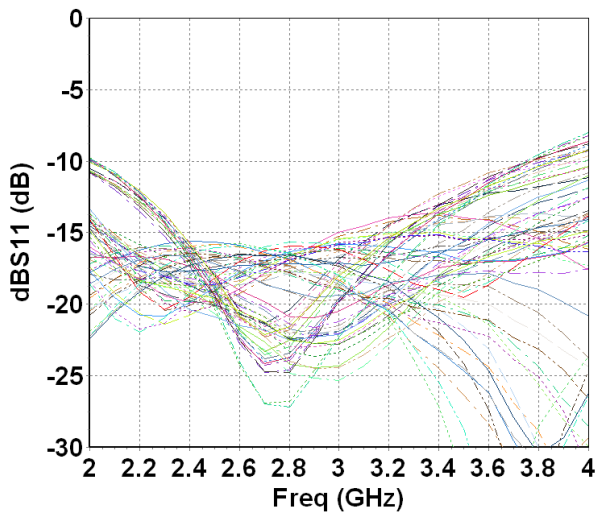
Output Return Loss @ All States

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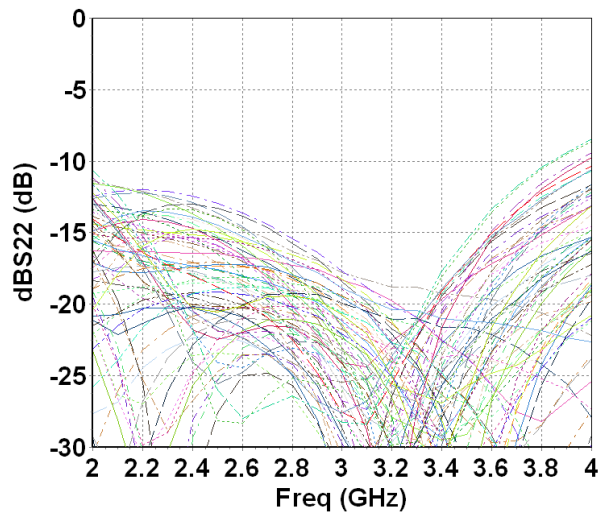
Typical on wafer Measurements

V+ = +5V, V- = -5V

Peak Phase Error versus Frequency (All States)
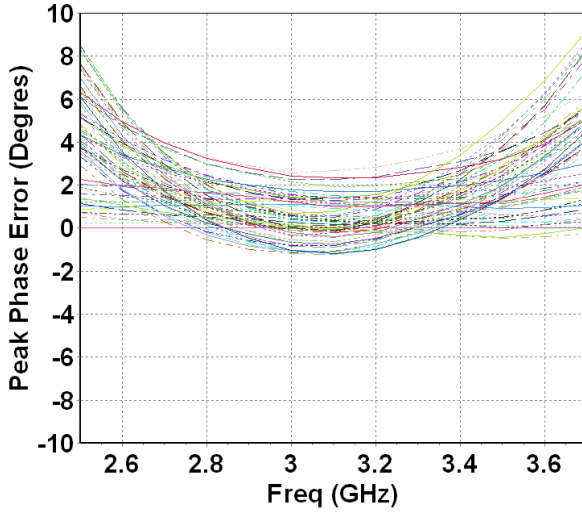
Peak Phase Error versus States 2.7GHz < frequency < 3.5GHz
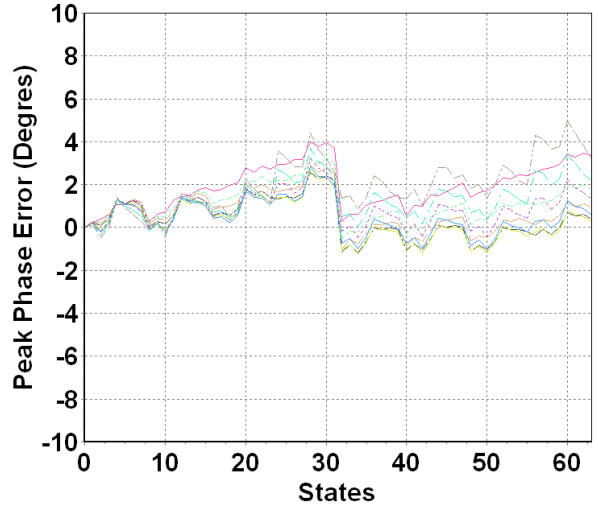
RMS Phase Error versus Frequency
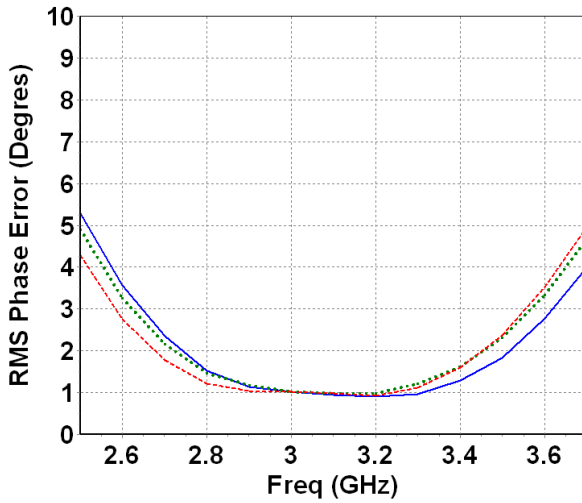
Phase Shift versus States 2.7GHz < frequency < 3.5GHz
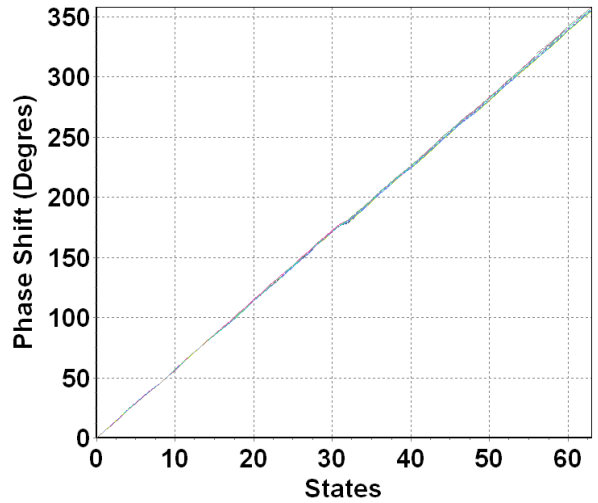
— -40°C   ···· +25°C   - - - - +85°C

Typical on wafer Measurements

V+ = +5V, V- = -5V

Amplitude Variation versus Frequency (All States)
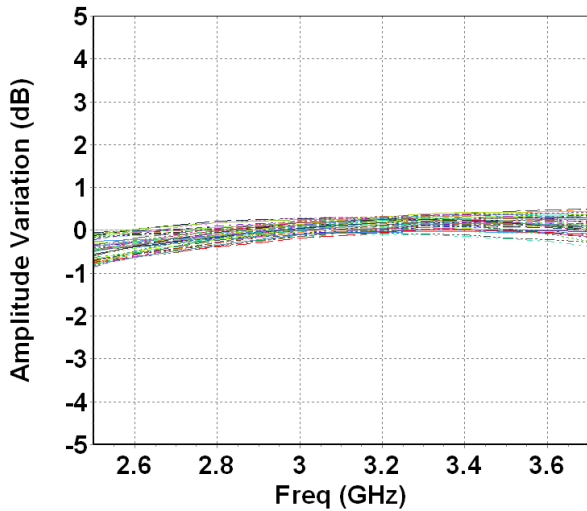
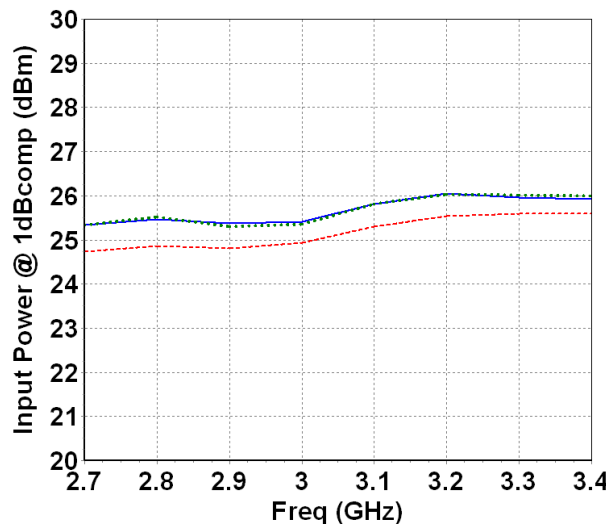### Amplitude Variation versus States 2.7GHz < frequency < 3.4GHz

RMS Amplitude Variation versus Frequency
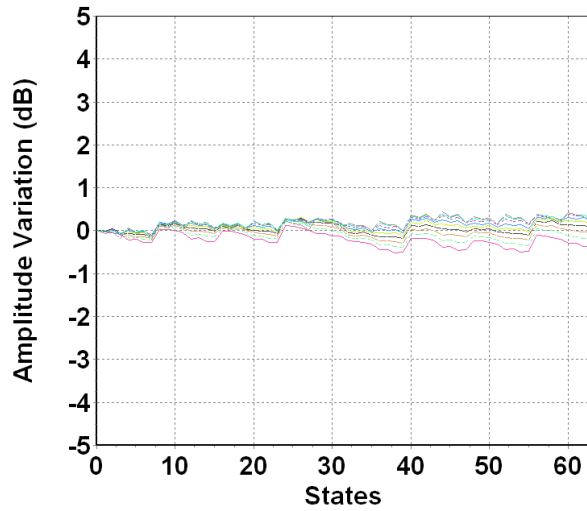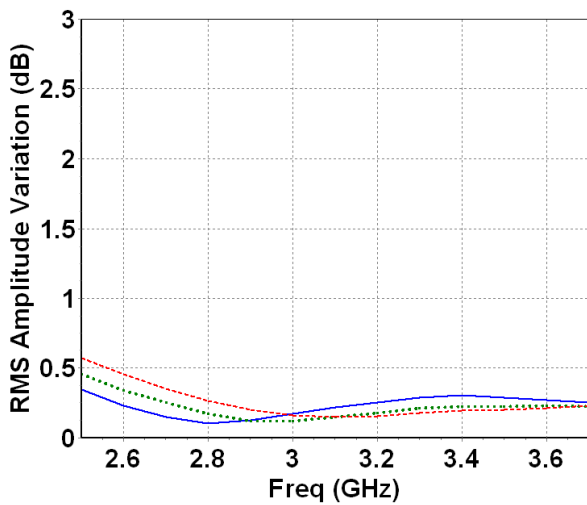
Input Power at 1dB gain compression versus Frequency

— -40°C   ···· +25°C   - - - - +85°C

— -40°C   ···· +25°C   - - - - +85°C

Mechanical data
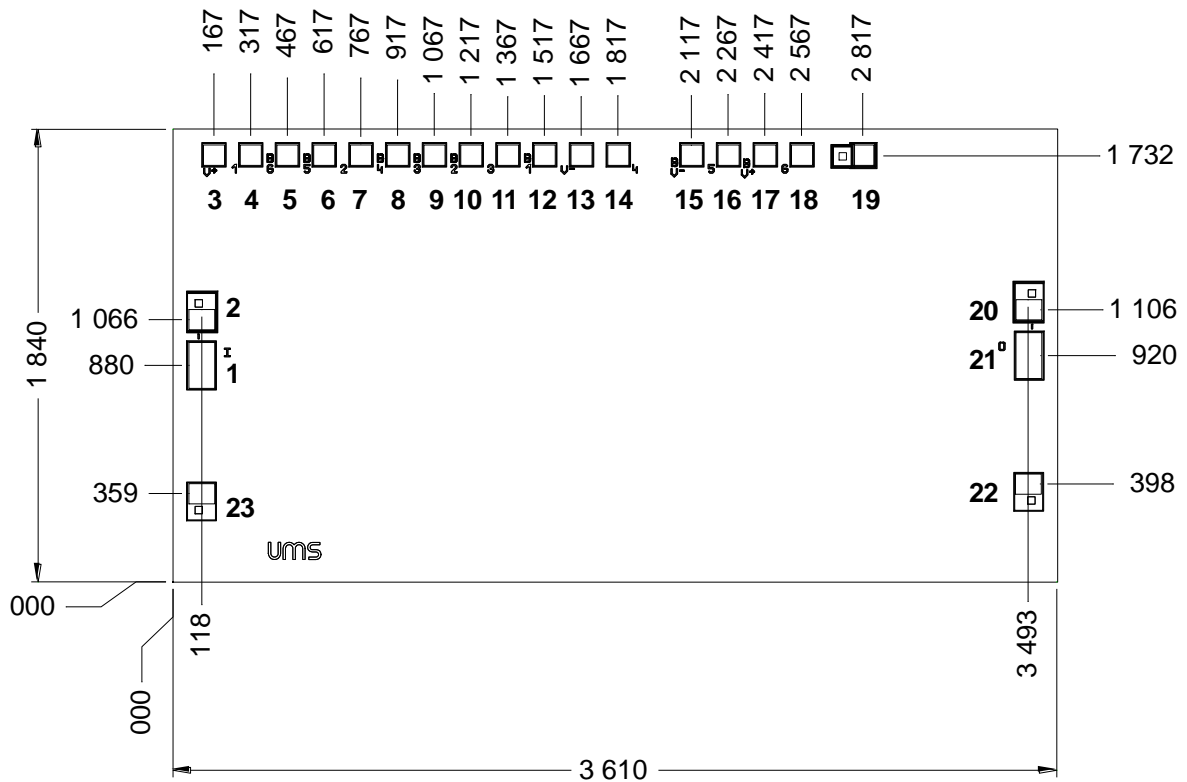
Chip thickness: 100µm.
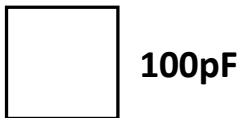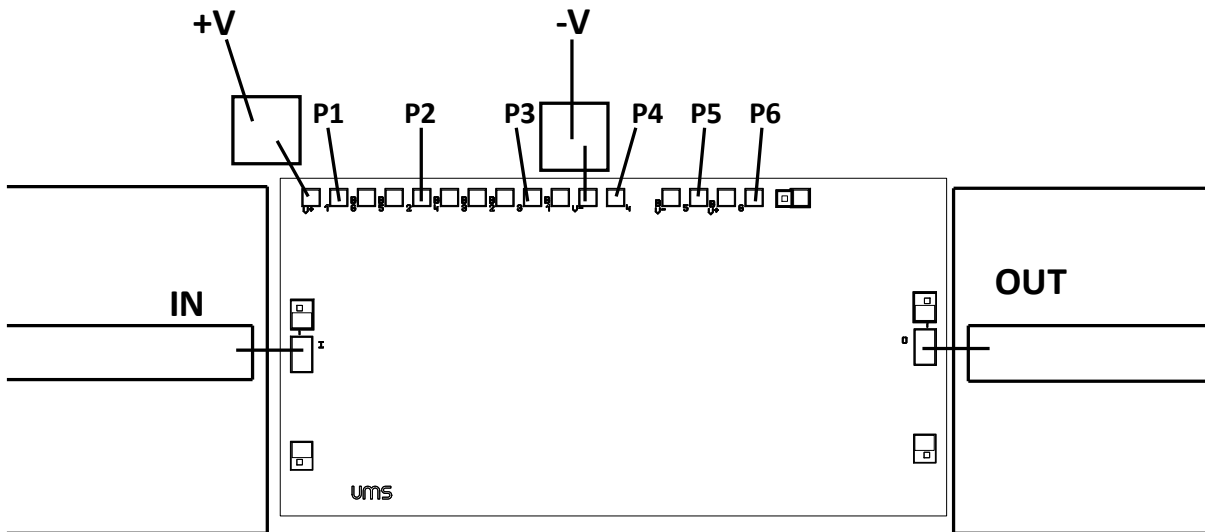Chip size: 3610x1840 ±35µm
All dimensions are in micrometers

Chip thickness = 100µm +/- 10µm.
RF pads (1, 21) = 142 x 200µm²
DC and control pads (3 to 18) = 100 x 100µm²

Pad number	Pad name	Description
1	IN	Input RF
5 or 18	P6	Phase Shift bit 6
6 or 16	P5	Phase Shift bit 5
8 or 14	P4	Phase Shift bit 4
9 or 11	P3	Phase Shift bit 3
10 or 7	P2	Phase Shift bit 2
12 or 4	P1	Phase Shift bit 1
15 or 13	V-	-5V supply voltage: interface
17 or 3	V+	+5V supply voltage: interface
21	OUT	Output RF
2, 19, 20, 22, 23	GND	NC

Recommended assembly plan : Option 1

+V   -V

P1   P2   P3   P4   P5   P6

IN

OUT

100pF

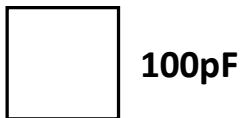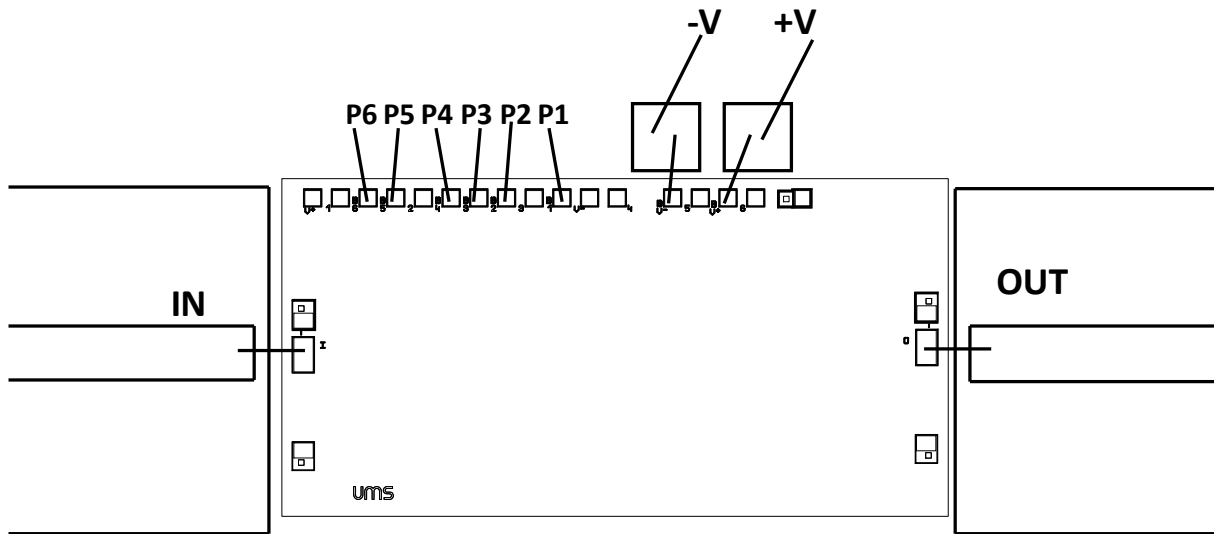25µm wedge bonding is preferred

Bonding recommendations

Port	Connection
IN (1) OUT (21)	Inductance (Lbonding) = 0.3nH one wire: diameter 25µm, length 0.4mm
DC and Interface pads	Inductance (Lbonding) = 0.8nH one wire: diameter 25µm, length 1.0mm

Recommended circuit bonding table

Pad name	Type	Decoupling	Comment
V-, V+	Bias	100pF	Supply Voltage
P1 to P6	Control	Not Required	Phase Shift Control

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Recommended assembly plan : Option 2

25µm wedge bonding is preferred

Bonding recommendations

Port	Connection
IN (1) OUT (21)	Inductance (Lbonding) = 0.3nH one wire: diameter 25µm, length 0.4mm
DC and Interface pads	Inductance (Lbonding) = 0.8nH one wire: diameter 25µm, length 1.0mm

Recommended circuit bonding table

Pad name	Type	Decoupling	Comment
V-, V+	Bias	100pF	Supply Voltage
P1 to P6	Control	Not Required	Phase Shift Control

Recommended ESD management

Refer to the application note AN0020 available at http://www.ums-gaas.com for ESD sensitivity and handling recommendations for the UMS products.

Ordering Information

Chip form: CHP4012a98F/00

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