

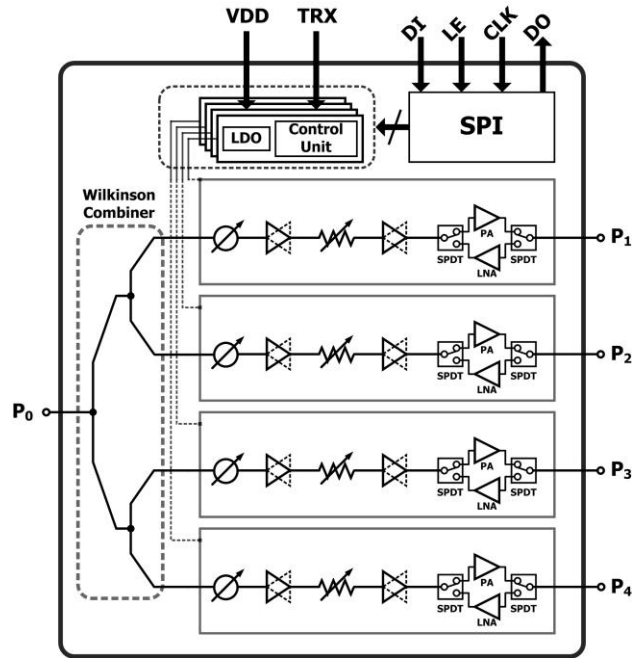
Preliminary datasheet of four channel X-band CMOS Core Chip

Description

RMF090100PA4CH is a QFN packaged four channel X-band core chip. This device is fabricated in CMOS process. Each channel includes 6-bit phase shifter, 5-bit attenuator, 6-bit tuning circuits, bidirectional gain blocks (BDGB), low dropout regulator (LDO), and serial to parallel interface (SPI). It covers frequency range from 9 GHz to 10 GHz, phase shifting range 360° with 5.625° step, and attenuation range 31 dB with 1dB step.

Features

- ◆ 6-Bit Digital Phase Shifter
- ◆ 5-Bit Digital Attenuator
- ◆ 6-Bit Tuning Circuits (phase and amplitude)
- ◆ LSB=5.625°, 1dB
- ◆ 360°, 31 dB coverage
- ◆ Power consumption:
830mW/ch (TX), 490mW/ch (RX)
- ◆ Package Size 10 x 5 x 1.2 mm³, 48 leads



Block diagram of the core chip

Main Characteristics (T_{amb}=25 °C)

Parameter	MIN.	TYP.	MAX.
Operation Frequency (GHz)	9		10
Tx mode linear gain S ₁₀ (dB)		13.7	
Rx mode linear gain S ₀₁ (dB)		10.2	
RMS Attenuation Error (dB)		0.3	
RMS Phase Error (°)		0.9	
Output P1 dB in TX mode (dBm)		13	
Input P1 dB in RX mode (dBm)		-17	
Noise Figure in RX mode (dB)		7.7	
Channel to Channel Isolation (dB)		38	
Switching time (ns): TX-to-RX / RX-to-TX		22 / 250	
SPI Clock Frequency (MHz)		50	

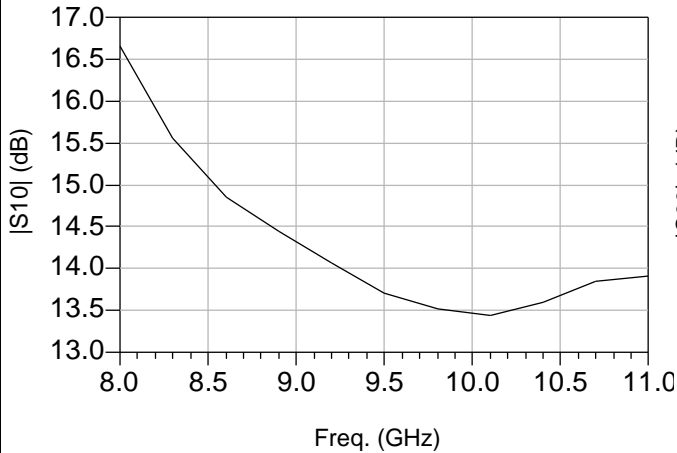
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Typical on Board Measurements

S-parameters and large signal performance in TX mode

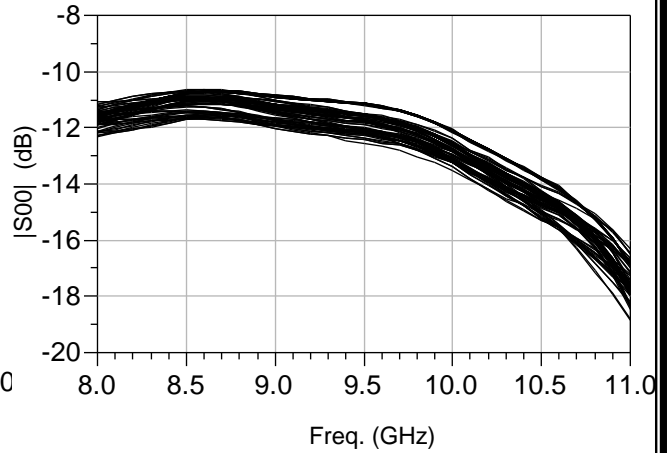
Small Signal Gain

(phase shifter state=ref., attenuator state=ref., $T_{amb}=25^{\circ}\text{C}$)



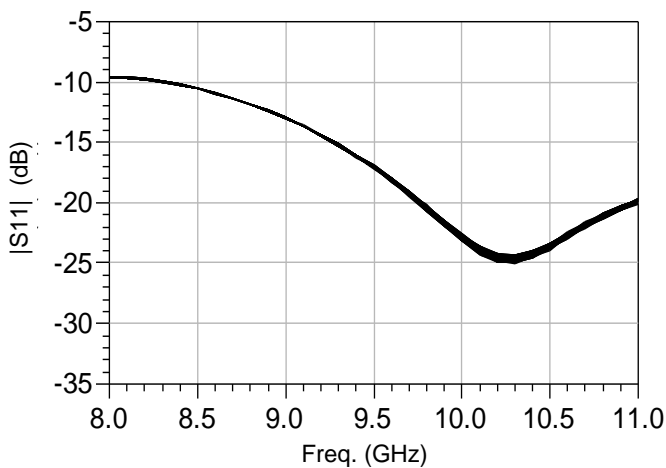
Port0 Return Loss

(for all attenuator and phase shifter states, $T_{amb}=25^{\circ}\text{C}$)



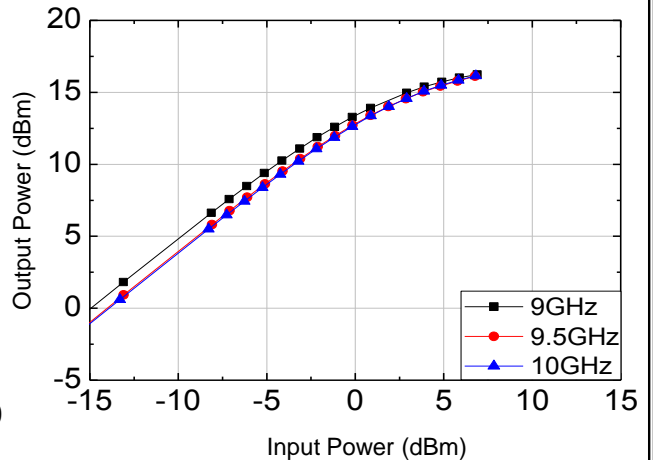
Port1 Return Loss

(for all attenuator and phase shifter states, $T_{amb}=25^{\circ}\text{C}$)



Output Power at Port1

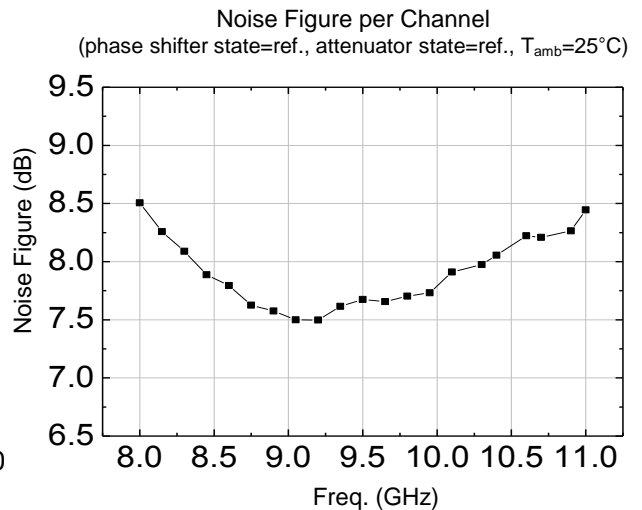
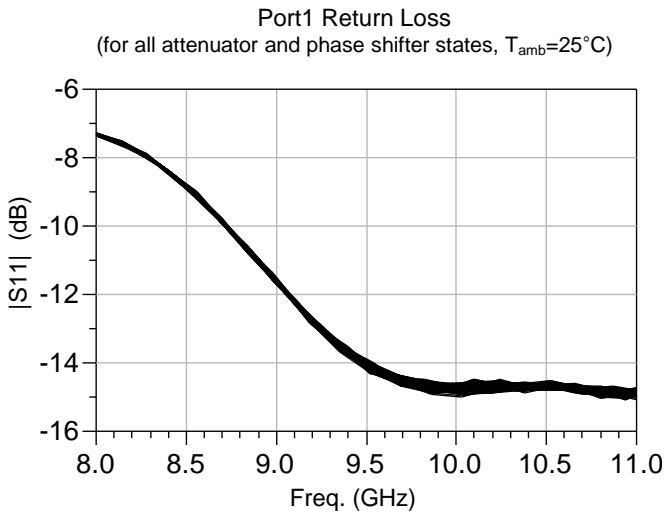
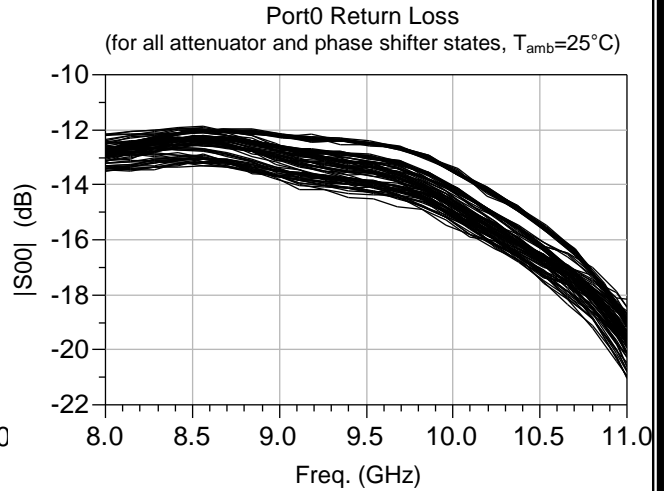
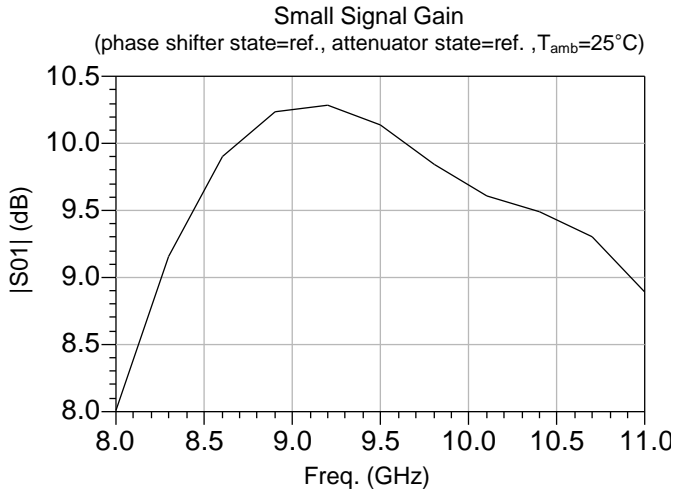
(phase shifter state=ref., attenuator state=ref., $T_{amb}=25^{\circ}\text{C}$)



Preliminary datasheet of four channel X-band CMOS Core Chip

Typical on Board Measurements

S-parameters and noise performance in RX mode

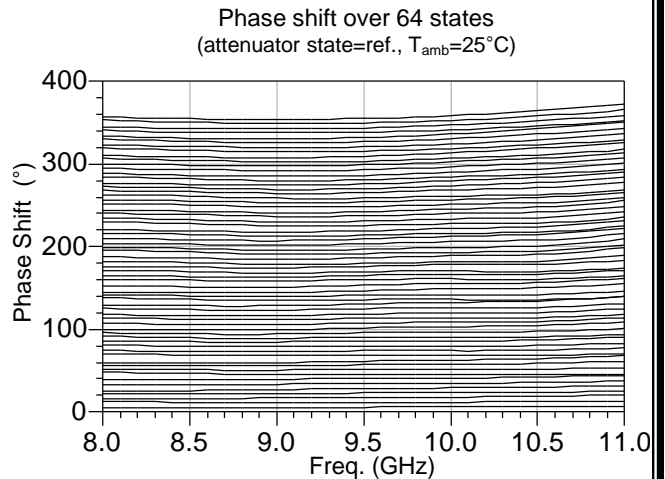
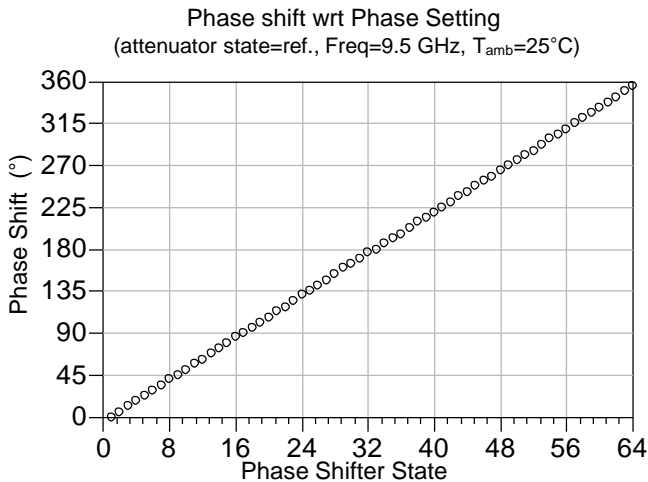
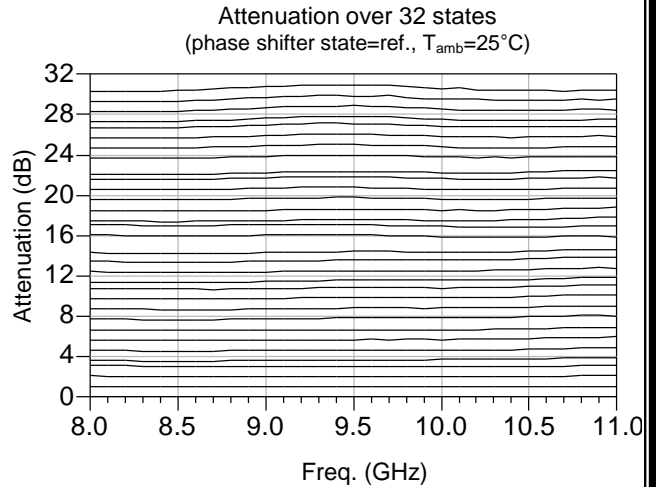
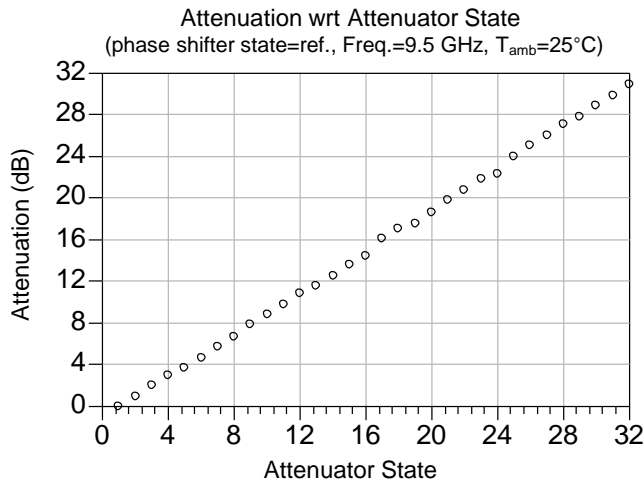


Note : This result was measured on evaluation module RMF090100PA4CH-EVM. Measurement losses with the connectors and PCB signal lines are included.

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Typical on Board Measurements

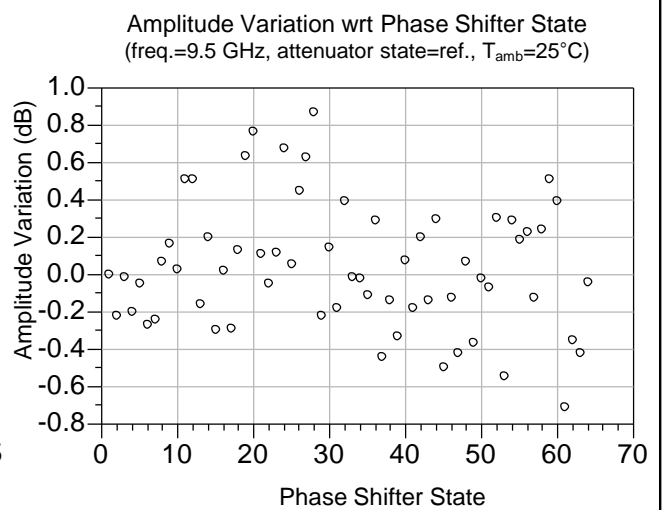
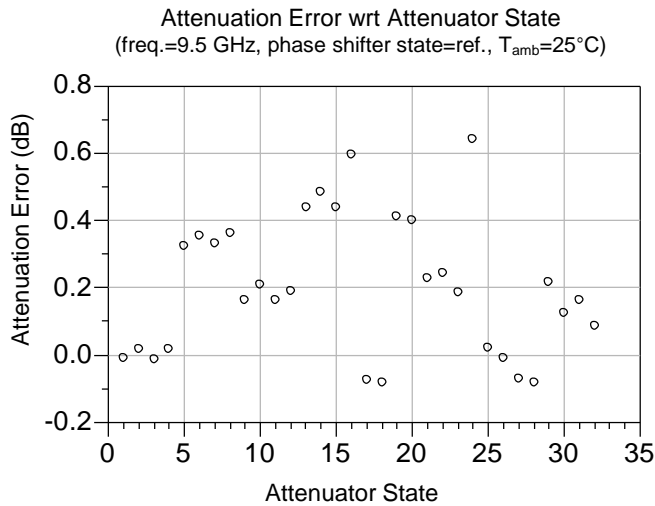
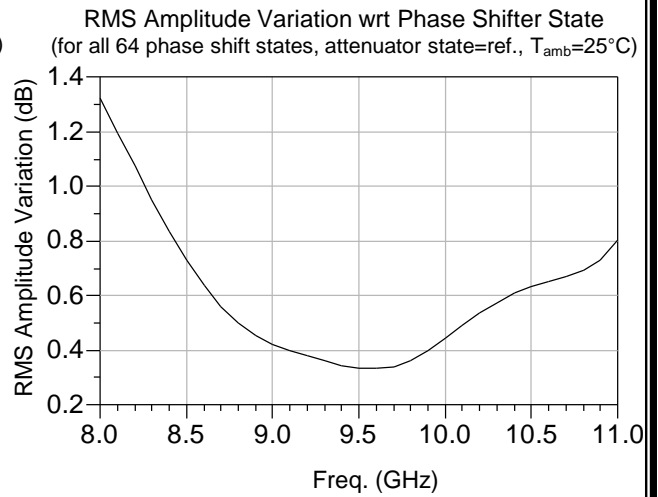
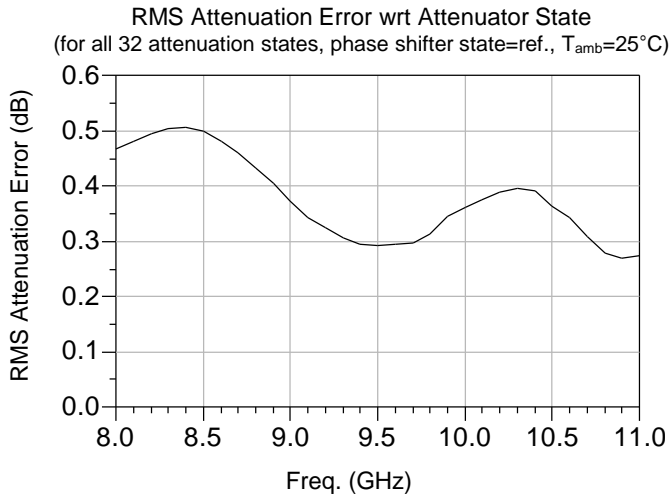
Attenuator and Phase Shifter Response



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Typical on Board Measurements

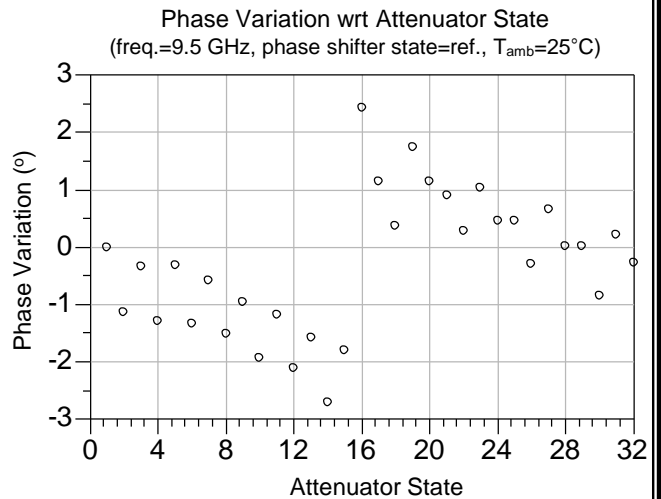
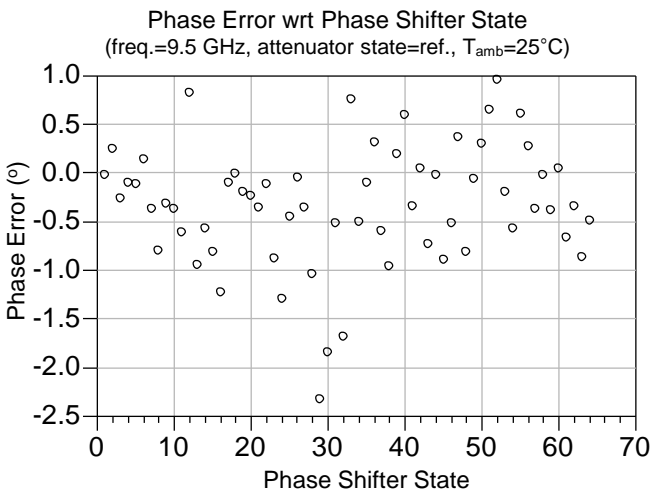
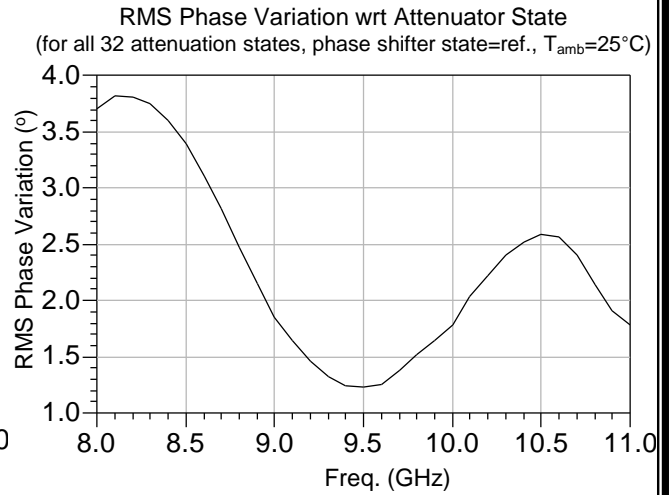
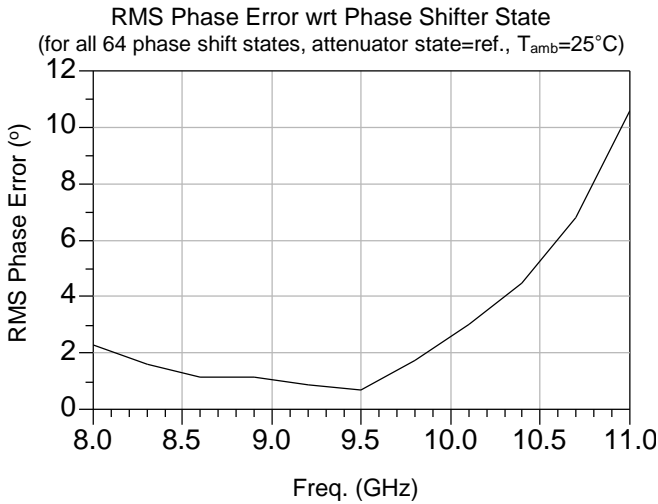
Attenuation Errors



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Typical on Board Measurements

Phase Shifting Errors

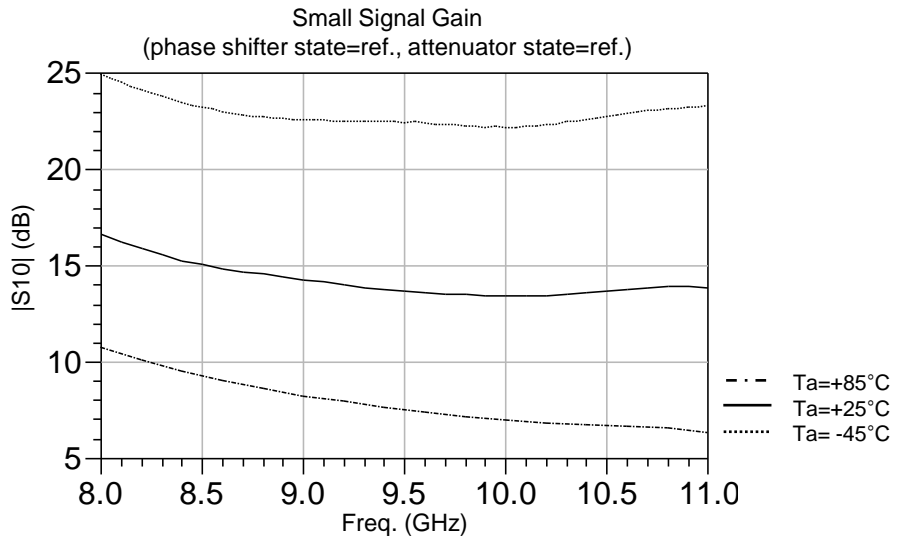


Preliminary datasheet of four channel X-band CMOS Core Chip

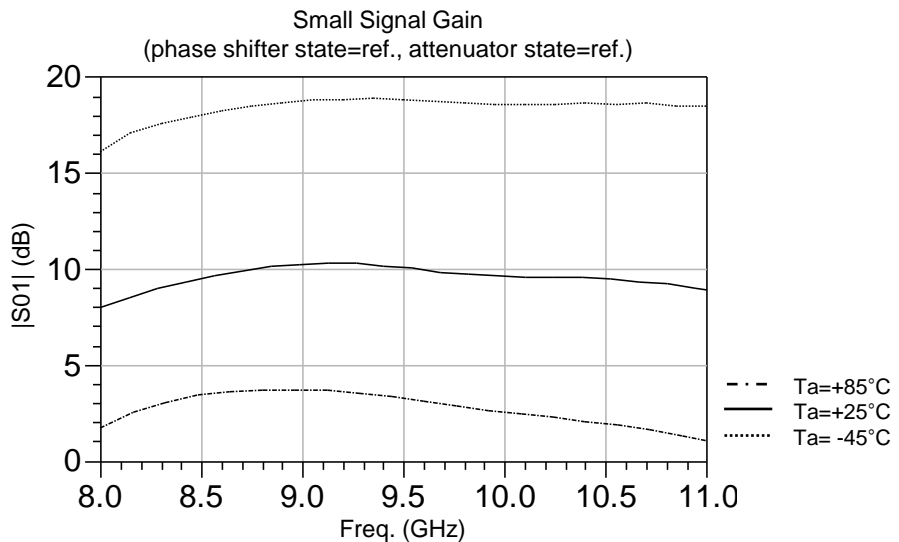
Typical Test Fixture Measurement in Temperature

Small Signal Gain

TX Mode



RX Mode

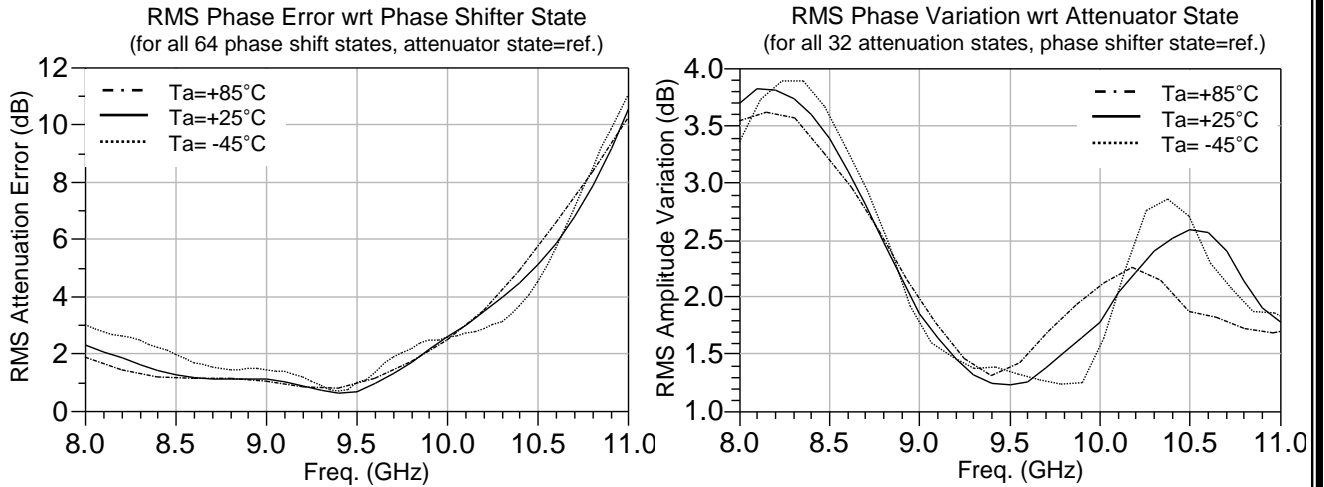


Preliminary datasheet of four channel X-band CMOS Core Chip

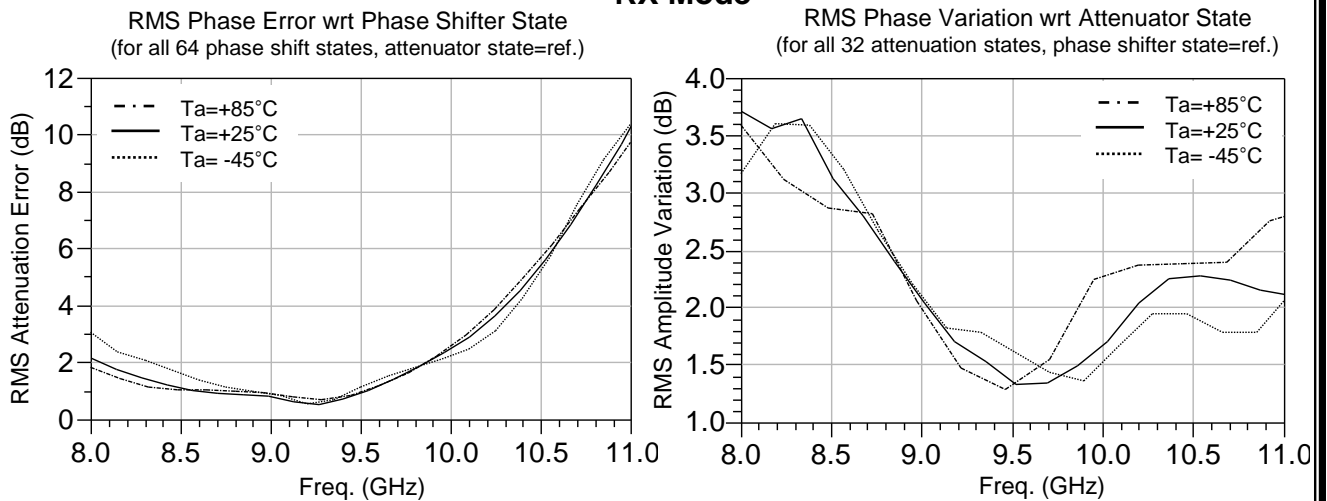
Typical Test Fixture Measurement in Temperature

Phase Shifting Errors

TX Mode



RX Mode



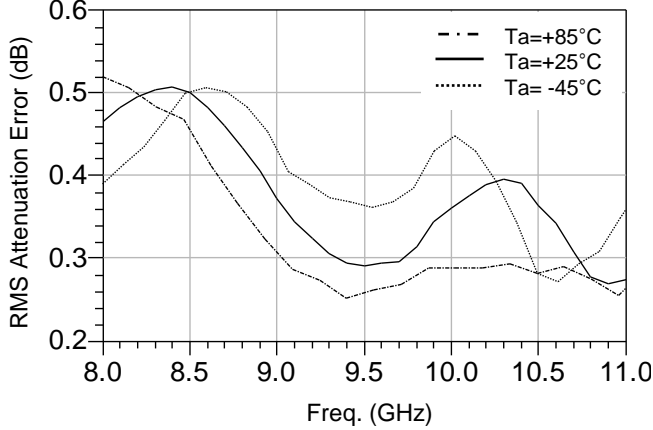
Preliminary datasheet of four channel X-band CMOS Core Chip

Typical Test Fixture Measurement in Temperature

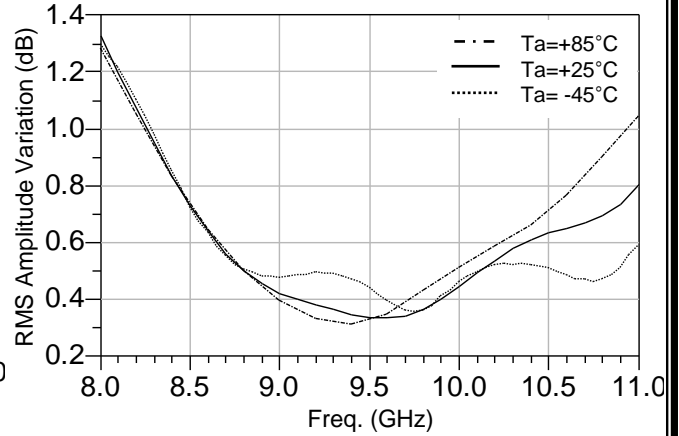
Attenuation Errors

TX Mode

RMS Attenuation Error wrt Attenuator State
(for all 32 attenuation states, phase shifter state=ref.)

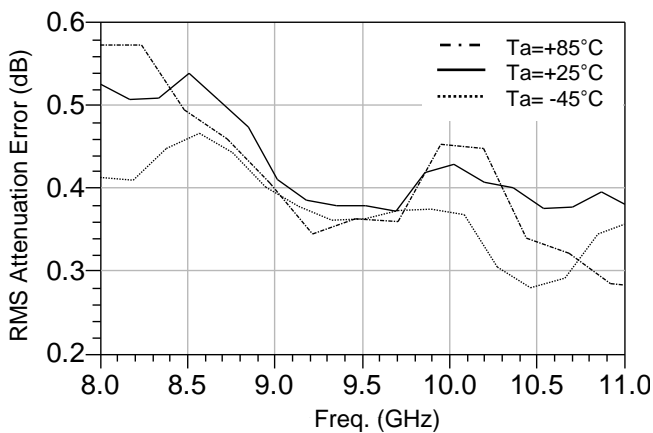


RMS Amplitude Variation wrt Phase Shifter State
(for all 64 phase shift states, attenuator state=ref.)

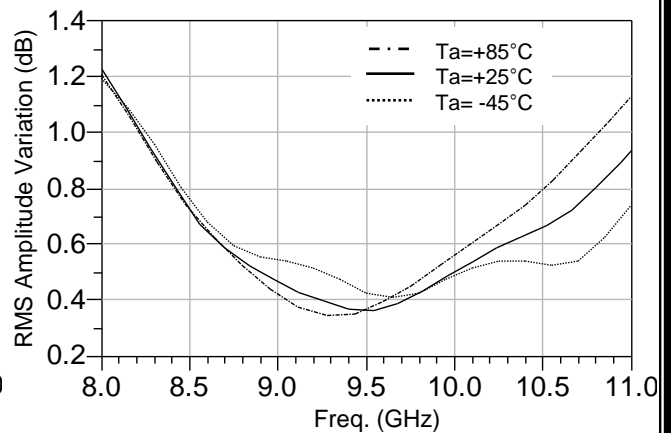


RX Mode

RMS Attenuation Error wrt Attenuator State
(for all 32 attenuation states, phase shifter state=ref.)

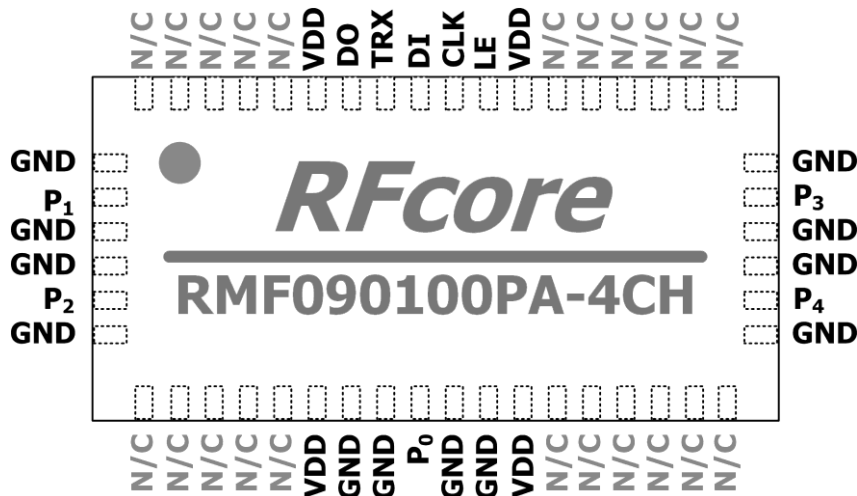


RMS Amplitude Variation wrt Phase Shifter State
(for all 64 phase shift states, attenuator state=ref.)



Preliminary datasheet of four channel X-band CMOS Core Chip

Pin Configuration

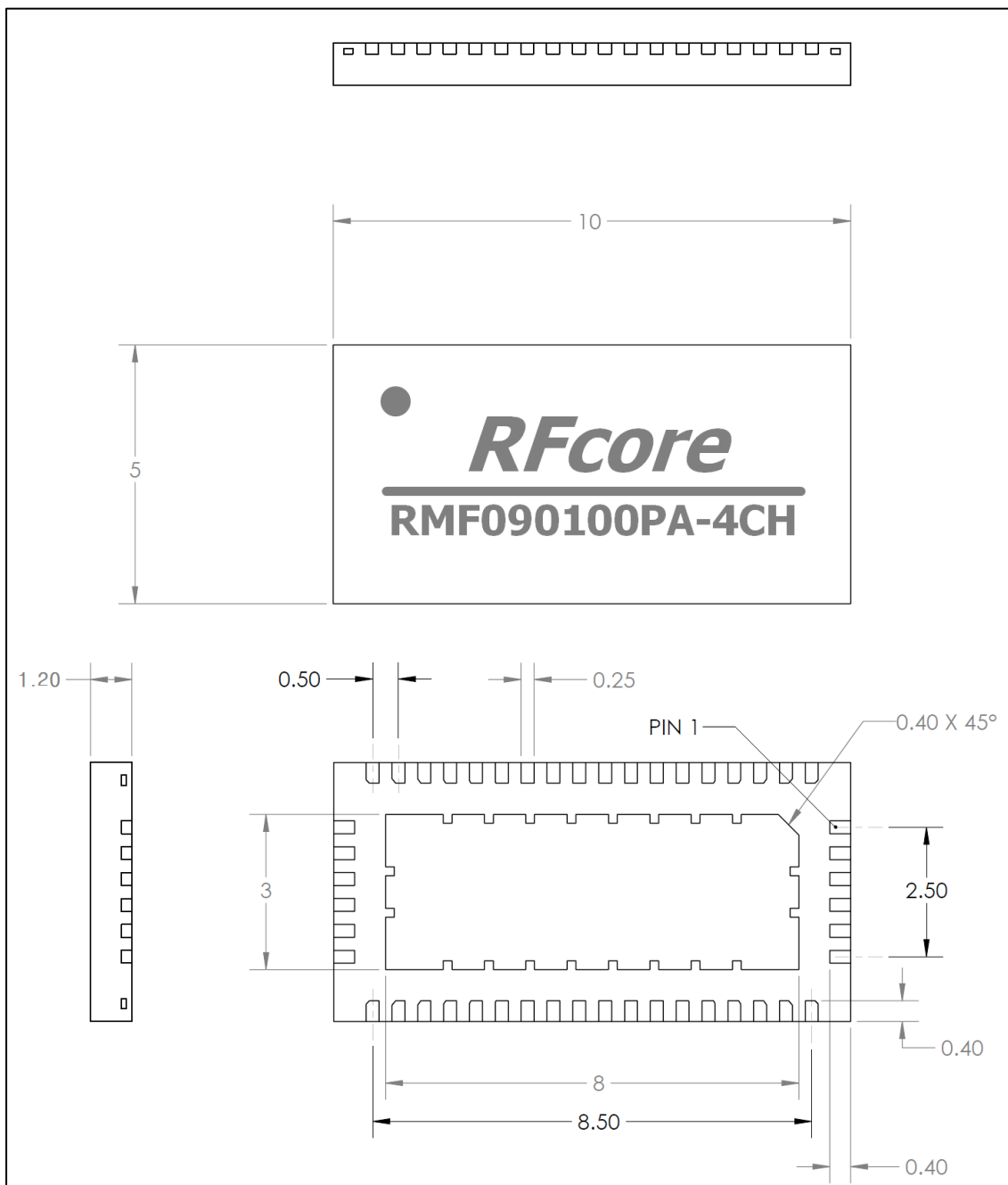


Symbol	Description	Recommended Operating Conditions
P ₀	Tx in / Rx out (Common port)	Z ₀ = 50Ω
P ₁	Tx out / Rx in (Channel1)	Z ₀ = 50Ω
P ₂	Tx out / Rx in (Channel2)	Z ₀ = 50Ω
P ₃	Tx out / Rx in (Channel3)	Z ₀ = 50Ω
P ₄	Tx out / Rx in (Channel4)	Z ₀ = 50Ω
VDD	Power Supply	3.3V I _{DC} =830mA/ch (TX), I _{DC} =490mA/ch (RX)
DI	SPI Data In	Low=0V, High=3.3V
DO	SPI Data Out	Low=0V, High=3.3V
CLK	CLK for SPI	Low=0V, High=3.3V
LE	SPI Latch Enable	Low=0V, High=3.3V
TRX	Transmit / Receive mode control	Low=0V, High=3.3V
N/C	Not Connected	Not Connected
GND	Ground	Ground

Preliminary datasheet of four channel X-band CMOS Core Chip

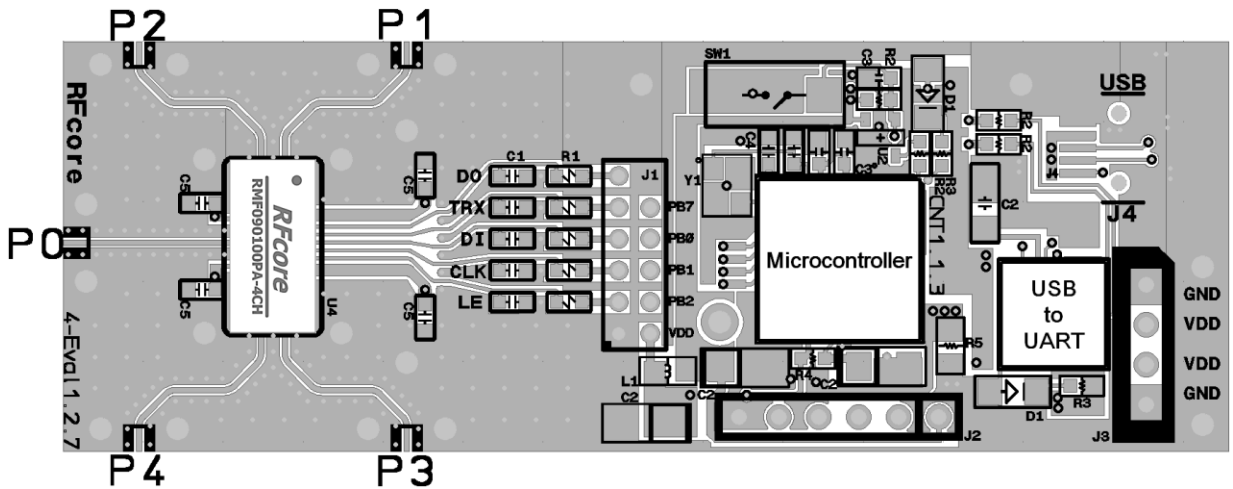
Package Outline

Type	Description	Terminals	Pitch (mm)	Package Size (mm)
QFN	Quad Flat No lead with exposed heat sink	48	0.5	10 x 5 x 1.2



Preliminary datasheet of four channel X-band CMOS Core Chip

Evaluation Module (RMF090100PA4CH-EVM)



-The evaluation module is an easy to use platform for evaluating the X-band four channel core chip RMF090100PA4CH. The user can evaluate the performance of the RMF090100PA4CH using a PC with USB interface and GUI software. The RMF090100PA4CH-EVM includes the evaluation software on a CD-ROM.

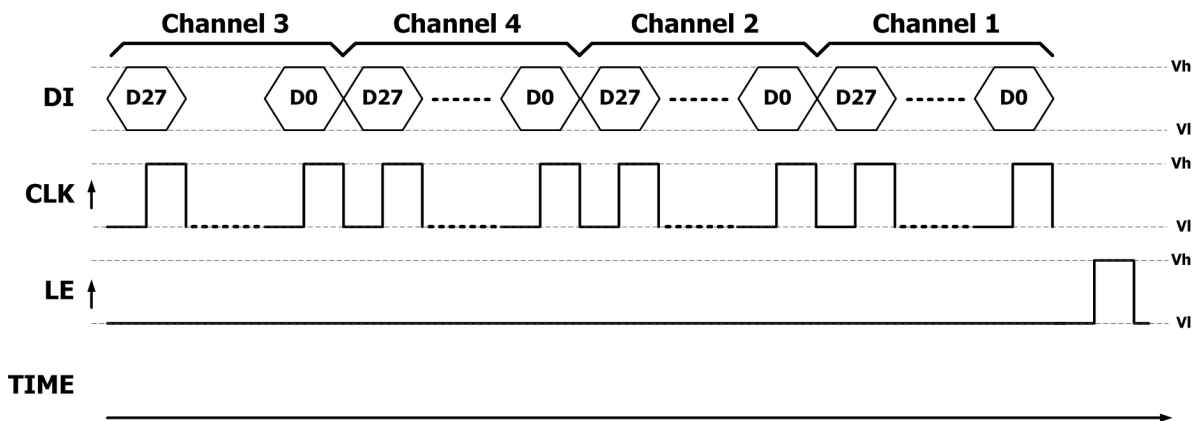
Ordering Information

Item	Contents	Part Number
Evaluation Kit	RMF090100PA4CH Core Chip Evaluation PCB mini USB Interface Board USB A Male to Mini USB 5Pin B Male 1.8M CD ROM (Evaluation Module User Guide, Evaluation Software)	RMF090100PA 4CH-EVM

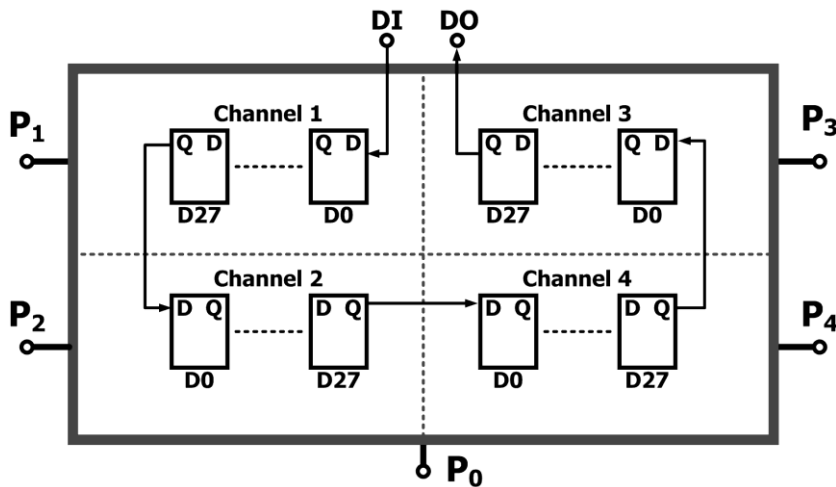
Preliminary datasheet of four channel X-band CMOS Core Chip

Time Diagram

- All functions of each channel are controlled by 28 bits of internal registers through serial interface.
- DI is sampled at the rising edge of CLK.
- LE must occur when all the bits are loaded.
- Logic Low (Vl) = 0 ~ 1.3 V
- Logic High (Vh)= 2.0 ~ 3.3 V



- Data loading sequence is as follows :
- Channel 3 → Channel 4 → Channel 2 → Channel 1



Preliminary datasheet of four channel X-band CMOS Core Chip

Control Data

Bit Number	Description	Reference State / Condition
D0	Tuning bit(attenuation)	High
D1	Tuning bit(attenuation)	High
D2	Attenuation	Low
D3	Attenuation	Low
D4	Attenuation	Low
D5	Attenuation	Low
D6	Attenuation	Low
D7	Attenuation	Low
D8	Tuning bit(phase)	Low
D9	Tuning bit(phase)	Low
D10	Phase	Low
D11	Tuning bit(phase)	Low
D12	Tuning bit(phase)	High
D13	Phase	Low
D14	Phase	Low
D15	Phase	Low
D16	Phase	Low
D17	Phase	Low
D18	Enable LDO	Low
D19	LDO Control	Low
D20	LDO Control	Low
D21	LDO Control	High
D22	Bias Control	Low
D23	Bias Control	Low
D24	Bias Control	High
D25	Transmit/Receive Mode Selection	Low=Internal Mode, (TRX mode is controlled by D26) High=External Mode, (TRX mode is controlled by TRX pin)
D26	Transmit/Receive Mode Control	Low=TX High=RX
D27	Enable MFC	Low=Disable High=Enable

Preliminary datasheet of four channel X-band CMOS Core Chip

Attenuator control table

Atten. State	Bit Num.	D2	D3	D4	D5	D6	D7	D12
	Atten.(dB)							
0	0	0	0	0	0	0	0	1
1	1	1	0	0	0	0	0	1
2	2	0	1	0	0	0	0	1
3	3	1	1	0	0	0	0	1
4	4	0	0	1	0	0	0	1
5	5	1	0	1	0	0	0	1
6	6	0	1	1	0	0	0	1
7	7	1	1	1	0	0	0	1
8	8	0	0	0	0	0	1	1
9	9	1	0	0	0	0	1	1
10	10	0	1	0	0	0	1	1
11	11	1	1	0	0	0	1	1
12	12	0	0	1	0	0	1	1
13	13	1	0	1	0	0	1	1
14	14	0	1	1	0	0	1	1
15	15	1	1	1	0	0	1	0
16	16	0	0	0	1	1	0	0
17	17	1	0	0	1	1	0	0
18	18	0	1	0	0	1	1	0
19	19	1	1	0	0	1	1	0
20	20	0	0	1	1	1	0	0
21	21	1	0	1	1	1	0	0
22	22	0	1	1	1	1	0	0
23	23	1	1	1	0	1	1	0
24	24	0	0	0	1	1	1	0
25	25	1	0	0	1	1	1	0
26	26	0	1	0	1	1	1	0
27	27	1	1	0	1	1	1	0
28	28	0	0	1	1	1	1	0
29	29	1	0	1	1	1	1	0
30	30	0	1	1	1	1	1	0
31	31	1	1	1	1	1	1	0

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Phase control table

Phase State	Bit Num.	D0	D1	D8	D9	D10	D11	D13	D14	D15	D16	D17
	Phase(°)											
0	0	1	1	0	0	0	0	0	0	0	0	0
1	5.625	0	1	0	0	1	0	0	0	0	0	0
2	11.25	1	0	1	1	0	0	1	0	0	0	0
3	16.875	0	0	1	1	1	0	1	0	0	0	0
4	22.5	1	1	1	0	0	0	0	1	0	0	0
5	28.125	0	1	1	0	1	0	0	1	0	0	0
6	33.75	1	0	1	1	0	0	1	1	0	0	0
7	39.375	0	1	1	1	1	0	1	1	0	0	0
8	45	1	1	0	1	0	0	0	0	1	0	0
9	50.625	0	1	1	0	1	0	0	0	1	0	0
10	56.25	0	1	1	1	0	1	0	0	1	0	0
11	61.875	0	0	1	1	1	1	0	0	1	0	0
12	67.5	1	1	0	1	0	0	0	1	1	0	0
13	73.125	1	1	0	1	1	0	0	1	1	0	0
14	78.75	1	0	1	1	0	0	1	1	1	0	0
15	84.375	0	1	1	1	1	0	1	1	1	0	0
16	90	0	1	0	1	0	0	0	0	0	1	0
17	95.625	0	1	1	0	1	0	0	0	0	1	0
18	101.25	0	1	1	1	0	1	0	0	0	1	0
19	106.875	0	1	1	0	0	1	1	0	0	1	0
20	112.5	1	1	1	1	0	0	0	1	0	1	0
21	118.125	0	1	1	1	1	0	0	1	0	1	0
22	123.75	1	0	0	1	1	0	1	1	0	1	0
23	129.375	1	0	1	1	0	1	1	1	0	1	0
24	135	0	1	1	1	0	0	0	0	1	1	0
25	140.625	0	1	1	1	1	0	0	0	1	1	0
26	146.25	0	0	1	0	1	1	0	0	1	1	0
27	151.875	0	0	0	1	1	1	1	0	1	1	0
28	157.5	1	0	1	1	0	0	0	1	1	1	0
29	163.125	1	0	1	1	1	0	0	1	1	1	0
30	168.75	0	1	1	1	0	0	1	1	1	1	0
31	174.375	0	1	1	0	0	1	1	1	1	1	0
32	180	1	1	0	0	0	0	0	0	0	0	1
33	185.625	1	0	0	1	1	0	0	0	0	0	1
34	191.25	0	1	1	1	0	0	1	0	0	0	1
35	196.875	0	1	1	1	1	0	1	0	0	0	1
36	202.5	1	0	1	1	0	0	0	1	0	0	1
37	208.125	0	1	1	1	1	0	0	1	0	0	1
38	213.75	0	1	1	1	0	0	1	1	0	0	1
39	219.375	0	1	1	1	1	0	1	1	0	0	1
40	225	1	0	1	1	0	0	0	0	1	0	1
41	230.625	1	0	1	1	1	0	0	0	1	0	1
42	236.25	0	0	0	0	0	1	1	0	1	0	1
43	241.875	0	0	0	0	1	1	1	0	1	0	1
44	247.5	1	0	1	1	0	0	0	1	1	0	1
45	253.125	1	0	1	1	1	0	0	1	1	0	1
46	258.75	0	1	1	1	0	0	1	1	1	0	1
47	264.375	0	1	0	1	0	1	1	1	1	0	1
48	270	1	0	1	0	0	0	0	0	0	1	1
49	275.625	1	0	1	0	1	0	0	0	0	1	1
50	281.25	0	1	1	1	0	0	1	0	0	1	1
51	286.875	0	1	1	1	1	0	1	0	0	1	1
52	292.5	1	0	1	1	0	0	0	1	0	1	1
53	298.125	1	1	1	1	1	0	0	1	0	1	1
54	303.75	1	1	1	1	0	0	1	1	0	1	1
55	309.375	1	0	0	1	0	1	1	1	0	1	1
56	315	1	0	1	1	0	0	0	0	1	1	1
57	320.625	1	0	1	1	1	0	0	0	1	1	1
58	326.25	1	0	0	0	0	1	1	0	1	1	1
59	331.875	0	0	0	0	1	1	1	0	1	1	1
60	337.5	1	0	0	1	0	0	0	1	1	1	1
61	343.125	1	0	0	1	1	0	0	1	1	1	1
62	348.75	1	0	1	1	0	0	1	1	1	1	1
63	354.375	1	0	1	1	1	0	1	1	1	1	1