SONY

5-bit series and 4-bit shunt Switchable Step Capacitor (SPI30-bit)

CXM3624UR

Ver. 0.1

Preliminary

Description

This product has 2-Bank tuning devices, one is 5-bit series cap-array and the other is 4-bit shunt cap-array.

And through path switch is prepared on 5-bit series cap-array and also shunt external switch is implemented on the opposite side of shunt cap-array for tuning area extension.
For realizing high linearity and high Quality factor, Sony GaAs JPHEMT process is utilized for antenna tuning.

Features

- **5-bit series and 4-bit shunt Topology**
- **Through path/ External switch integrated**
- High power handling and High linearity
- High Q-factor and small tolerance capacitor (+/-3 % typ.)
- Low insertion loss (Through path < 0.5 dB @ 2 GHz)
- Applicable frequency 100 MHz to 3 GHz
- Standby mode (Wakeup time < 40 µs)
- **SPI 30-bit Interface (1.8 V typ.)**
- Low voltage operation : 2.4 V to 3.3 V
- **Small package: UQFN-18P (2.8 mm × 3.0 mm × 0.6 mm Max.)**
- Robustness against ESD
- Lead-Free and RoHS Compliant

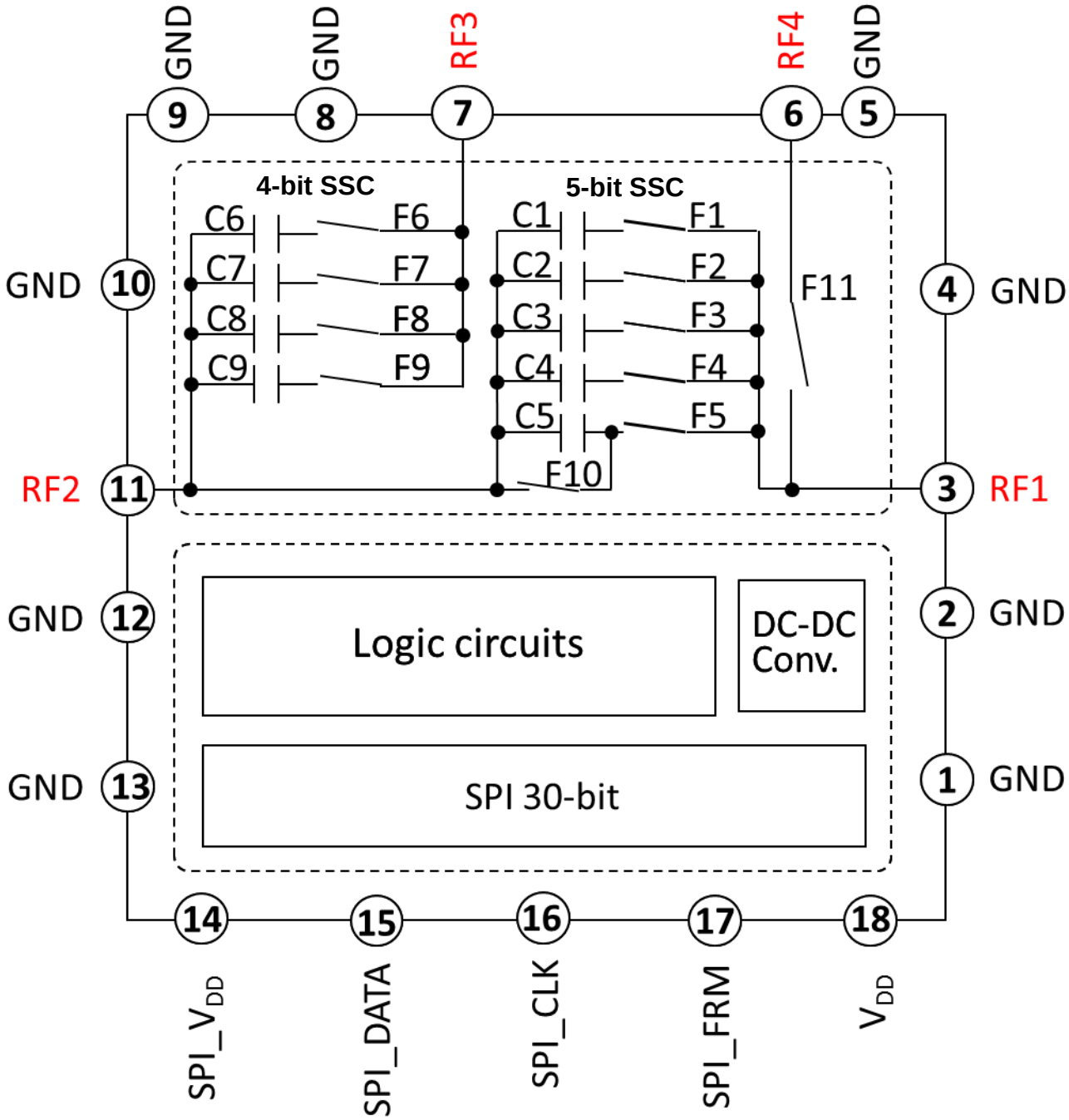
Structure

Capacitor Array: Sony original GaAs Junction Gate pHEMT (JPHEMT) utilized.
Driver IC: Sony original CMOS process utilized

This IC is ESD sensitive device. Special handling precautions are required.

Block Diagram & Pin Configuration

UQFN-18P PKG (2.8 mm × 3.0 mm × 0.6 mm Max.)



Truth Table

Bit	Init.	Set	Function		Description
29	-	0	Write mode		Write to the Device
28	-	1	Address (Slave Type)		
27	-	0			
26	-	1			
25	-	0	Address (Slave Identifier)		
24	-	0			
23	-	0			
22	-	0			
21	-	0			
20	-	0	Address (Slave SPI register)		[20:16]=01000b
19	-	1			
18	-	0			
17	-	0			
16	-	0			
15	-	0	Not Used		
14	1	1/0	Data	Standby *1	"1"=Active Mode, "0"=Standby Mode
13	0	1/0		F1 selected	"1"=ON, "0"=OFF
12	0	1/0		F2 selected	"1"=ON, "0"=OFF
11	0	1/0		F3 selected	"1"=ON, "0"=OFF
10	0	1/0		F4 selected	"1"=ON, "0"=OFF
9	0	1/0		F5 selected	"1"=ON, "0"=OFF (C5ON or Through path *2)
8	0	1/0		F6 selected	"1"=ON, "0"=OFF
7	0	1/0		F7 selected	"1"=ON, "0"=OFF
6	0	1/0		F8 selected	"1"=ON, "0"=OFF
5	0	1/0		F9 selected	"1"=ON, "0"=OFF
4	1	1/0		F10 selected	"1"=ON, "0"=OFF (Through path)
3	0	1/0		F11 selected	"1"=ON, "0"=OFF (Ext. branch)
2	0	0		Fixed	
1	0	0		Fixed	
0	-	0	Not Used		

*1 Standby
Standby bit is for low current operation in SSC disabled in mobile phone.
On Standby mode bias voltage for SSC part is shutoff.
Regardless of standby and active, IC can receive SPI data during supplying regular voltage to SPI_V_{DD}.

*2 Through path
F5 and F10 must be turned ON to be able to make use of through path.

DC Bias Condition

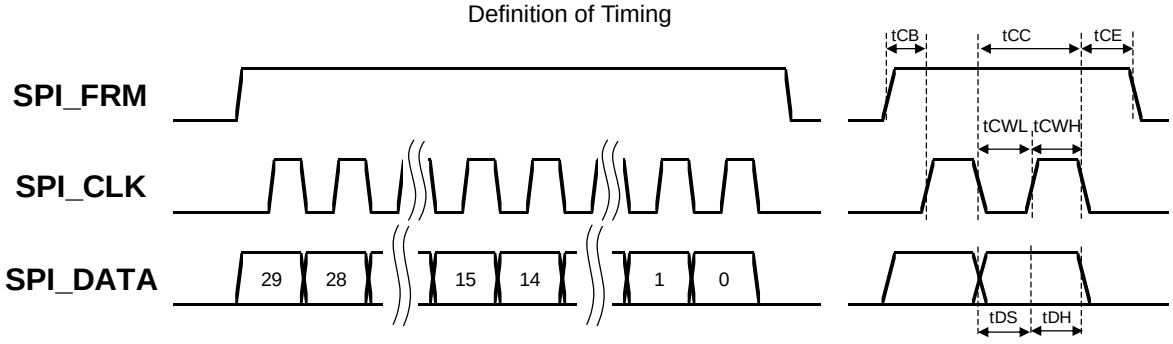
Ta = 25 ˚C

Parameter	Symbol	Min.	Typ.	Max.	Unit
V_{DD}	V_{DD}	2.4	2.8	3.3	V
SPI_V_{DD}(H)	SPI_V_{DD}	1.62	1.80	1.98	
SPI_DATA(H) SPI_CLK(H) SPI_FRM(H)	SPI_DATA SPI_CLK SPI_FRM	SPI_V_{DD} x 0.8	—	SPI_V_{DD} + 0.3	
SPI_DATA(L) SPI_CLK(L) SPI_FRM(L)		-0.3	—	SPI_V_{DD} x 0.2	

SPI Interface

Parameter	Specification
Address bits	14 bits
Data bits	16 bits
Total bits	30 bits
Clock rate	26 MHz max.
Clock edge (data sampling)	Rising edge

Definition of Timing



Absolute Maximum Ratings

Bias Voltage	V_{DD}	4	V	Ta = 25 ˚C
Control Voltage	SPI_V_{DD}, SPI_DATA, SPI_CLK, SPI_FRM	3.5	V	Ta = 25 ˚C
Maximum input power		+36	dBm	Duty cycle = 12.5 % to 50 %, Ta = 25 ˚C
Operating Temperature	Topr	−30 to +90	˚C	
Storage Temperature	Tstg	−65 to +150	˚C	

Electrical Characteristics

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
SPI_Bias current	SPI_I_{DD}	RF pins 50Ω terminated. No RF power input. SPI_V_{DD} = 1.8 V	SPI_FRM = H, When signal is input.	140	-	300	μA
SPI_Enable	SPI_EN	Time from SPI_V_{DD}, turn on to SPI_FRM H_level		-	-	150	ns
Clock frequency	CLK_Freq	SPI_V_{DD} Enable		-	-	26	MHz
Clock cycle	tCC	CLK_Freq = 26 MHz		34	39	42	ns
Clock begin time	tCB			19.5	-	-	ns
Clock end time	tCE			19.5	-	-	ns
Clock width High	tCWH	tCC/2		17	-	21	ns
Clock width Low	tCWL	tCC/2		17	-	21	ns
Data setup time	tDS			14	-	-	ns
Data hold time	tDH			14	-	-	ns
Wake-up time	tWakeup	Wake-up time of inside DC-DC converter (V_{DD} On, release standby mode)		-	-	40	μs

Ta = 25 ˚C, V_{DD} = 2.8 V, SPI_V_{DD} = 1.8 V

Item	Symbol	Condition	State	Min.	Typ.	Max.	Unit
DC Supply Current	IDD	Active mode, SPI: bit [14] = H	-	140	190	300	μA
		Standby mode, SPI bit [14] = L	-	5	7	10	
	SPI_IDD	Active mode, SPI bit [14] = H	-	1.5	4	16	
		Standby mode, SPI bit [14] = L	-	1.5	4	16	

Electrical Characteristics are measured with all RF ports terminated by 50 Ω.

Ta = 25 ˚C, V_{DD} = 2.8 V, SPI_V_{DD} = 1.8 V

Item	Symbol	Path	Condition		State	Min.	Typ.	Max.	Unit
Transmission Performance	S12	RF1-RF2	5-bit Series	Freq. = 900 MHz F6 to F9 : OFF F10, F11 : OFF RF3 : GND RF4 : OPEN	F1 to F5 : OFF		-8.61		dB
					F1 ON (C1)		-6.50		
					F2 ON (C2)		-4.97		
					F3 ON (C3)		-3.32		
					F4 ON (C4)		-1.84		
					F5 ON (C5)		-0.81		
					F1 to F5 : ON (C1+C2+C3+C4+C5)		-0.48		
				Freq. = 2 GHz F6 to F9 : OFF F10, F11 : OFF RF3 : GND RF4 : OPEN	F1 to F5 : OFF		-4.83		
					F1 ON (C1)		-3.48		
					F2 ON (C2)		-2.61		
					F3 ON (C3)		-1.77		
					F4 ON (C4)		-1.13		
					F5 ON (C5)		-0.73		
					F1 to F5 : ON (C1+C2+C3+C4+C5)		-0.58		
			Through path	Freq. = 900 MHz F1 to F4 : OFF F6 to F9 : OFF F11 : OFF RF3 : GND RF4 : OPEN	F5, F10 ON	-0.40	-0.25		
				Freq. = 2 GHz F1 to F4 : OFF F6 to F9 : OFF F11 : OFF RF3 : GND RF4 : OPEN	F5, F10 ON	-0.65	-0.49		

Item	Symbol	Path	Condition		State	Min	Typ.	Max.	Unit
Transmission Performance	S12	RF1-RF2	4-bit Shunt	Freq. = 900 MHz F1 to F4 : OFF, F5, F10 : ON RF3 : GND RF4 : OPEN	F6 ON (C6)		-0.31		dB
					F7 ON (C7)		-0.40		
					F8 ON (C8)		-0.62		
					F9 ON (C9)		-1.47		
					F6 to F9 : ON (C6+C7+C8+C9)		-3.06		
				Freq. = 2 GHz F1 to F4 : OFF, F5, F10 : ON RF3 : GND RF4 : OPEN	F6 ON (C6)		-0.79		
					F7 ON (C7)		-1.23		
					F8 ON (C8)		-2.57		
					F9 ON (C9)		-8.51		
					F6 to F9 : ON (C6+C7+C8+C9)		-19.1		
	S14	RF1-RF4	Ext branch	Freq. = 900 MHz F1 to F5 : OFF, F6 to F9 : OFF F10 : OFF RF2 : OPEN RF3 : OPEN	F11 ON		-0.17		
				Freq. = 2 GHz F1 to F5 : OFF, F6 to F9 : OFF F10 : OFF RF2 : OPEN RF3 : OPEN	F11 ON		-0.21		

Item	Symbol	Path	Condition	State	Min.	Typ.	Max.	Unit
Capacitance *1	C_F1-F5 off	RF1 : port1	Calculated by Z - parameter at 700MHz. F6 to F9 : OFF, F10, F11 : OFF RF2 : port2 50Ω RF3 : port3 OPEN RF4 : port4 OPEN	0 (F1 to F5 : OFF)		1.10		pF
	C1			1 (F1 ON)		1.43		
	C2			2 (F2 ON)		1.74		
				3		2.04		
	C3			4 (F3 ON)		2.31		
				5		2.61		
				6		2.88		
				7		3.17		
	C4			8 (F4 ON)		3.42		
				9		3.70		
				10		3.99		
				11		4.26		
				12		4.48		
				13		4.75		
				14		4.99		
				15		5.25		
	C5			16 (F5 ON)		6.13		
				17		6.37		
				18		6.61		
				19		6.83		
				20		7.03		
				21		7.26		
				22		7.47		
				23		7.68		
				24		7.86		
				25		8.08		
				26		8.29		
				27		8.50		
				28		8.67		
				29		8.88		
				30		9.06		
	C_F1-F5 on			31(F1 to F5 : ON)		9.26		

*1: Capacitance calculation $Z = R + jX$, $X = 1 / (\omega \cdot C) \Rightarrow \therefore C = 1 / (2\pi \cdot f \cdot X)$

Item	Symbol	Path	Condition	State	Min.	Typ.	Max.	Unit
Capacitance *2	C_F6-F9 off	RF2-RF3 RF2 : port2 RF3 : port3	Calculated by Y-parameter at 700MHz. F1 to F5 : OFF, F10, F11 : OFF RF1 : port1 OPEN RF4 : port4 OPEN	0 (F6 to F9 : OFF)		0.48		pF
	C6			1 (F6 ON)		0.80		
	C7			2 (F7 ON)		1.11		
				3		1.41		
	C8			4 (F8 ON)		1.76		
				5		2.08		
				6		2.39		
				7		2.69		
	C9			8 (F9 ON)		3.31		
				9		3.64		
				10		3.93		
				11		4.23		
				12		4.60		
				13		4.92		
				14		5.22		
	C_F6-F9 on			15 (F6 to F9 : ON)		5.52		

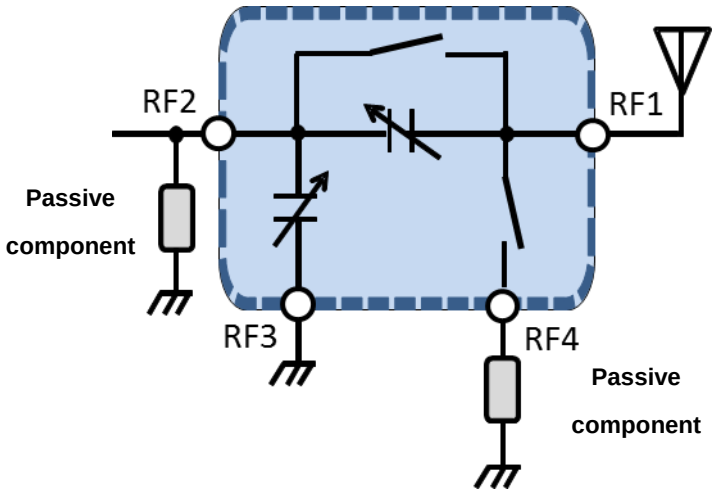
*2: Capacitance calculation C = - Im(Y32) / (2π・f)

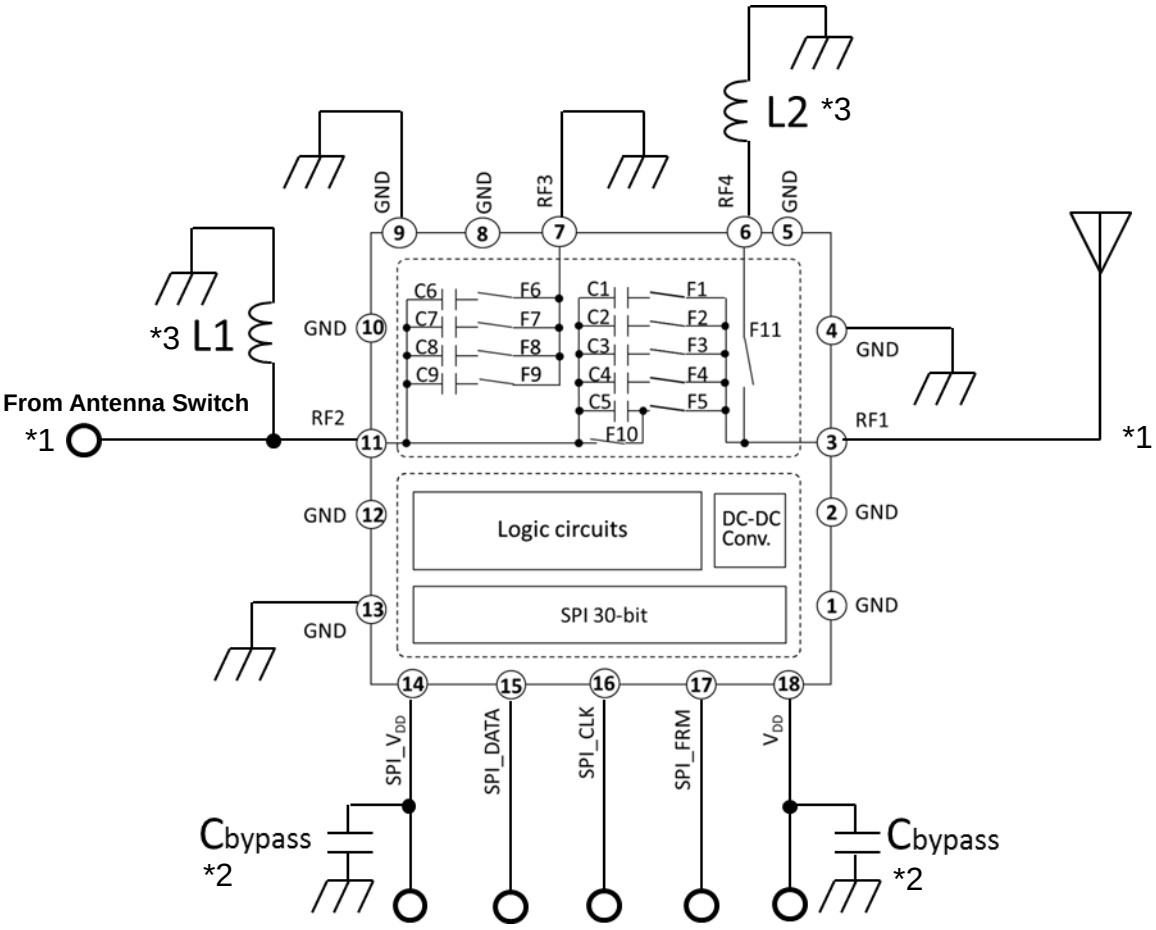
Item	Symbol	Path	Condition						State	Min.	Typ.	Max.	Unit
					SSC1 (5-bit)		SSC2 (4-bit)						
					F1-F5	F10 Through	F6-F9	F11 Ext.Branch					
Harmonics Zs, Zl = 50Ω	**2fo**	**RF1-RF2**	**5-bit Series**	**Input Port : RF2 Freq. = 900 MHz Pin = 35 dBm 50 Ω LOAD RF3 : GND RF4 : OPEN**	See State	Off	Off	Off	F1 ON (C1)		-40	-38	dBm
									F2 ON (C2)		-43	-38	
									F3 ON (C3)		-45	-38	
									F4 ON (C4)		-47	-38	
									F5 ON (C5)		-51	-38	
									F1-F5 ON		-50	-38	
					F5 On only	On	Off	Off	F5, F10 ON Through path		-47	-38	
	3fo				See State	Off	Off	Off	F1 ON (C1)		-42	-38	
									F2 ON (C2)		-45	-38	
									F3 ON (C3)		-49	-38	
									F4 ON (C4)		-53	-38	
									F5 ON (C5)		-56	-38	
									F1-F5 ON		-57	-38	
					F5 On only	On	Off	Off	F5, F10 ON Through path		-56	-38	
	2fo		**4-bit Shunt**	**Input Port : RF2 Freq. = 900 MHz Pin = 35 dBm 50 Ω LOAD RF3 : GND RF4 : OPEN**	Off	On	See state	Off	F6 ON (C6)		-51	-40	
									F7 ON (C7)		-55	-40	
									F8 ON (C8)		-56	-40	
									F9 ON (C9)		-49	-40	
									F6-F9 ON		-52	-40	
	3fo				Off	On	See state	Off	F6 ON (C6)		-57	-40	
									F7 ON (C7)		-57	-40	
									F8 ON (C8)		-59	-40	
									F9 ON (C9)		-57	-40	
									F6-F9 ON		-65	-40	
	2fo	**RF1-RF2**	**5-bit Series**	**Input Port : RF2 Freq. = 2 GHz Pin = 32 dBm 50 Ω LOAD RF3 : GND RF4 : OPEN**	See State	Off	Off	Off	F1 ON (C1)		-46	-40	
									F2 ON (C2)		-47	-40	
									F3 ON (C3)		-49	-40	
									F4 ON (C4)		-49	-40	
									F5 ON (C5)		-50	-40	
									F1-F5 ON		-50	-40	
					F5 On only	On	Off	Off	F5, F10 ON Through path		-50	-40	
	3fo				See State	Off	Off	Off	F1 ON (C1)		-56	-40	
									F2 ON (C2)		-58	-40	
									F3 ON (C3)		-59	-40	
									F4 ON (C4)		-61	-40	
									F5 ON (C5)		-61	-40	
									F1-F5 ON		-61	-40	
					F5 On only	On	Off	Off	F5, F10 ON Through path		-61	-40	
	2fo		**4-bit Shunt**	**Input Port : RF2 Freq. = 2 GHz Pin = 32 dBm 50 Ω LOAD RF3 : GND RF4 : OPEN**	Off	On	See state	Off	F6 ON (C6)		-51	-40	
									F7 ON (C7)		-52	-40	
									F8 ON (C8)		-59	-40	
									F9 ON (C9)		-56	-40	
									F6-F9 ON		-64	-40	
	3fo				Off	On	See state	Off	F6 ON (C6)		-60	-40	
									F7 ON (C7)		-55	-40	
									F8 ON (C8)		-57	-40	
									F9 ON (C9)		-61	-40	
									F6-F9 ON		-76	-40	

Item	Symbol	Path	Condition						State	Min.	Typ.	Max.	Unit
					SSC1 (5-bit)		SSC2 (4-bit)						
					F1-F5	F10 Through	F6-F9	F11 Ext.Branch					
Harmonics Zs = 50Ω , Zl = valiable	**2fo**	**RF1-RF2**	**5-bit Series**	**Input Port : RF2 Freq. = 900 MHz Pin = 35 dBm RF3 : GND RF4 : OPEN**	See State	Off	Off	Off	F1 ON (C1)			-36	dBm
									F2 ON (C2)			-36	
									F3 ON (C3)			-36	
									F4 ON (C4)			-36	
									F5 ON (C5)			-36	
									F1-F5 ON			-36	
					F5 On only	On	Off	Off	F5, F10 ON Through path			-36	
	3fo				See State	Off	Off	Off	F1 ON (C1)			-36	
									F2 ON (C2)			-36	
									F3 ON (C3)			-36	
									F4 ON (C4)			-36	
									F5 ON (C5)			-36	
									F1-F5 ON			-36	
					F5 On only	On	Off	Off	F5, F10 ON Through path			-36	
	2fo		**4-bit Shunt**	**Input Port : RF2 Freq. = 900 MHz Pin = 35 dBm RF3 : GND RF4 : OPEN**	Off	On	See state	Off	F6 ON (C6)			-36	
									F7 ON (C7)			-36	
									F8 ON (C8)			-36	
									F9 ON (C9)			-36	
									F6-F9 ON			-36	
	3fo				Off	On	See state	Off	F6 ON (C6)			-36	
									F7 ON (C7)			-36	
									F8 ON (C8)			-36	
									F9 ON (C9)			-36	
									F6-F9 ON			-36	
	2fo	**RF1-RF2**	**5-bit Series**	**Input Port : RF2 Freq. = 2 GHz Pin = 32 dBm RF3 : GND RF4 : OPEN**	See State	Off	Off	Off	F1 ON (C1)			-36	
									F2 ON (C2)			-36	
									F3 ON (C3)			-36	
									F4 ON (C4)			-36	
									F5 ON (C5)			-36	
									F1-F5 ON			-36	
					F5 On only	On	Off	Off	F5, F10 ON Through path			-36	
	3fo				See State	Off	Off	Off	F1 ON (C1)			-36	
									F2 ON (C2)			-36	
									F3 ON (C3)			-36	
									F4 ON (C4)			-36	
									F5 ON (C5)			-36	
									F1-F5 ON			-36	
					F5 On only	On	Off	Off	F5, F10 ON Through path			-36	
	2fo		**4-bit Shunt**	**Input Port : RF2 Freq. = 2 GHz Pin = 32 dBm RF3 : GND RF4 : OPEN**	Off	On	See state	Off	F6 ON (C6)			-36	
									F7 ON (C7)			-36	
									F8 ON (C8)			-36	
									F9 ON (C9)			-36	
									F6-F9 ON			-36	
	3fo				Off	On	See state	Off	F6 ON (C6)			-36	
									F7 ON (C7)			-36	
									F8 ON (C8)			-36	
									F9 ON (C9)			-36	
									F6-F9 ON			-36	

Item	Symbol	Path	Condition	State	Min.	Typ.	Max.	Unit
Switching Time	tSW	RF1-RF2	Time from falling edge of SPI_FRM to 100 % RF transient power Freq.= 824 to 915 MHz Pin = 35 dBm 50 Ω LOAD	In all states	10	12	14	µs

Recommended Circuit1





*1: RF1 and RF2 connecting to signal line.

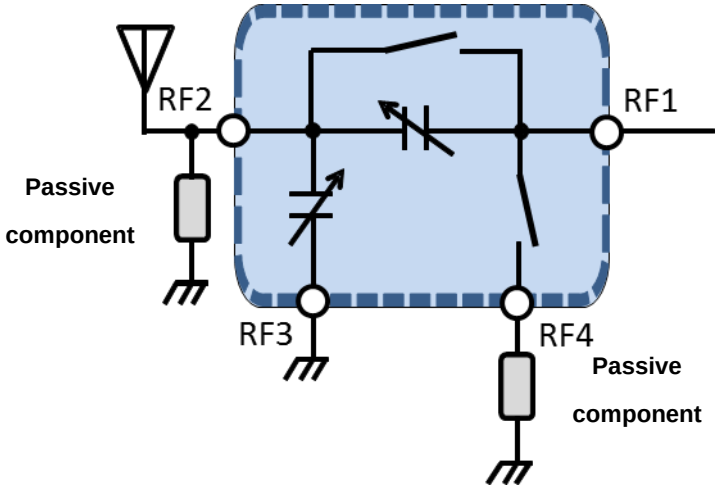
*2: Cbypass = 0.1 µF

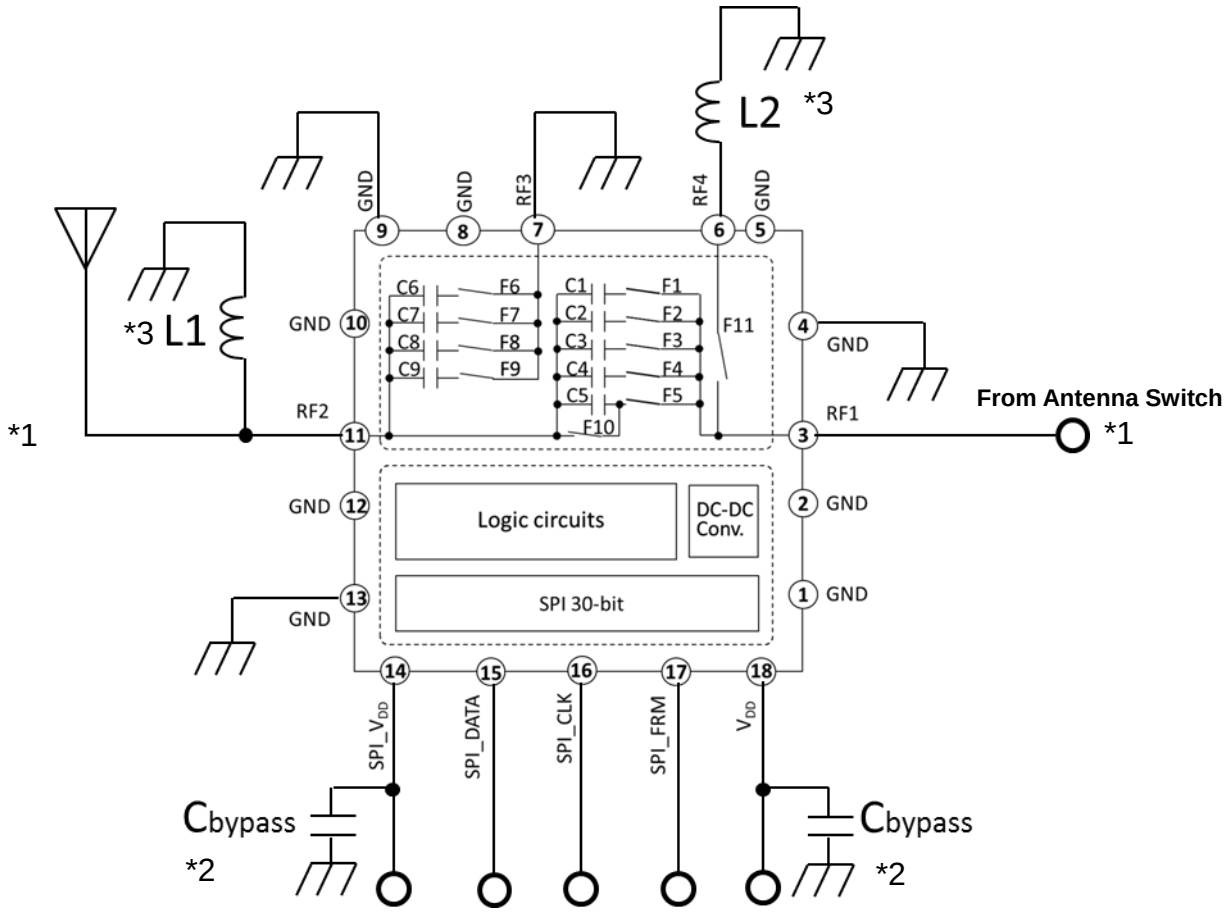
*3: Inductance L1 = TBD, L2 = TBD for loss minimization in all-off of shunt bank

L2 also can be replaced to another reactance component for matching.

Details are described on technical note for this product.

Recommended Circuit2





*1: RF1 and RF2 connecting to signal line.

*2: Cbypass = 0.1 µF

*3: Inductance L1 = TBD, L2 = TBD for loss minimization in all-off of shunt bank

L2 also can be replaced to another reactance component for matching.

Details are described on technical note for this product.

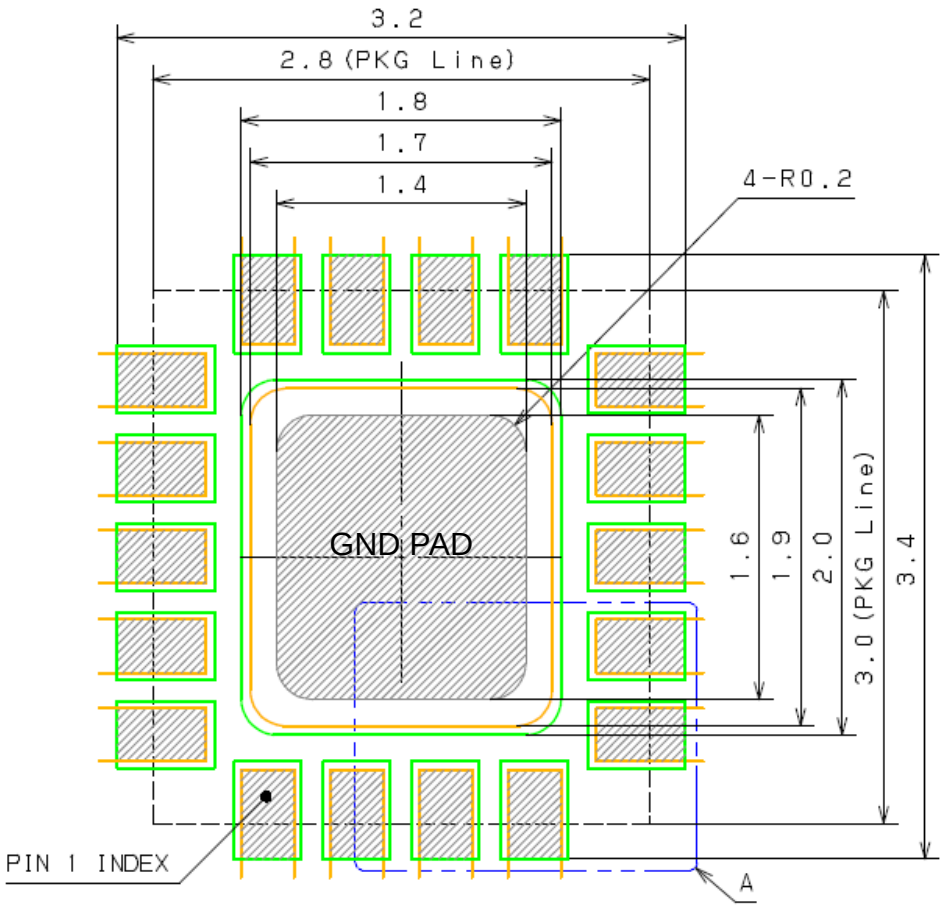
Recommended Pattern

(Unit : mm)

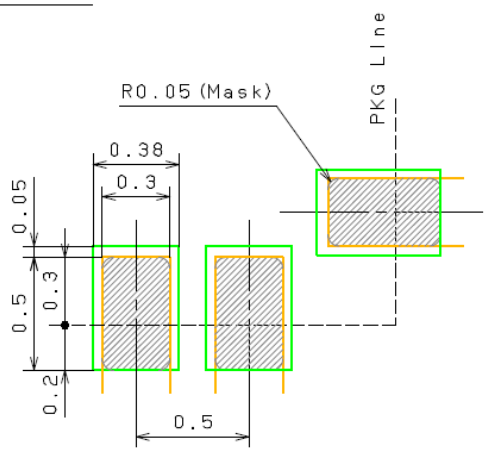
: Land
: Mask (Open area)
: Resist (Open area)

・PKG : 2.8mm×3.0mm
・Pin pitch : 0.5mm

*Metal mask thickness : 110μm

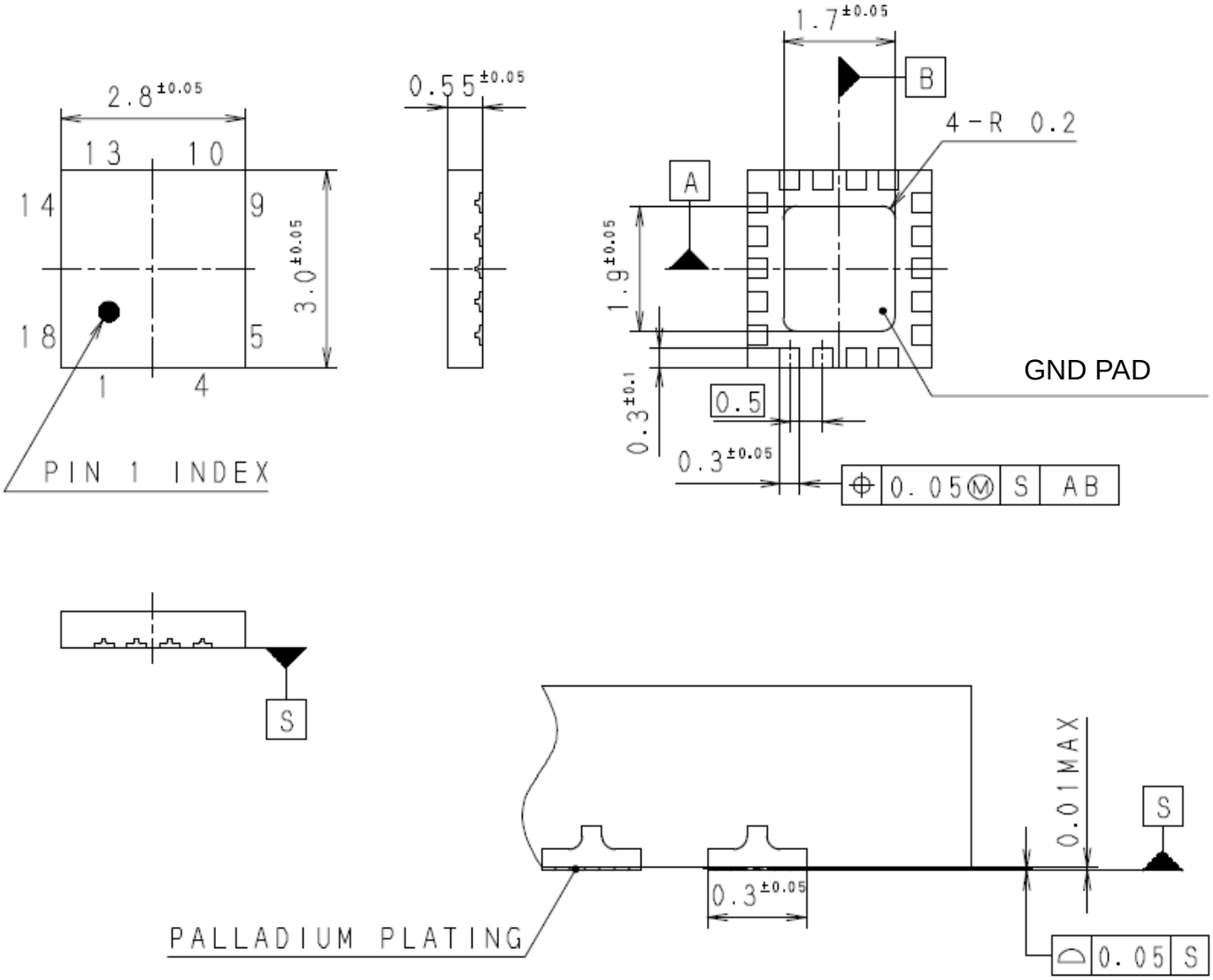


Detail A



Package Outline

(Unit : mm)



PACKAGE STRUCTURE

PACKAGE MATERIAL	EPOXY RESIN
LEAD TREATMENT	PALLADIUM PLATING
LEAD MATERIAL	COPPER ALLOY
PACKAGE MASS	*. ***g

Note

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Application circuits shown, if any, are typical examples illustrating the operation of the devices. Sony cannot assume responsibility for any problems arising out of the use of these circuits