NEC

BIPOLAR ANALOG INTEGRATED CIRCUIT
μ**PC8186K**

DIRECT QUADRATURE MODULATOR IC FOR PDC SYSTEMS

DESCRIPTION

The μPC8186K is a silicon microwave monolithic IC developed as quadrature modulator for PDC systems. This IC integrates a pre-mixer for local signals plus a quadrature modulator operating from 893 MHz to 1 453 MHz. This IC is packaged in 24-pin QFN and therefore is suitable for higher density mounting. This low power IC employs NEC's proprietary bipolar process NESAT™ III (f$_T$ = 20 GHz) and also has a built-in power save function and can operate 2.7 to 3.6 V supply voltage.

Consequenty the μPC8186K can contribute to make RF blocks smaller size, higher performance and lower power consumption.

FEATURES

- Directly modulate in 893 to 1 453 MHz
- Built-in pre-mixer for local signals
- External LC filter can be applied between modulator output and pre-mixer input terminal
- Current consumption: I$_{CC}$ = 34 mA TYP. @V$_{CC}$ = 3.0 V
- Equipped with power save function
- 24-pin QFN suitable for higher density mounting

APPLICATION

- Digital cellular telephone: PDC800 MHz, PDC1.5 GHz

ORDERING INFORMATION

Part Number	Package	Supplying Form
μPC8186K-E1	24-pin plastic QFN $(4.1 \times 5.2 \times 0.95$ mm)	Embossed tape 12 mm wide. Pin 1 is in pull-out direction. QTY 2.5 kpcs/reel.

Remark To order evaluation samples, please contact your local NEC sales office. (Part number for sample order: μPC8186K)
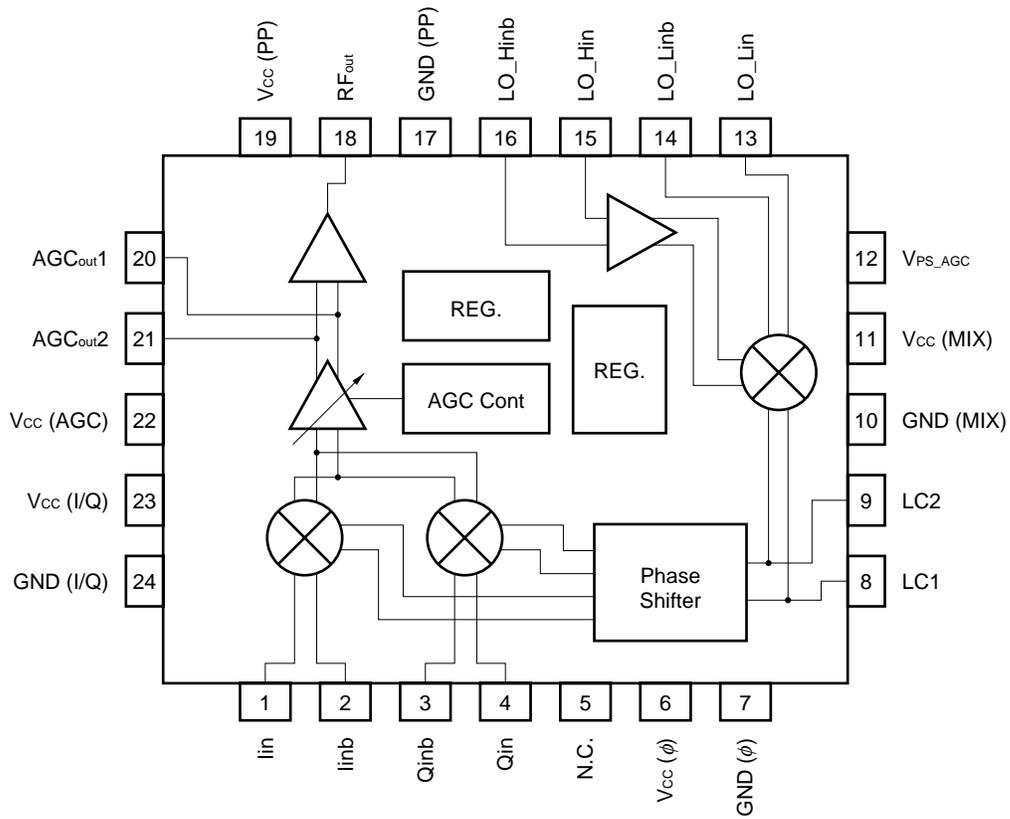
Caution   Electro-static sensitive devices

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INTERNAL BLOCK DIAGRAM AND PIN CONNECTIONS

(TOP View)

QUADRATURE MODULATOR SERIES

Part Number	Functions	I_{CC} (mA)	f_{LO1in} (MHz)	f_{MODout} (MHz)	Up-Converter f_{RFout} (MHz)	Phase Shifter	Package	Application
*μ*PC8101GR	150 MHz Quad. Mod	15/@ 2.7 V	100 to 300	50 to 150	External	F/F	20-pin SSOP (5.72 mm (225))	CT-2, etc.
*μ*PC8104GR	RF Up-Converter + IF Quad. Mod	28/@ 3.0 V	100 to 400		900 to 1 900	Doubler + F/F		Digital Comm.
*μ*PC8105GR	400 MHz Quad. Mod	16/@ 3.0 V	100 to 400		External		16-pin SSOP (5.72 mm (225))	
*μ*PC8110GR	1GHz Direct Quad. Mod	24/@ 3.0 V	800 to 1 000		Direct		20-pin SSOP (5.72 mm (225))	PDC800 MHz, etc.
*μ*PC8125GR	RF Up-Converter + IF Quad. Mod + AGC	36/@ 3.0 V	220 to 270		1 800 to 2 000			PHS
*μ*PC8126GR	900 MHz Direct Quad. Mod with Offset-Mixer	35/@ 3.0 V	915 to 960		915 to 960 (LO pre-mixer)			PDC800 MHz
*μ*PC8126K			889 to 960				28-pin QFN	
*μ*PC8129GR	×2LO IF Quad. Mod + RF Up-Converter	28/@ 3.0 V	200 to 800	100 to 400	800 to 1900	F/F	20-pin SSOP (5.72 mm (225))	GSM, DCS1800, etc.
*μ*PC8158K	RF Up-Converter + IF Quad. Mod + AGC	28/@ 3.0 V	100 to 300		800 to 1 500	CR	28-pin QFN	PDC800 M/ 1.5 G
*μ*PC8186K	Direct Quad. Mod. with Offset-Mixer	34/@ 3.0 V	893 to 1 453				24-pin QFN	

For outline of the quadrature modulator series, please refer to the application note 'Usage of *μ*PC8101, 8104, 8105, 8125, 8129' (Document No. P13251E) and so on.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Ratings	Unit
Supply Voltage	V_{CC}	Pins 6, 11, 19, 22, 23 T_A = +25°C	5.0	V
Power Save and AGC Control Pin Applied Voltage	V_{PS}/V_{AGC}	Pin 12, T_A = +25°C	5.0	V
Power Dissipation	P_D	T_A = +85°C**Note**	300	mW
Operating Ambient Temperature	T_A		−30 to +85	°C
Storage Temperature	T_{stg}		−55 to +150	°C

Note Mounted on double sided copper clad $50 \times 50 \times 1.6$ mm epoxy glass PWB.

RECOMMENDED OPERATING RANGE

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Supply Voltage	V_{CC}	Pins 6, 11, 19, 22, 23	2.7	3.0	4.0	V
Power Save Voltage	V_{PS}	Pin 12	0	–	0.3	V
AGC Control Voltage	V_{AGC}	Pin 12	1.0	–	2.5	V
Operating Ambient Temperature	T_A		−30	+25	+80	°C
Pre-Mixer Output Frequency	f_{MIXout}		893	–	1 453	MHz
Modulator Output Frequency	f_{RFout}	f_{MIXout} + $f_{I/Qin}$	893	–	1 453	MHz
LO_H Input Frequency	f_{LO_Hin}	P_{LO_Hin} = −10 dBm	600	–	1 738	MHz
LO_L Input Frequency	f_{LO_Lin}	P_{LO_Lin} = −10 dBm	120	–	285	MHz
I/Q Input Frequency	$f_{I/Qin}$	$V_{I/Qin}$ = 500 mV$_{P-P}$/pin(MAX) Differential phase input	DC	–	10	MHz
LO_H Input Power	P_{LO_Hin}		−13	−10	−7	dBm
LO_L Input Power	P_{LO_Lin}		−13	−10	−7	dBm
I/Q Input Amplitude	$V_{I/Qin}$	Differential phase input I/Q (DC) = Ib/Qb (DC) = $V_{CC}/2$	–	–	500	mV$_{P-P}$
I/Q Offset Voltage	I/Q(DC) Ib/Qb(DC)	$V_{I/Qin}$ = 700 mV$_{P-P}$ Single end input	–	1.6	–	V

ELECTRICAL SPECIFICATIONS 1 (BY TEST CIRCUIT 1)

T_A = +25°C, $V_{CC}1$ = $V_{CC}2$ = $V_{CC}3$ = $V_{CC}4$ = $V_{CC}5$ = 3.0 V, unless otherwise specified, V_{PS}/V_{AGC} = 2.5 V (High), I/Q (DC) = Ib/Qb (DC) = V_{CC}/2 = 1.5 V, $V_{I/Ibin}$ = $V_{Q/Qbin}$ = 500 mV$_{P-P}$/pin (differential phase input), $f_{I/Qin}$ = 2.625 kHz, π/4DQPSK modulated wave input, Transmission rate: 42 kbps, Filter roll-off rate: α = 0.5, MOD pattern: all zero, f_{LO_Lin} = 180 MHz, P_{LO_Lin} = −10 dBm,
f_{LO_Hin} = 768 MHz, P_{LO_Hin} = −10 dBm,
f_{RFout} = 948 MHz + $f_{I/Qin}$

Parameter		Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Modulator + Pre-Mixer							
Total Circuit Current		$I_{CC(TOTAL)}$	No signal input	28	34	41	mA
Total Circuit Current at Power Save Mode		$I_{CC(PS)TOTAL}$	V_{PS} ≤ 0.3 V (Low), No signal input	–	0.3	1	μA
AGC Control Current		I_{AGC}	V_{AGC} = 3.0 V	–	110	–	μA
Total RF Output Power 1		$P_{RFout}1$	V_{AGC} = 2.5 V	−9.5	−6.5	−4	dBm
Total RF Output Power 2		$P_{RFout}2$	V_{AGC} = 1.0 V	–	−40	–	dBm
Local Carrier Leak		LOL	f_{LOL} = f_{LO_Lin} + f_{LO_Hin}	–	−40	−30	dBc
Image Rejection (Side-band Leak)		ImR		–	−40	−30	dBc
I/Q 3rd Order Intermodulation Distortion		$IM_{3(I/Q)}$		–	−50	−30	dBc
AGC Gain Control Range		GCR	V_{AGC} = 2 V → 1 V	27	32	–	dB
Adjacent Channel Power Leakage		P_{adj}	Δf = ±50 kHz, MOD Pattern: PN 9	–	−65	−60	dBc
Power Saving Response Time	Rise Time	$T_{PS(Rise)}$	V_{PS_AGC} (Pin12) = 0 V → 2.5 V	–	2	5	μs
	Fall Time	$T_{PS(Fall)}$	V_{PS_AGC} (Pin12) = 2.5 V → 0 V	–	2	5	μs
I/Q Input Impedance		$Z_{I/Q}$	Value between Pins I/Ib and Q/Qb	–	200	–	kΩ
I/Q Input Bias Current		$I_{I/Q}$	Value between Pin I and Ib or between Q and Qb	–	5	13	μA
Error Vector Magnitude (Vector Error)		EVM	MOD pattern: PN 9	–	1.2	3.0	%rms
Noise Floor Level		NFL	f_{RFout} = 893 MHz f_{center} = 885 MHz, SPAN = 0 Hz, RBW = 30 kHz, VBW = 100 kHz, ATT = 0 dB	–	−134	−131	dBc/Hz

ELECTRICAL SPECIFICATIONS 2 (BY TEST CIRCUIT 2)

T_A = +25°C, $V_{CC}1$ = $V_{CC}2$ = $V_{CC}3$ = $V_{CC}4$ = $V_{CC}5$ = 3.0 V, unless otherwise specified, V_{PS}/V_{AGC} = 2.5 V (High),
I/Q (DC) = Ib/Qb (DC) = $V_{CC}/2$ = 1.5 V, $V_{I/Ibin}$ = $V_{Q/Qbin}$ = 500 mV$_{P-P}$/pin (differential phase input), $f_{I/Qin}$ = 2.625 kHz,
π/4DQPSK modulated wave input, Transmission rate: 42 kbps, Filter roll-off rate: α = 0.5, MOD pattern: all zero,
f_{LO_Lin} = 178.05 MHz, P_{LO_Lin} = −10 dBm,
f_{LO_Hin} = 1 619.05 MHz, P_{LO_Hin} = −10 dBm,
f_{RFout} = 1 441 MHz + $f_{I/Qin}$

Parameter		Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Modulator + Pre-Mixer							
Total Circuit Current		$I_{CC(TOTAL)}$	No signal input	28	34	41	mA
Total Circuit Current at Power Save Mode		$I_{CC(PS)TOTAL}$	V_{PS} ≤ 0.3 V (Low), No signal input	–	0.3	1	μA
AGC Control Current		I_{AGC}	V_{AGC} = 3.0 V	–	110	–	μA
Total RF Output Power 1		$P_{RFout}1$	V_{AGC} = 2.5 V	−11	−9	−6	dBm
Total RF Output Power 2		$P_{RFout}2$	V_{AGC} = 1.0 V	–	−44	–	dBm
Local Carrier Leak		LOL	f_{LOL} = f_{LO_Lin} + f_{LO_Hin}	–	−40	−30	dBc
Image Rejection (Side-band Leak)		ImR		–	−40	−29	dBc
I/Q 3rd Order Intermodulation Distortion		$IM_{3(I/Q)}$		–	−50	−30	dBc
AGC Gain Control Range		GCR	V_{AGC} = 2 V → 1 V	27	32	–	dB
Adjacent Channel Power Leakage		P_{adj}	Δf = ±50 kHz, MOD Pattern: PN 9	–	−65	−60	dBc
Power Saving Response Time	Rise Time	$T_{PS(Rise)}$	V_{PS_AGC} (Pin12) = 0 V → 2.5 V	–	2	5	μs
	Fall Time	$T_{PS(Fall)}$	V_{PS_AGC} (Pin12) = 2.5 V → 0 V	–	2	5	μs
I/Q Input Impedance		$Z_{I/Q}$	Value between Pins I/Ib and Q/Qb	–	200	–	kΩ
I/Q Input Bias Current		$I_{I/Q}$	Value between Pin I and Ib or between Q and Qb	–	5	13	μA
Error Vector Magnitude (Vector Error)		EVM	MOD pattern: PN 9	–	1.2	3.0	%rms
Suprious within the TX Band		P_{sup}	f_{LO_L} ×8, f_{LO_L} ×8 (Image)	–	−70	−65	dBc

ELECTRICAL SPECIFICATIONS 3 (BY TEST CIRCUIT 2[Note])

T_A = +25°C, $V_{CC}1$ = $V_{CC}2$ = $V_{CC}3$ = $V_{CC}4$ = $V_{CC}5$ = 2.8 V, unless otherwise specified, V_{PS}/V_{AGC} = 2.5 V (High), I/Q (DC) = Ib/Qb (DC) = $V_{CC}/2$ = 1.6 V, $V_{I/Qin}$ = 700 mV_{P-P}, $V_{Ib/Qbin}$ = 0 V_{P-P} (Single end input), $f_{I/Qin}$ = 2.625 kHz, π/4DQPSK modulated wave input, Transmission rate: 42 kbps, Filter roll-off rate: α = 0.5, MOD pattern: all zero, f_{LO_Lin} = 178.05 MHz, P_{LO_Lin} = −10 dBm, f_{LO_Hin} = 1619.05 MHz, P_{LO_Hin} = −10 dBm, f_{RFout} = 1441 MHz + $f_{I/Qin}$

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Modulator + Pre-Mixer						
Total RF Output Power	P_{RFout}	V_{AGC} = 2.5 V	−	−12.5	−	dBm
Error Vector Magnitude (Vector Error)	EVM	MOD pattern: PN 9	−	1.5	−	%rms
Adjacent Channel Power Leakage	P_{adj}	Δf = ±50 kHz, MOD Pattern: PN 9	−	−65	−60	dBc

Note Resistor value between pins 20 and 21: 1.3 kΩ

PIN EXPLANATIONS

| Pin No.	Symbol	Supply Voltage (V)	Pin Voltage (V)[Note]	Function and Applications	Internal Equivalent Circuit
1	Iin	Vcc/2	–	Input for I signal. This input impedance is 200 kΩ. In case of that I/Q input signals are differential, amplitude of the signal is 500 mVP-P max.	
2	Iinb	Vcc/2	–	Input for I signal. This input impedance is 200 kΩ. In case of that I/Q input signals are single ended, Vcc/2 biased DC signal should be input. In case of the I/Q input signals are differential, amplitude of the signal is 500 mVP-P max.	
3	Qinb	Vcc/2	–	Input for Q signal. This input impedance is 200 kΩ. In case of that I/Q input signals are differential, amplitude of the signal is 500 mVP-P max.	
4	Qin	Vcc/2	–	Input for I signal. This input impedance is 200 kΩ. In case of that I/Q input signals are single ended, Vcc/2 biased DC signal should be input. In case of the I/Q input signals are differential, amplitude of the signal is 500 mVP-P max.	
5	N.C.	–	–	This pin is not connected to internal circuit. This pin should be opened or grounded.	
6	Vcc(φ)	2.7 to 4.0	–	Supply voltage pin for modulator circuit.	
7	GND(φ)	0	–	Ground pin for modulator circuit. This pin should be grounded with minimum inductance. Form the ground pattern as widely as possible to minimize ground impedance.	
8	LC1	–	2.64	External inductor and capacitor can supress harmonics spurious of LO frequency. LC value should be determined according to LO input frequency and suppression level.	
9	LC2	–	2.64		

Note Pin Voltages are measured at Vcc = 3.0 V.

Pin No.	Symbol	Supply Voltage (V)	Pin Voltage (V)[Note]	Function and Applications	Internal Equivalent Circuit
10	GND (MIX)	0	–	Ground pin for pre-mixer circuit. This pin should be grounded with minimum inductance. Form the ground pattern as widely as possible to minimize ground impedance.	
11	V$_{CC}$ (MIX)	2.7 to 4.0	–	Supply voltage pin for pre-mixer circuit.	
12	V$_{PS\_AGC}$	V$_{PS}$/V$_{AGC}$	–	Power save control pin for modulator, pre-mixer and AGC circuits. This pin also assigned as gain control pin for AGC circuits. Operation status with applied voltages are as follows. | V$_{PS}$/V$_{AGC}$ (V)	State
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0 to 0.3	OFF (Sleep Mode)
1 to 2.5	On (AGC Mode)		
13	LO_Lin	–	1.87	Low-band local signal input for pre-mixer. This pin must be coupled with DC cut capacitor 330 pF and should be terminated with 51Ω resistor.	
14	LO_Linb	–	1.87	Bypass pin of pre-mixer's low-band local input. This pin should be decoupled with 330 pF capacitor.	
15	LO_Hin	–	1.93	High-band local signal input for pre-mixer. This pin must be coupled with DC cut capacitor 330 pF and should be terminated with 51Ω resistor.	
16	LO_Hinb	–	1.93	Bypass pin of pre-mixer's high-band local input. This pin should be decoupled with 330 pF capacitor.	
17	GND (PP)	0	–	Ground pin for RF output buffer. This pin should be grounded with minimum inductance. Form the ground pattern as widely as possible to minimize ground impedance.	
18	RF$_{out}$	–	2.07	RF output pin. This pin is emitter follower which is low impedance output port. This pin can be easily matched to 50Ω impedance using external coupling capacitor.	
19	V$_{CC}$ (PP)	2.7 to 4.0	–	Supply voltage pin for RF output buffer.	

Note   Pin Voltages are measured at V$_{CC}$ = 3.0 V.

Pin No.	Symbol	Supply Voltage (V)	Pin Voltage (V)[Note]	Function and Applications	Internal Equivalent Circuit
20	AGCout1	–	2.99	Due to the external inductor to output line of internal AGC amplifier, suprious can be suppressed.	External
21	AGCout2	–	2.99		
22	Vcc (AGC)	2.7 to 4.0	–	Supply voltage pin for internal AGC amplifier circuit.	
23	Vcc (I/Q)	2.7 to 4.0	–	Supply voltage pin for I/Q mixer circuit.	
24	GND (I/Q)	0	–	Ground pin for modulator circuit. This pin should be grounded with minimum inductance.	

Note Pin Voltages are measured at Vcc = 3.0 V.

TEST CIRCUIT 1

(For f$_{RFout}$ = 948 MHz + f$_{I/Qin}$)
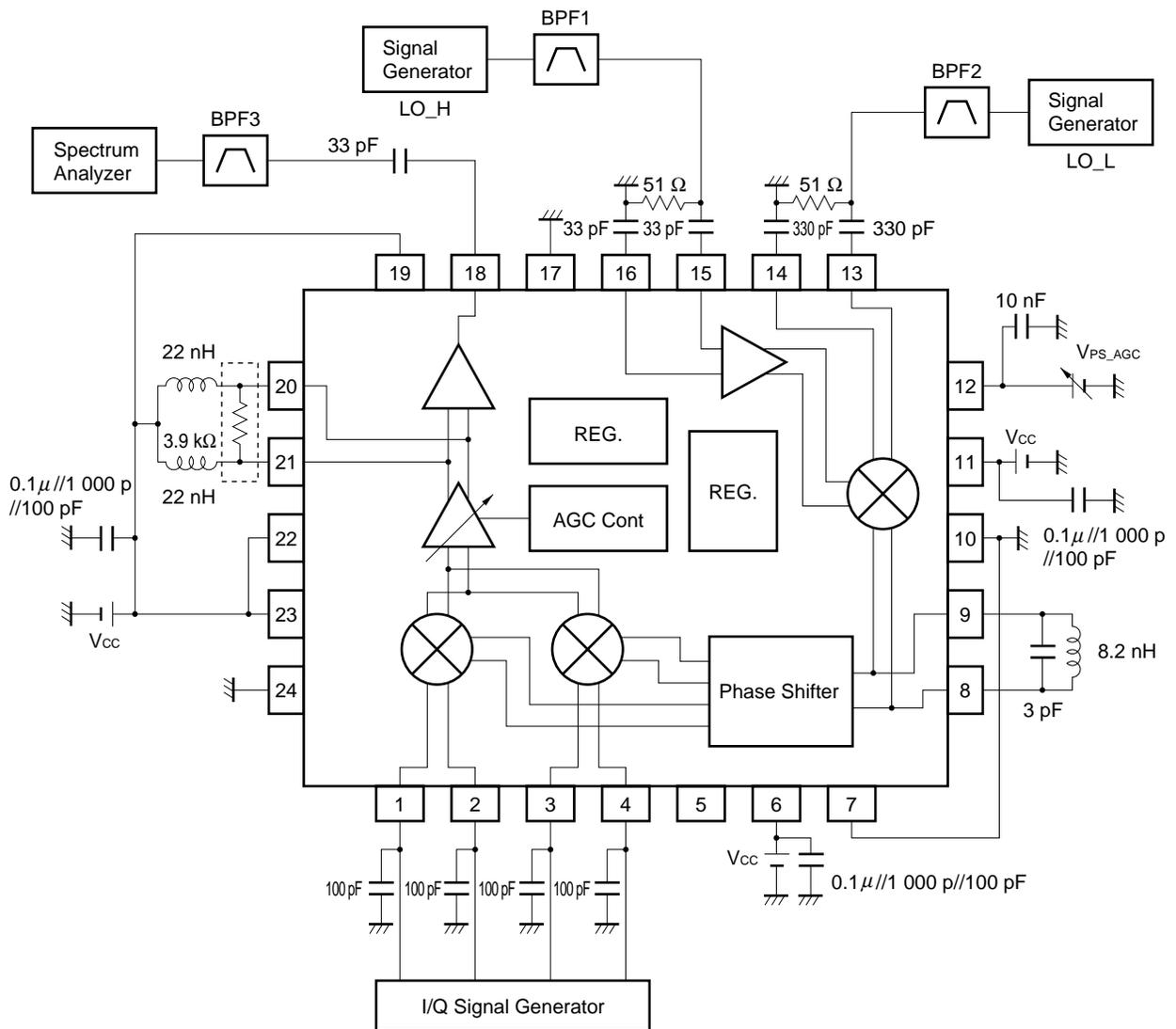
TEST CIRCUIT 2

(For f_{RFout} = 1 441 MHz + $f_{I/Qin}$)
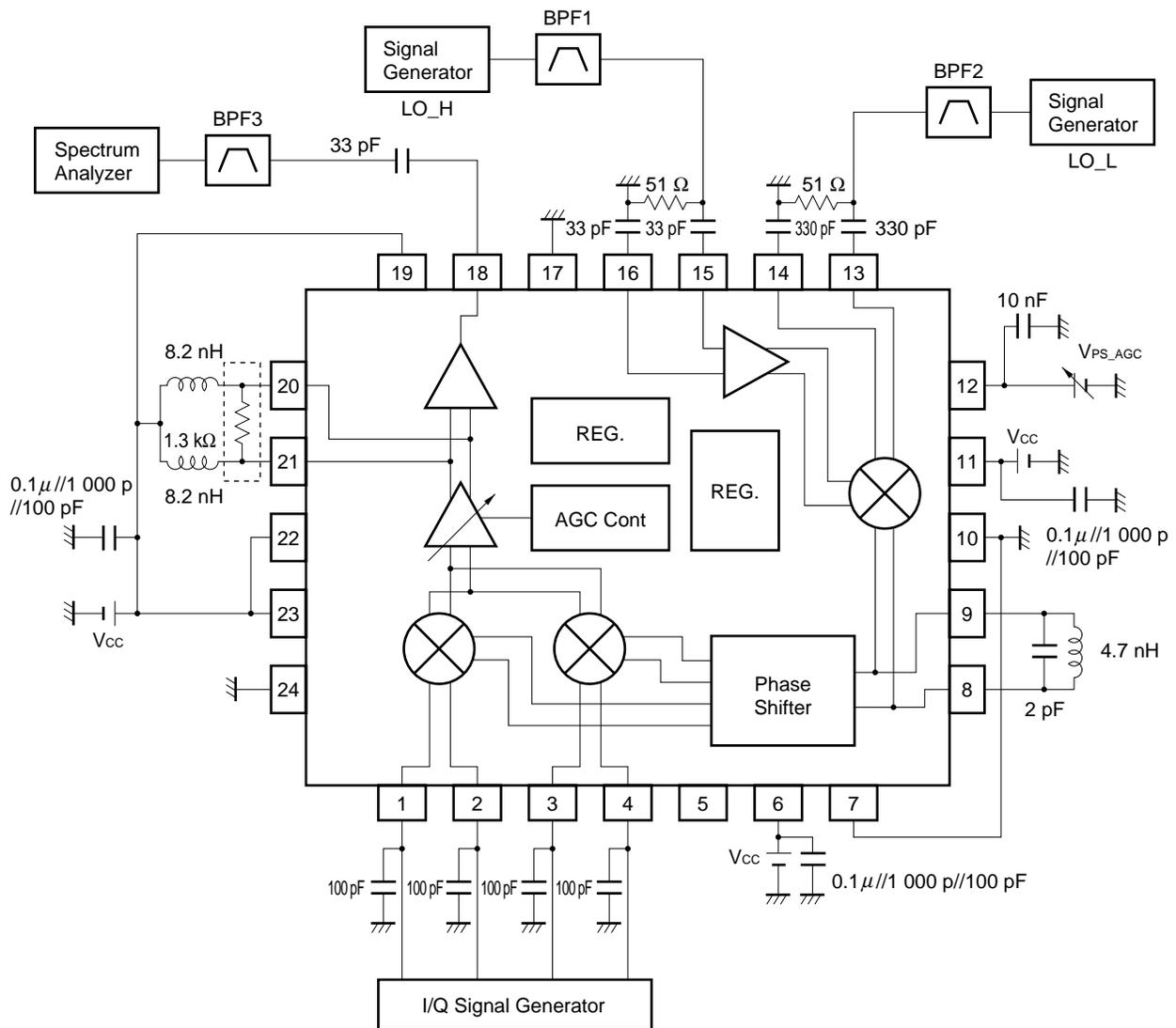
PACKAGE DIMENSIONS

24-PIN PLASTIC QFN (UNIT: mm)
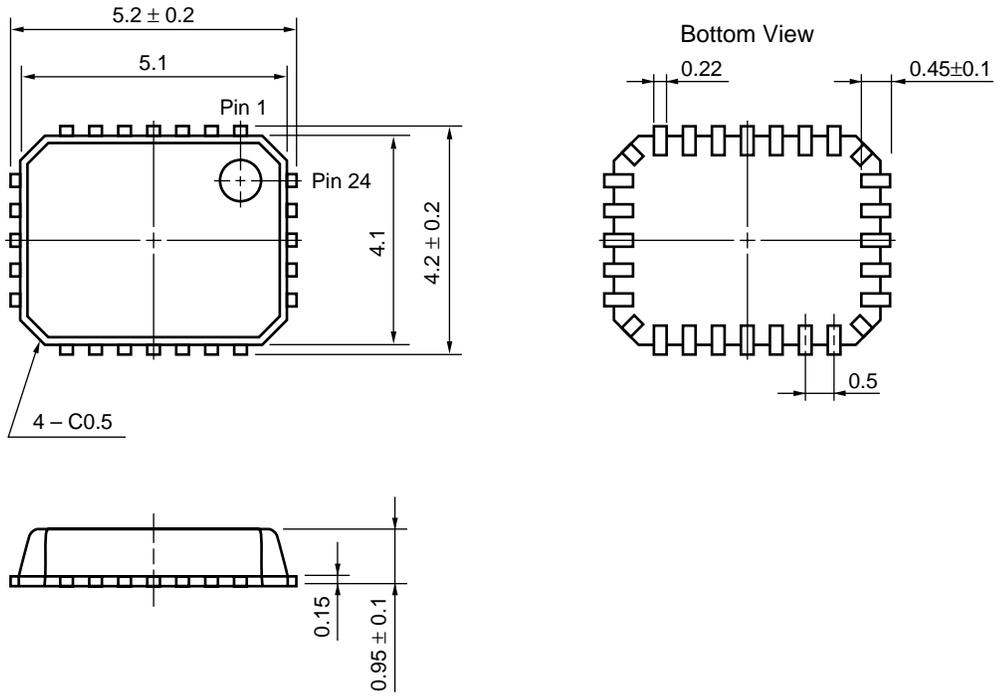
NOTES ON CORRECT USE

(1) Observe precautions for handling because of electro-static sensitive devices.

(2) Form a ground pattern as widely as possible to minimize ground impedance (to prevent undesired oscillation).

(3) Keep the track length of the ground pins as short as possible.

(4) Connect a bypass capacitor to the V_{CC} pin.

RECOMMENDED SOLDERING CONDITIONS

This product should be soldered under the following recommended conditions. For soldering methods and conditions other than those recommended below, contact your NEC sales representative.

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared Reflow	Package peak temperature: 235°C or below Time: 30 seconds or less (at 210°C) Count: 3, Exposure limit: None[Note]	IR35-00-3
VPS	Package peak temperature: 215°C or below Time: 40 seconds or less (at 200°C) Count: 3, Exposure limit: None[Note]	VP15-00-3
Partial Heating	Pin temperature: 300°C Time: 3 seconds or less (per side of device) Exposure limit: None[Note]	–

Note After opening the dry pack, keep it in a place below 25°C and 65% RH for the allowable storage period.

Caution Do not use different soldering methods together (except for partial heating).

For details of recommended soldering conditions for surface mounting, refer to information document **SEMICONDUCTOR DEVICE MOUNTING TECHNOLOGY MANUAL** (C10535E).

[MEMO]
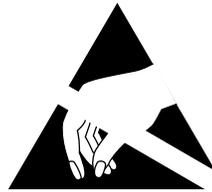
ATTENTION
OBSERVE PRECAUTIONS
FOR HANDLING
ELECTROSTATIC
SENSITIVE
DEVICES

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