

BIPOLAR ANALOG INTEGRATED CIRCUIT

μ PC8186K

DIRECT QUADRATURE MODULATOR IC FOR PDC SYSTEMS

DESCRIPTION

The μ PC8186K 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.

Consequently the μ PC8186K 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 |
|------------------|---|--|
| μ PC8186K-E1 | 24-pin plastic QFN (4.1 × 5.2 × 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: μ PC8186K)

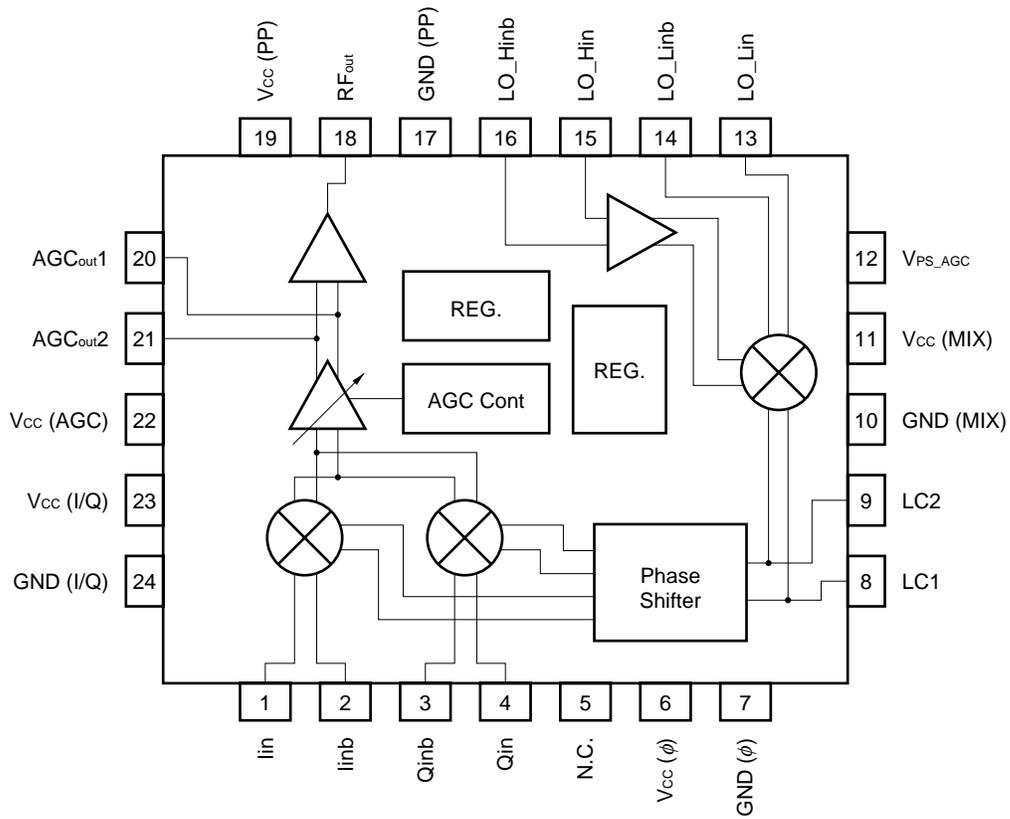
Caution Electro-static sensitive devices

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.

Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

INTERNAL BLOCK DIAGRAM AND PIN CONNECTIONS

(TOP View)



QUADRATURE MODULATOR SERIES

| Part Number | Functions | I _{CC} (mA) | f _{LOin} (MHz) | f _{MODout} (MHz) | Up-Converter f _{RFout} (MHz) | Phase Shifter | Package | Application |
|-------------|--|----------------------|-------------------------|---------------------------|---------------------------------------|---------------|-----------------------------|--------------------|
| μPC8101GR | 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. |
| μPC8104GR | RF Up-Converter + IF Quad. Mod | 28/@ 3.0 V | 100 to 400 | | 900 to 1 900 | Doubler + F/F | 20-pin SSOP (5.72 mm (225)) | Digital Comm. |
| μPC8105GR | 400 MHz Quad. Mod | 16/@ 3.0 V | 100 to 400 | | External | | | |
| μPC8110GR | 1GHz Direct Quad. Mod | 24/@ 3.0 V | 800 to 1 000 | | Direct | | 20-pin SSOP (5.72 mm (225)) | PDC800 MHz, etc. |
| μPC8125GR | RF Up-Converter + IF Quad. Mod + AGC | 36/@ 3.0 V | 220 to 270 | | 1 800 to 2 000 | | | PHS |
| μPC8126GR | 900 MHz Direct Quad. Mod with Offset-Mixer | 35/@ 3.0 V | 915 to 960 | | 915 to 960 (LO pre-mixer) | | 28-pin QFN | PDC800 MHz |
| μPC8126K | | | 889 to 960 | | | | | |
| μPC8129GR | ×2LO IF Quad. Mod + RF Up-Converter | 28/@ 3.0 V | 200 to 800 | 100 to 400 | 800 to 1 900 | F/F | 20-pin SSOP (5.72 mm (225)) | GSM, DCS1800, etc. |
| μPC8158K | 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 |
| μPC8186K | 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 μPC8101, 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 × 50 × 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) = I _b /Q _b (DC) = V _{CC} /2 | – | – | 500 | mV _{P-P} |
| I/Q Offset Voltage | I/Q(DC) I _b /Q _b (DC) | V _{I/Qin} = 700 mV _{P-P} Single end input | – | 1.6 | – | V |

ELECTRICAL SPECIFICATIONS 1 (BY TEST CIRCUIT 1)

$T_A = +25^{\circ}\text{C}$, $V_{CC1} = V_{CC2} = V_{CC3} = V_{CC4} = V_{CC5} = 3.0\text{ V}$, unless otherwise specified, $V_{PS}/V_{AGC} = 2.5\text{ V (High)}$,
 $I/Q\text{ (DC)} = I_b/Q_b\text{ (DC)} = V_{CC}/2 = 1.5\text{ V}$, $V_{I/Ibin} = V_{Q/Qbin} = 500\text{ mV}_{P-P/pin}$ (differential phase input), $f_{I/Qin} = 2.625\text{ kHz}$,
 $\pi/4\text{DQPSK}$ modulated wave input, Transmission rate: 42 kbps, Filter roll-off rate: $\alpha = 0.5$, MOD pattern: all zero,
 $f_{LO_Lin} = 180\text{ MHz}$, $P_{LO_Lin} = -10\text{ dBm}$,
 $f_{LO_Hin} = 768\text{ MHz}$, $P_{LO_Hin} = -10\text{ dBm}$,
 $f_{RFout} = 948\text{ MHz} + f_{I/Qin}$

| 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 | | $I_{CC(PS)TOTAL}$ | $V_{PS} \leq 0.3\text{ V (Low)}$, No signal input | – | 0.3 | 1 | μA |
| AGC Control Current | | I_{AGC} | $V_{AGC} = 3.0\text{ V}$ | – | 110 | – | μA |
| Total RF Output Power 1 | | P_{RFout1} | $V_{AGC} = 2.5\text{ V}$ | –9.5 | –6.5 | –4 | dBm |
| Total RF Output Power 2 | | P_{RFout2} | $V_{AGC} = 1.0\text{ V}$ | – | –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 | $V_{AGC} = 2\text{ V} \rightarrow 1\text{ V}$ | 27 | 32 | – | dB |
| Adjacent Channel Power Leakage | | P_{adj} | $\Delta f = \pm 50\text{ kHz}$, MOD Pattern: PN 9 | – | –65 | –60 | dBc |
| Power Saving Response Time | Rise Time | $T_{PS(Rise)}$ | $V_{PS_AGC} (Pin12) = 0\text{ V} \rightarrow 2.5\text{ V}$ | – | 2 | 5 | μs |
| | Fall Time | $T_{PS(Fall)}$ | $V_{PS_AGC} (Pin12) = 2.5\text{ V} \rightarrow 0\text{ V}$ | – | 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 | $f_{RFout} = 893\text{ MHz}$ $f_{center} = 885\text{ MHz}$, SPAN = 0 Hz, RBW = 30 kHz, VBW = 100 kHz, ATT = 0 dB | – | –134 | –131 | dBc/Hz |

ELECTRICAL SPECIFICATIONS 2 (BY TEST CIRCUIT 2)

$T_A = +25^{\circ}\text{C}$, $V_{CC1} = V_{CC2} = V_{CC3} = V_{CC4} = V_{CC5} = 3.0\text{ V}$, unless otherwise specified, $V_{PS}/V_{AGC} = 2.5\text{ V}$ (High),
 I/Q (DC) = I_b/Q_b (DC) = $V_{CC}/2 = 1.5\text{ V}$, $V_{I/bin} = V_{Q/Qbin} = 500\text{ mV}_{P-P}$ /pin (differential phase input), $f_{I/Qin} = 2.625\text{ kHz}$,
 $\pi/4$ DQPSK modulated wave input, Transmission rate: 42 kbps, Filter roll-off rate: $\alpha = 0.5$, MOD pattern: all zero,
 $f_{LO_Lin} = 178.05\text{ MHz}$, $P_{LO_Lin} = -10\text{ dBm}$,
 $f_{LO_Hin} = 1\ 619.05\text{ MHz}$, $P_{LO_Hin} = -10\text{ dBm}$,
 $f_{RFout} = 1\ 441\text{ MHz} + f_{I/Qin}$

| 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 | $I_{CC(PS)TOTAL}$ | $V_{PS} \leq 0.3\text{ V}$ (Low), No signal input | – | 0.3 | 1 | μA | |
| AGC Control Current | I_{AGC} | $V_{AGC} = 3.0\text{ V}$ | – | 110 | – | μA | |
| Total RF Output Power 1 | P_{RFout1} | $V_{AGC} = 2.5\text{ V}$ | –11 | –9 | –6 | dBm | |
| Total RF Output Power 2 | P_{RFout2} | $V_{AGC} = 1.0\text{ V}$ | – | –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 | $V_{AGC} = 2\text{ V} \rightarrow 1\text{ V}$ | 27 | 32 | – | dB | |
| Adjacent Channel Power Leakage | P_{adj} | $\Delta f = \pm 50\text{ kHz}$, MOD Pattern: PN 9 | – | –65 | –60 | dBc | |
| Power Saving Response Time | Rise Time | $T_{PS(Rise)}$ | $V_{PS_AGC} (Pin12) = 0\text{ V} \rightarrow 2.5\text{ V}$ | – | 2 | 5 | μs |
| | Fall Time | $T_{PS(Fall)}$ | $V_{PS_AGC} (Pin12) = 2.5\text{ V} \rightarrow 0\text{ V}$ | – | 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} | $f_{LO_L} \times 8$, $f_{LO_L} \times 8$ (Image) | – | –70 | –65 | dBc | |

ELECTRICAL SPECIFICATIONS 3 (BY TEST CIRCUIT 2^{Note})

$T_A = +25^{\circ}\text{C}$, $V_{CC1} = V_{CC2} = V_{CC3} = V_{CC4} = V_{CC5} = 2.8\text{ V}$, unless otherwise specified, $V_{PS}/V_{AGC} = 2.5\text{ V}$ (High),
 I/Q (DC) = I_b/Q_b (DC) = $V_{CC}/2 = 1.6\text{ V}$, $V_{I/Qin} = 700\text{ mV}_{P-P}$, $V_{Ib/Qbin} = 0\text{ V}_{P-P}$ (Single end input), $f_{I/Qin} = 2.625\text{ kHz}$,
 $\pi/4\text{DQPSK}$ modulated wave input, Transmission rate: 42 kbps, Filter roll-off rate: $\alpha = 0.5$, MOD pattern: all zero,
 $f_{LO_Lin} = 178.05\text{ MHz}$, $P_{LO_Lin} = -10\text{ dBm}$,
 $f_{LO_Hin} = 1619.05\text{ MHz}$, $P_{LO_Hin} = -10\text{ dBm}$,
 $f_{RFout} = 1441\text{ MHz} + f_{I/Qin}$

| Parameter | Symbol | Conditions | MIN. | TYP. | MAX. | Unit |
|---------------------------------------|-------------|--|------|-------|------|------|
| Modulator + Pre-Mixer | | | | | | |
| Total RF Output Power | P_{RFout} | $V_{AGC} = 2.5\text{ V}$ | - | -12.5 | - | dBm |
| Error Vector Magnitude (Vector Error) | EVM | MOD pattern: PN 9 | - | 1.5 | - | %rms |
| Adjacent Channel Power Leakage | P_{adj} | $\Delta f = \pm 50\text{ kHz}$, 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) <small>Note</small> | Function and Applications | Internal Equivalent Circuit |
|---------|---------------------|--------------------|--|---|-----------------------------|
| 1 | lin | V _{cc} /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 mV _{P-P} max. | |
| 2 | linb | V _{cc} /2 | – | Input for I signal. This input impedance is 200 kΩ. In case of that I/Q input signals are single ended, V _{cc} /2 biased DC signal should be input. In case of the I/Q input signals are differential, amplitude of the signal is 500 mV _{P-P} max. | |
| 3 | Qinb | V _{cc} /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 mV _{P-P} max. | |
| 4 | Qin | V _{cc} /2 | – | Input for I signal. This input impedance is 200 kΩ. In case of that I/Q input signals are single ended, V _{cc} /2 biased DC signal should be input. In case of the I/Q input signals are differential, amplitude of the signal is 500 mV _{P-P} max. | |
| 5 | N.C. | – | – | This pin is not connected to internal circuit. This pin should be opened or grounded. | _____ |
| 6 | V _{cc} (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 suppress 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 V_{cc} = 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. <table border="1" style="margin: 10px auto;"> <thead> <tr> <th>V_{PS}/V_{AGC} (V)</th> <th>State</th> </tr> </thead> <tbody> <tr> <td>0 to 0.3</td> <td>OFF (Sleep Mode)</td> </tr> <tr> <td>1 to 2.5</td> <td>On (AGC Mode)</td> </tr> </tbody> </table> | V _{PS} /V _{AGC} (V) | State | 0 to 0.3 | OFF (Sleep Mode) | 1 to 2.5 | On (AGC Mode) | |
| V _{PS} /V _{AGC} (V) | State | | | | | | | | | | |
| 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. | | | | | | | |

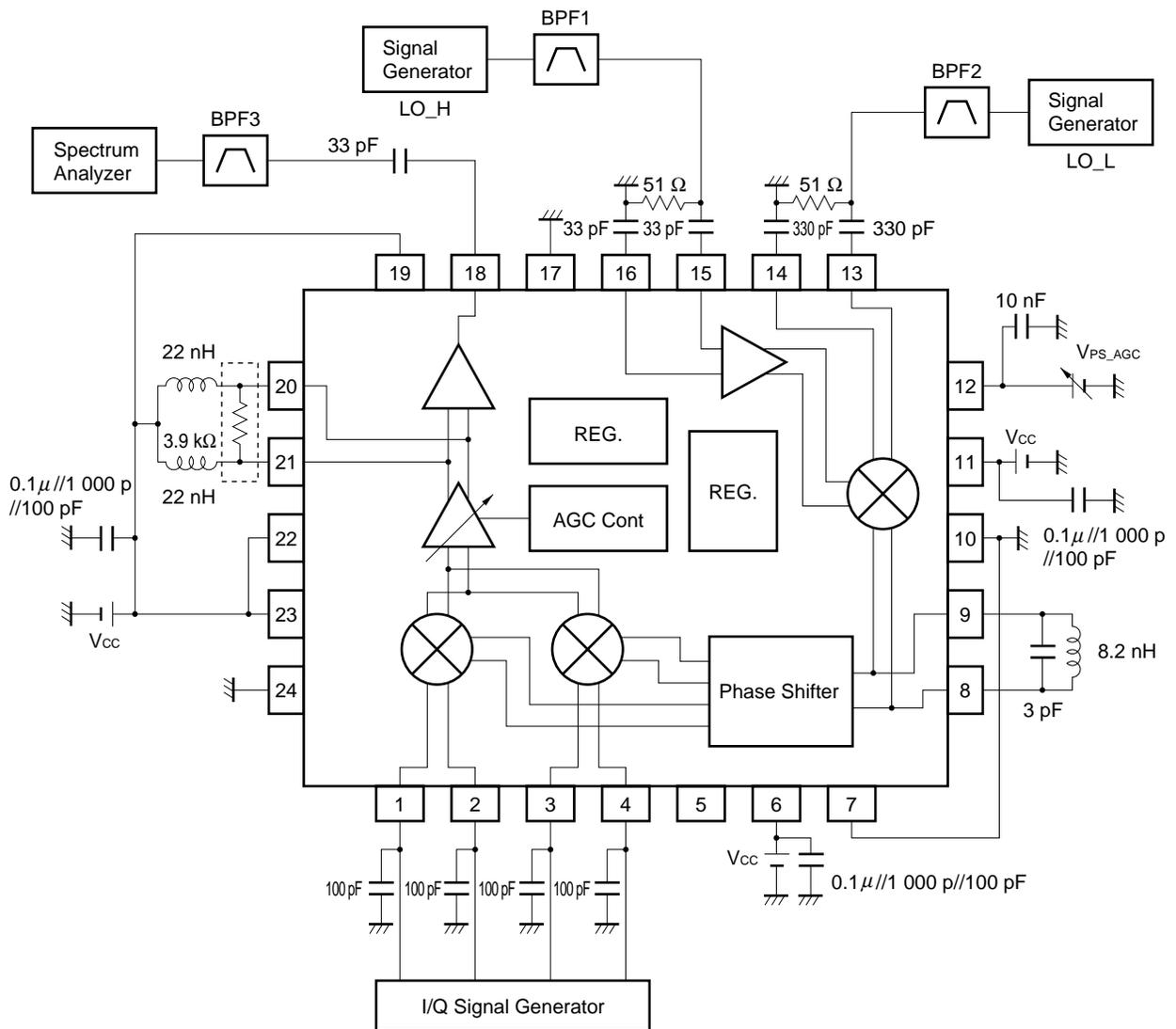
Note Pin Voltages are measured at V_{CC} = 3.0 V.

| Pin No. | Symbol | Supply Voltage (V) | Pin Voltage (V) <small>Note</small> | Function and Applications | Internal Equivalent Circuit |
|---------|--------------------------|--------------------|--|--|-----------------------------|
| 20 | AGC _{out1} | – | 2.99 | Due to the external inductor to output line of internal AGC amplifier, suprious can be suppressed. | |
| 21 | AGC _{out2} | – | 2.99 | | |
| 22 | V _{CC} (AGC) | 2.7 to 4.0 | – | Supply voltage pin for internal AGC amplifier circuit. | _____ |
| 23 | V _{CC} (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 V_{CC} = 3.0 V.

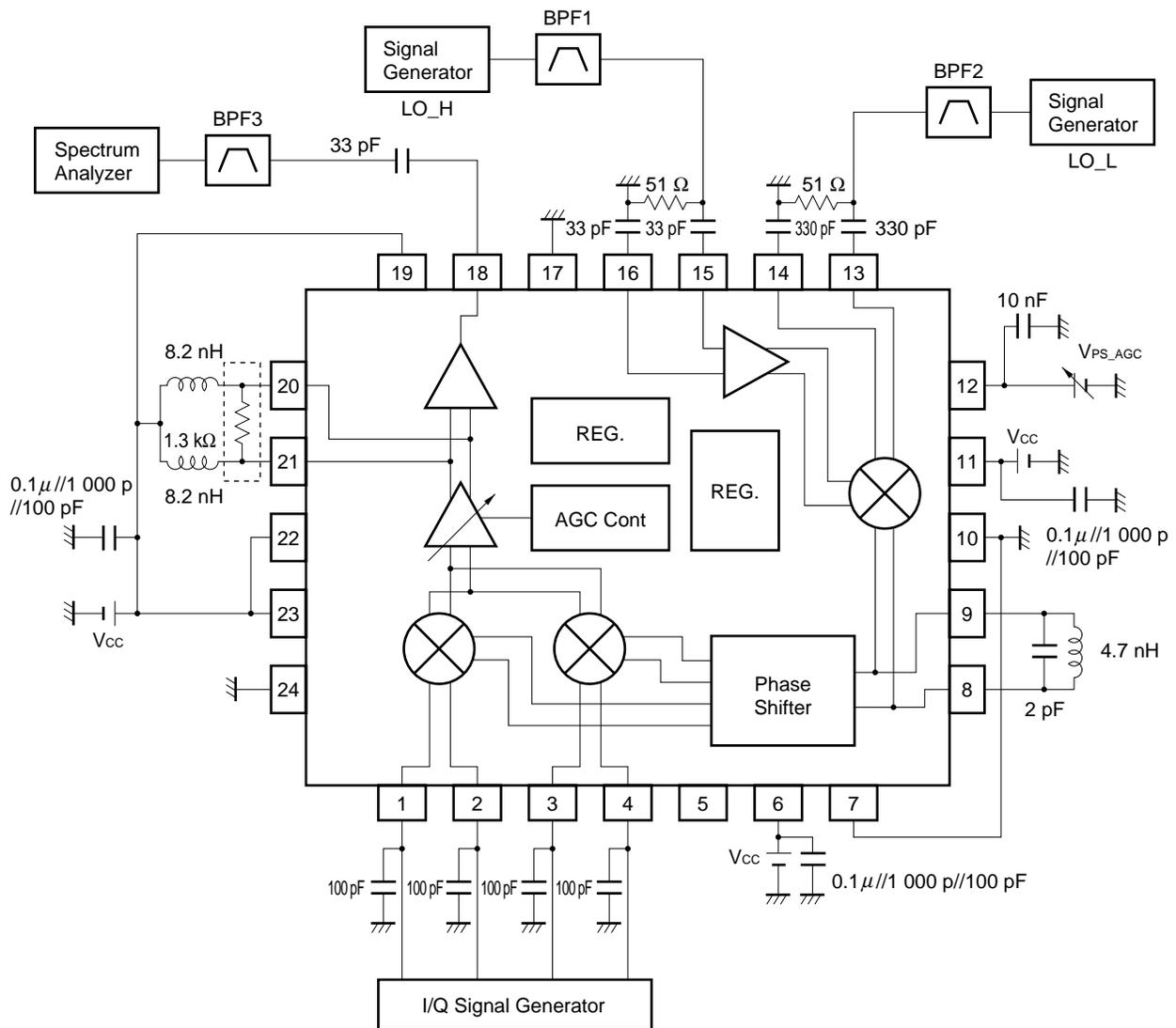
TEST CIRCUIT 1

(For $f_{RFout} = 948 \text{ MHz} + f_{I/Qin}$)



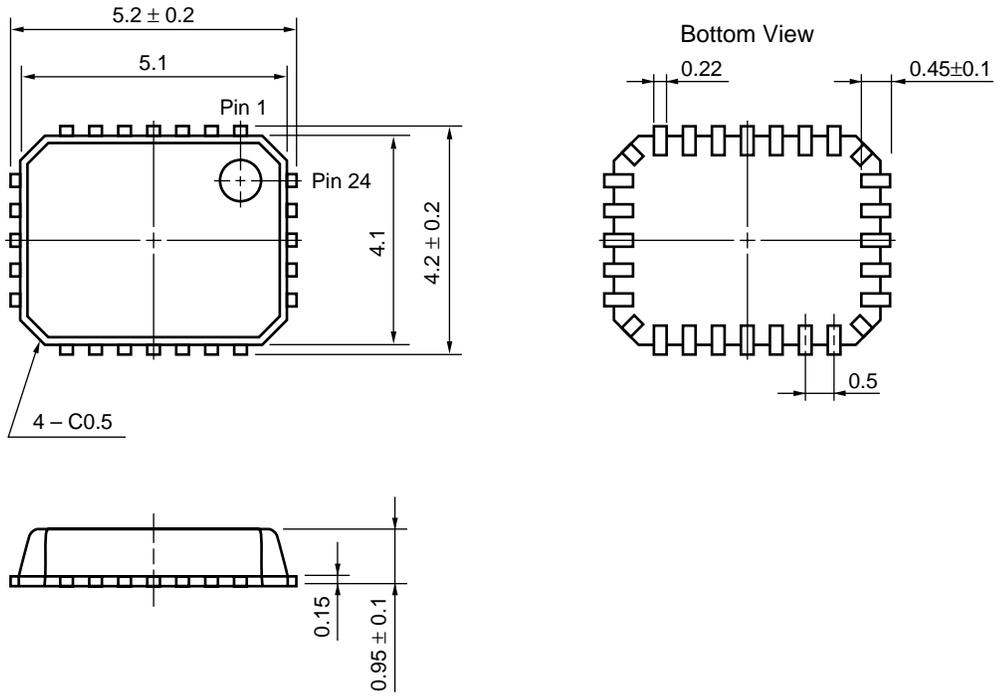
TEST CIRCUIT 2

(For $f_{RFout} = 1\,441\text{ MHz} + f_{I/Qin}$)



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.

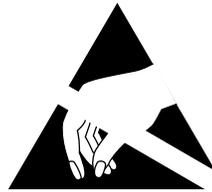
| Soldering Method | Soldering Conditions | Recommended Condition Symbol |
|------------------|---|------------------------------|
| Infrared Reflow | Package peak temperature: 235°C or below Time: 30 seconds or less (at 210°C) Count: 3, Exposure limit: None ^{Note} | IR35-00-3 |
| VPS | Package peak 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]



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 OBSERVE PRECAUTIONS
 FOR HANDLING
 ELECTROSTATIC
 SENSITIVE
 DEVICES

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