

To our customers,

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## Old Company Name in Catalogs and Other Documents

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On April 1<sup>st</sup>, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: <http://www.renesas.com>

April 1<sup>st</sup>, 2010  
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (<http://www.renesas.com>)

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## RF UP-CONVERTER WITH AGC FUNCTION + IF QUADRATURE MODULATOR IC FOR DIGITAL MOBILE COMMUNICATION SYSTEMS

### DESCRIPTION

The μPC8158K is a silicon microwave monolithic integrated circuit designed as quadrature modulator for digital mobile communication systems. This MMIC consists of 0.8 GHz to 1.5 GHz up-converter and 100 MHz to 300 MHz quadrature modulator which are equipped with AGC and power save functions. This configuration suits to IF modulation system. The package is 28-pin QFN suitable for high density mounting. The chip is manufactured using NEC's 20 GHz fr silicon bipolar process NESAT™ III to realize low power consumption. Consequently the μPC8158K can contribute to make RF blocks smaller size, higher performance and lower power consumption.

### FEATURES

- Supply voltage:  $V_{cc} = 2.7$  to  $4.0$  V,  $I_{cc} = 28$  mA @  $V_{cc} = 3.0$  V
- Built-in LPF suppresses spurious multiplied by TX local (LO1)
- AGC amplifier is installed in local port of up converter:  $GCR = 35$  dB MIN. @  $f_{out} = 1.5$  GHz
- Excellent performance:  $P_{adj} = -65$  dBc TYP. @  $\Delta f = \pm 50$  kHz,  $EVM = 1.2$  % rms TYP.
- External IF filter can be applied between modulator output and up converter input terminal.

### APPLICATIONS

- Digital cellular phones (PDC800M, PDC1.5G and so on)

### ORDERING INFORMATION

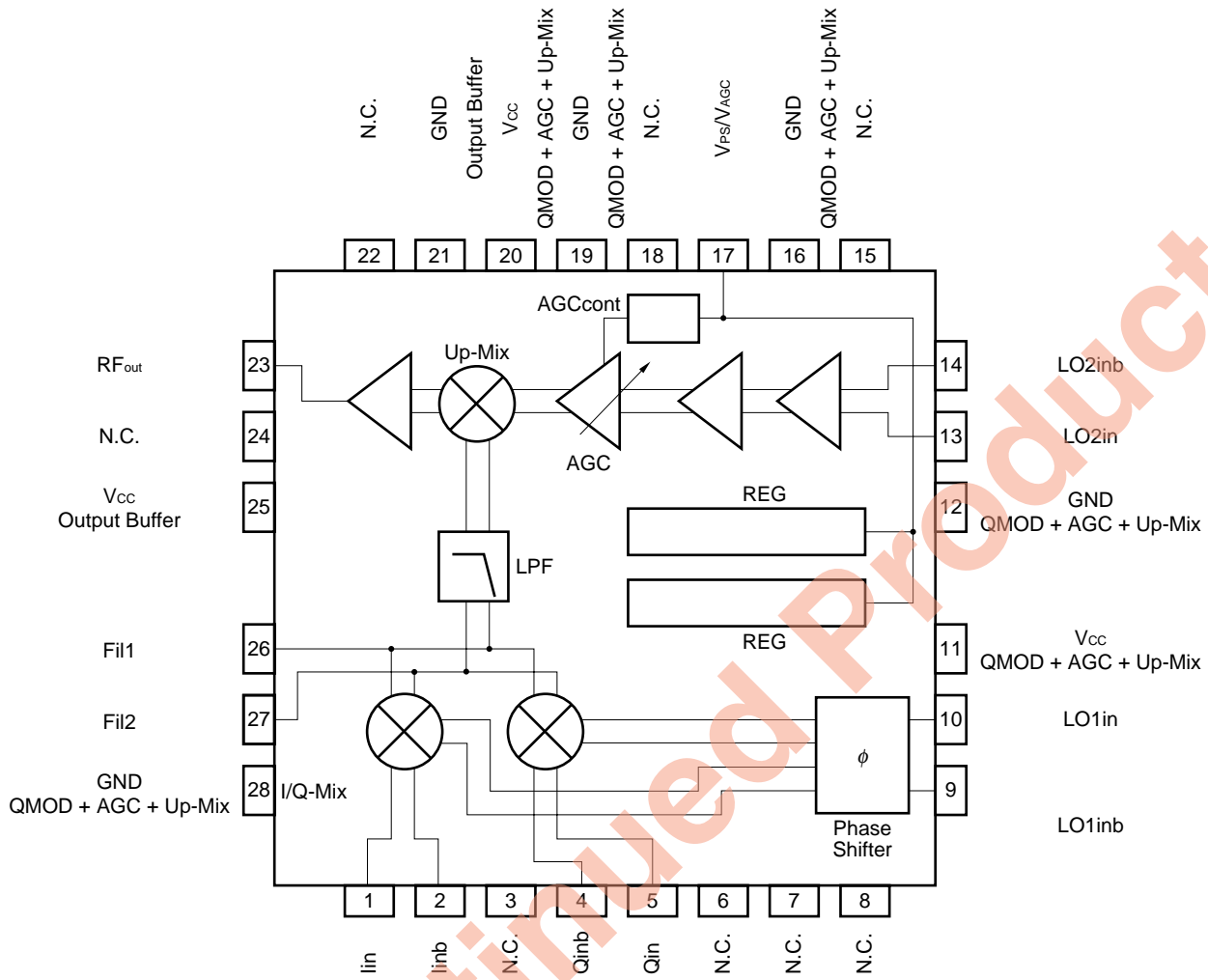
Part Number	Package	Supplying Form
μPC8158K-E1	28-pin plastic QFN (5.1 × 5.5 × 0.95 mm)	Embossed tape 12 mm wide. Pin 1 is in pull-out direction. QTY 2.5 kp/Reel.

**Remark** To order evaluation samples, please contact your local NEC sales office. (Part number for sample order: μPC8158K)

**Caution** Electro-static sensitive device

The information in this document is subject to change without notice.

INTERNAL BLOCK DIAGRAM AND PIN CONNECTIONS (TOP View)



Discontinued Product

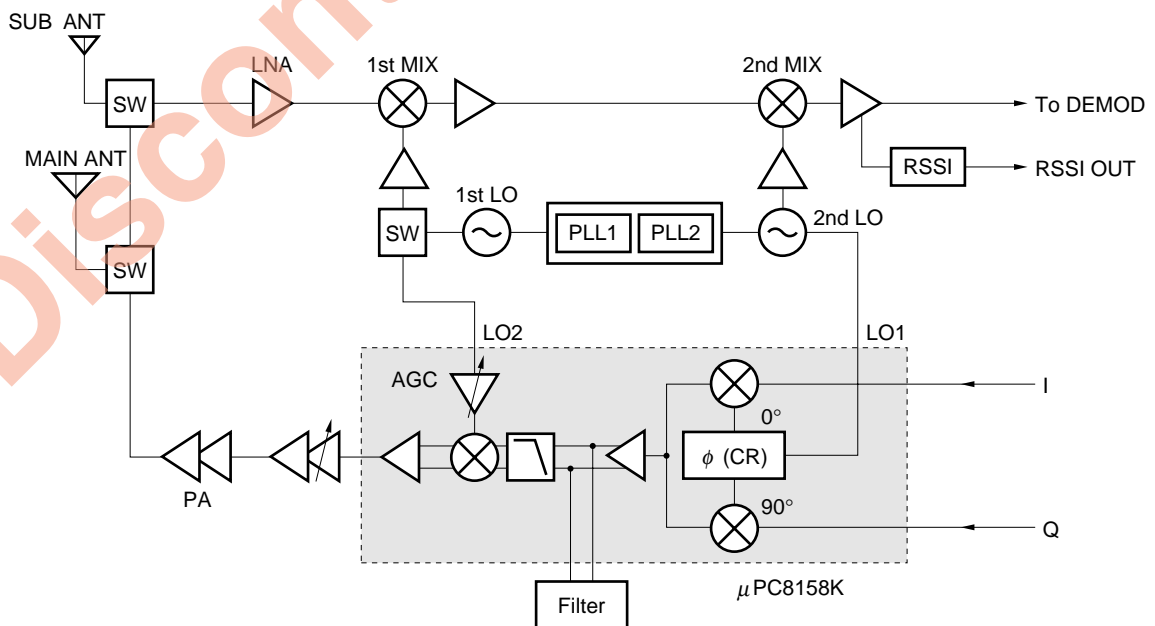
QUADRATURE MODULATOR SERIES

Part Number	Functions	I <sub>cc</sub> (mA)	f <sub>LOin</sub> (MHz)	f <sub>MODout</sub> (MHz)	Up-Converter f <sub>RFout</sub> (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 (225 mil)	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 (225 mil)	Digital Comm.
μPC8105GR	400 MHz Quad. Mod	16/@ 3.0 V	100 to 400		External		16-pin SSOP (225 mil)	
μPC8110GR	1GHz Direct Quad. Mod	24/@ 3.0 V	800 to 1 000		Direct	CR	20-pin SSOP (225 mil)	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)		PDC800 MHz	
μPC8126K			889 to 960				28-pin QFN	
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 (225 mil)	GSM, DCS1800, etc.
μPC8139GR-7JH	Transceiver IC (1.9 GHz Indirect Quad. Mod + RX-IF + IF VCO)	TX: 32.5 RX: 4.8 /@ 3.0 V	220 to 270		1 800 to 2 000	CR	30-pin TSSOP (225 mil)	PHS
μPC8158K	RF Up-Converter + IF Quad. Mod + AGC	28/@ 3.0 V	100 to 300		800 to 1 500		28-pin QFN	PDC800 M/ 1.5 G

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.

SYSTEM APPLICATION EXAMPLE

[PDC800 MHz/1.5 GHz]



**ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Conditions	Rating	Unit
Supply Voltage	V <sub>CC</sub>	Pin11, 20 and 25, T <sub>A</sub> = +25°C	5.0	V
Power Save and AGC Control Pin Applied Voltage	V <sub>PS</sub> /V <sub>AGC</sub>	Pin17, T <sub>A</sub> = +25°C	5.0	V
Power Dissipation	P <sub>D</sub>	T <sub>A</sub> = +85°C <sup>Note</sup>	430	mW
Operating Ambient Temperature	T <sub>A</sub>		-40 to +85	°C
Storage Temperature	T <sub>stg</sub>		-55 to +150	°C

**Note** Mounted on double sided copper clad 50 × 50 × 1.6 mm epoxy glass PWB.

**RECOMMENDED OPERATING CONDITIONS**

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Supply Voltage	V <sub>CC</sub>	Pin11, 20 and 25	2.7	3.0	4.0	V
Power Save Voltage	V <sub>PS</sub>	Pin17	0	-	0.3	V
AGC Control Voltage	V <sub>AGCPS</sub>	Pin17	1.0	-	2.5	V
Operating Ambient Temperature	T <sub>A</sub>		-30	+25	+80	°C
Up-converter RF Output Frequency	f <sub>RFout</sub>		800	-	1500	MHz
LO2 Input Frequency	f <sub>LO2in</sub>	P <sub>LO2in</sub> = -15 dBm	600	-	1750	MHz
I/Q Input Frequency	f <sub>I/Qin</sub>	V <sub>I/Qin</sub> = 500 mV <sub>P-P</sub> MAX. (Differential input)	DC	-	10	MHz
LO1 Input Level	P <sub>LO1in</sub>		-18	-15	-12	dBm
LO2 Input Level	P <sub>LO2in</sub>		-18	-15	-12	dBm
I/Q Input Amplitude	V <sub>I/Qin</sub>	I, Ib, Q, Qb each	-	420	500	mV <sub>P-P</sub>
Up-converter Input Frequency	f <sub>UPCONin</sub>		100	-	300	MHz
Modulator Output Frequency	f <sub>MODout</sub>					
LO1 Input Frequency	f <sub>LO1in</sub>	P <sub>LO1in</sub> = -15 dBm				

**ELECTRICAL CHARACTERISTICS**

Conditions (Unless otherwise specified):

$T_A = +25\text{ }^\circ\text{C}$ ,  $V_{CC1} = V_{CC2} = V_{CC3} = 3.0\text{ V}$ ,  $V_{PS}/V_{AGC} = 2.5\text{ V}$ ,

$I/Q\text{ (DC)} = I_b/Q_b\text{ (DC)} = V_{CC}/2 = 1.5\text{ V}$ ,  $V_{I/bin} = V_{Q/Qbin} = 500\text{ mV}_{P-P}$  (each),  $f_{I/Qin} = 2.625\text{ kHz}$ ,

$\pi/4$ DQPSK wave input, transmission rate 42 kbps, filter roll-off  $\alpha = 0.5$ ,

Modulation Pattern: <0000>

$f_{LO1in} = 178.05\text{ MHz}$ ,  $P_{LO1in} = -15\text{ dBm}$

$f_{LO2in} = 1619.05\text{ MHz}$ ,  $P_{LO2in} = -15\text{ dBm}$

$f_{RFout} = 1441\text{ MHz} - f_{I/Qin}$

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
<b>UP-CONVERTER + QUADRATURE MODULATOR TOTAL</b>						
Total Circuit Current	$I_{CC(TOTAL)}$	No input signal	23.7	28	37.6	mA
Total Circuit Current at Power Save Mode	$I_{CC(PS)TOTAL}$	$V_{PS} \leq 0.5\text{ V}$ (Low), No input signal	–	0.3	10	μA
Total Output Power 1	$P_{RFout1}$	$V_{AGC} = 2.5\text{ V}$	–15	–11.5	–8	dBm
Total Output Power 2	$P_{RFout2}$	$V_{AGC} = 1.0\text{ V}$	–56.5	–52	–46.5	dBm
LO Carrier Leak	LOL	$f_{LOL} = f_{LO1} + f_{LO2}$	–	–40	–30	dBc
Image Rejection (Side Band Leak)	ImR		–	–40	–30	dBc
I/Q 3rd order distortion	$IM_3(I/Q)$		–	–50	–30	dBc
AGC Gain Control Range	GCR	$V_{AGC} = 2\text{ V} \rightarrow 1\text{ V}$	35	40	–	dB
Error Vector Magnitude	EVM	MOD Pattern: PN9	–	1.2	3.0	%rms
Adjacent channel interference	$P_{adj}$	$\Delta f = \pm 50\text{ kHz}$ , MOD Pattern: PN9	–	–65	–60	dBc
Spurious suppression	$P_{out}(8f_{LO1})$	$f_{LO1} \times 8$ , $f_{LO1} \times 8$ (image) <sup>Note</sup>	–	–70	–65	dBc
Power Save Rise Time	$T_{PS(Rise)}$	$V_{PS(Low)} \rightarrow V_{PS(High)}$	–	2	5	μs
Power Save Fall Time	$T_{PS(Fall)}$	$V_{PS(High)} \rightarrow V_{PS(Low)}$	–	2	5	μs
I/Q input impedance	$Z_{I/Q}$	Between pin I/Ib, Q/Qb	80	200	–	kΩ
I/Q input bias current	$I_{I/Q}$	Between pin I/Ib, Q/Qb	–	5	13	μA
LO1 input VSWR	$Z_{LO1}$	$f_{LO1} = 100\text{ M to }300\text{ MHz}$	–	1.5:1	–	–

**Note** Without external LC between Fil1 and Fil2 pin on this frequency conditions.

Spectrum analyzer conditions: VBW = 300 Hz, RBW = 300 Hz.


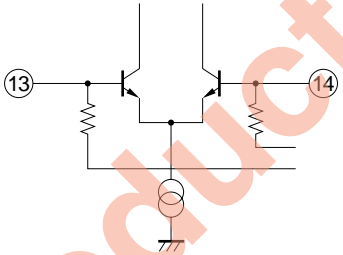


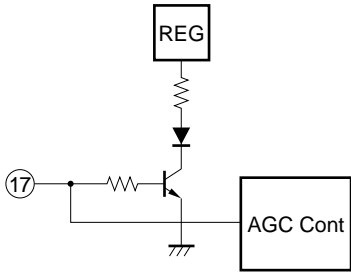




**Remark** Electrical characteristics in this document is described for 1.5 GHz system.

PIN EXPLANATIONS

Pin No.	Symbol	Supply Voltage (V)	Pin Voltage (V) <small>Note</small>	Function and Application	Internal Equivalent Circuit
1	lin	V <sub>cc</sub> /2	–	Input for I signal. This input impedance is 200 kΩ. In the case of that I/Q input signals are single ended, amplitude of the signal is 500 m V <sub>P-P</sub> max.	
2	linb	V <sub>cc</sub> /2	–	Input for I signal. This input impedance is 200 kΩ. In the case of that I/Q input signals are single ended, V <sub>cc</sub> /2 biased DC signal should be input. In the case of the I/Q input signals are differential, amplitude of the signal is 500 m V <sub>P-P</sub> max.	
3	N.C.	–	–	This pin is not connected to internal circuit. This pin should be opened or grounded.	_____
4	Qinb	V <sub>cc</sub> /2	–	Input for Q signal. This input impedance is 200 kΩ. In the case of that I/Q input signals are single ended, amplitude of the signal is 500 m V <sub>P-P</sub> max.	
5	Qin	V <sub>cc</sub> /2	–	Input for I signal. This input impedance is 200 kΩ. In the case of that I/Q input signals are single ended, V <sub>cc</sub> /2 biased DC signal should be input. In case of the I/Q input signals are differential, amplitude of the signal is 500 m V <sub>P-P</sub> max.	
6	N.C.	–	–	These pins are not connected to internal circuit. These pins should be opened or grounded.	_____
7	N.C.				
8	N.C.				
9	LO1inb	–	2.98	Bypass pin of modulator's local input. This pin should be decoupled with 330 pF capacitor.	
10	LO1in	–	2.98	Local signal input for modulator. This pin must be coupled with DC cut capacitor 330 pF and should be terminated with 51 Ω resistor.	
11	V <sub>cc</sub>	2.7 to 4.0	–	Supply voltage pin for modulator, up-converter and AGC circuits.	_____

**Note** Pin Voltages are measured on V<sub>cc</sub> = 3.0 V.



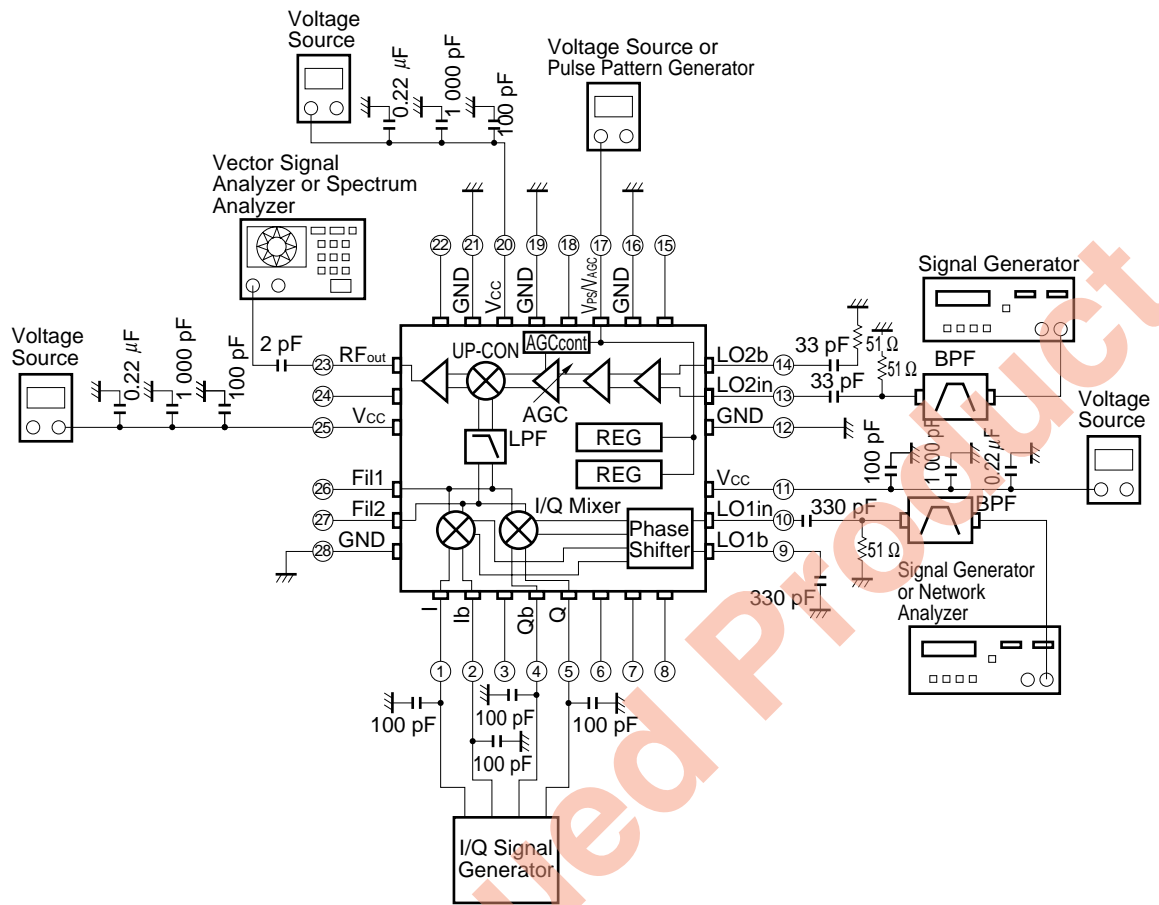
Pin No.	Symbol	Supply Voltage (V)	Pin Voltage (V) <sup>Note</sup>	Function and Application	Internal Equivalent Circuit						
12	GND	0	–	Ground pin for modulator, up-converter and AGC circuits. This pin should be grounded with minimum inductance. Form the ground pattern as widely as possible to minimize ground impedance.							
13	LO2in	–	1.8	Local signal input for modulator. This pin must be coupled with DC cut capacitor 33 pF and should be terminated with 51 Ω resistor.							
14	LO2inb	–	1.8	Bypass pin of up-converter's local signal input. This pin should be decoupled with 33 pF capacitor.							
15	N.C.	–	–	This pin is not connected to internal circuit. This pin should be opened or grounded.							
16	GND	0	–	Ground pin for modulator, up-converter and AGC circuits. This pin should be grounded with minimum inductance.							
17	Vps/V <sub>AGC</sub>	Vps/V <sub>AGC</sub>	–	Power save control pin for modulator, up-converter 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" data-bbox="641 1186 974 1312"> <thead> <tr> <th>Vps/V<sub>AGC</sub> (V)</th> <th>STATE</th> </tr> </thead> <tbody> <tr> <td>0 to 0.4</td> <td>OFF (Sleep Mode)</td> </tr> <tr> <td>1 to 2.5</td> <td>On (AGC Mode)</td> </tr> </tbody> </table>	Vps/V <sub>AGC</sub> (V)	STATE	0 to 0.4	OFF (Sleep Mode)	1 to 2.5	On (AGC Mode)	
Vps/V <sub>AGC</sub> (V)	STATE										
0 to 0.4	OFF (Sleep Mode)										
1 to 2.5	On (AGC Mode)										
18	N.C.	–	–	This pin is not connected to internal circuit. This pin should be opened or grounded.							
19	GND	0	–	Ground pin for modulator, up-converter and AGC circuits. This pin should be grounded with minimum inductance.							
20	V <sub>cc</sub>	2.7 to 4.0	–	Supply voltage pin for modulator, up-converter and AGC circuits.							
21	GND	0	–	Ground pin for RF output buffer. This pin should be grounded with minimum inductance.							

**Note** Pin Voltages are measured on V<sub>cc</sub> = 3.0 V.

Pin No.	Symbol	Supply Voltage (V)	Pin Voltage (V) <small>Note</small>	Function and Application	Internal Equivalent Circuit
22	N.C.	–	–	This pin is not connected to internal circuit. This pin should be opened or grounded.	_____
23	RFout	–	1.75	RF output pin. This pin is emitter follower which is low impedance output port. This pin can be easily matched to 50 Ω impedance using external coupling and decoupling capacitors.	<p>The diagram shows an emitter follower circuit. The base of a transistor is connected to a biasing network consisting of a resistor and a capacitor to ground. The emitter is connected to ground through a resistor. The collector is connected to a supply rail. The output is taken from the emitter, which is labeled as pin 23. An external matching network, shown in a dashed box, consists of a series capacitor and a shunt capacitor to ground.</p>
24	N.C.	–	–	These pins are not connected to internal circuit. These pins should be opened or grounded.	_____
25	V <sub>cc</sub>	2.7 to 4.0	–	Supply voltage pin for RF output buffer.	_____
26	Fil1	–	2.76	External inductor and capacitor can suppress harmonics spurious of LO1 frequency. LC value should be determined according to LO1 input frequency and suppression level.	<p>The diagram shows an LC filter network. It consists of a series inductor connected between pins 26 and 27. A shunt capacitor is connected from the node between the inductor and pin 27 to ground. The circuit is part of a larger stage, with a resistor and a transistor base connected to pin 26, and another resistor and transistor base connected to pin 27.</p>
27	Fil2	–	2.76		
28	GND	0	–	Ground pin for modulator, up-converter and AGC circuits. This pin should be grounded with minimum inductance. Form the ground pattern as widely as possible to minimize ground impedance.	_____

**Note** Pin Voltages are measured on V<sub>cc</sub> = 3.0 V.

TEST CIRCUIT



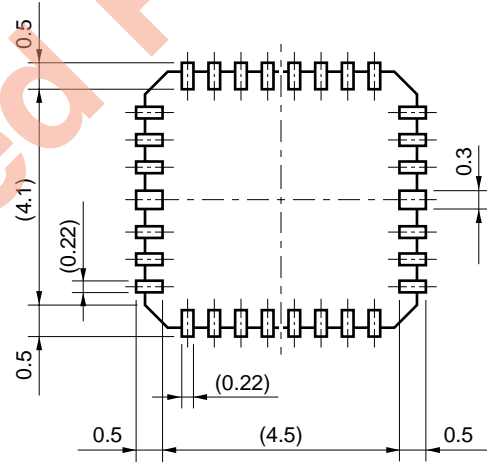
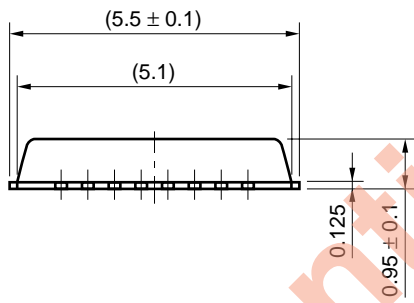
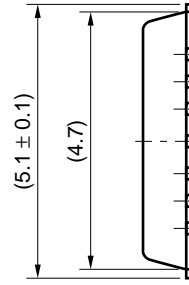
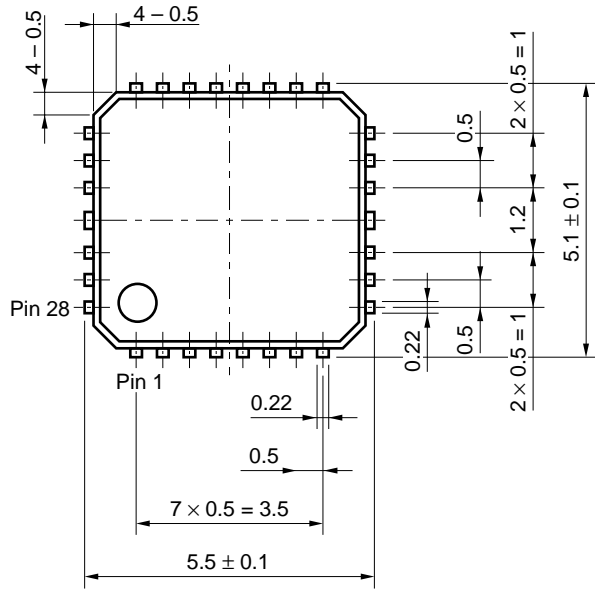
TEST CONDITIONS

$f_{LO1in} = 178.05 \text{ MHz}$ ,  $P_{LO1in} = -15 \text{ dBm}$   
 $f_{LO2in} = 1619.05 \text{ MHz}$ ,  $P_{LO2in} = -15 \text{ dBm}$   
 $f_{RFout} = 1441 \text{ MHz} - f_{I/Qin}$

Discontinued Product

PACKAGE DIMENSIONS

28 pin plastic QFN (UNIT: mm)



Bottom View

Discontinued Product

**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.

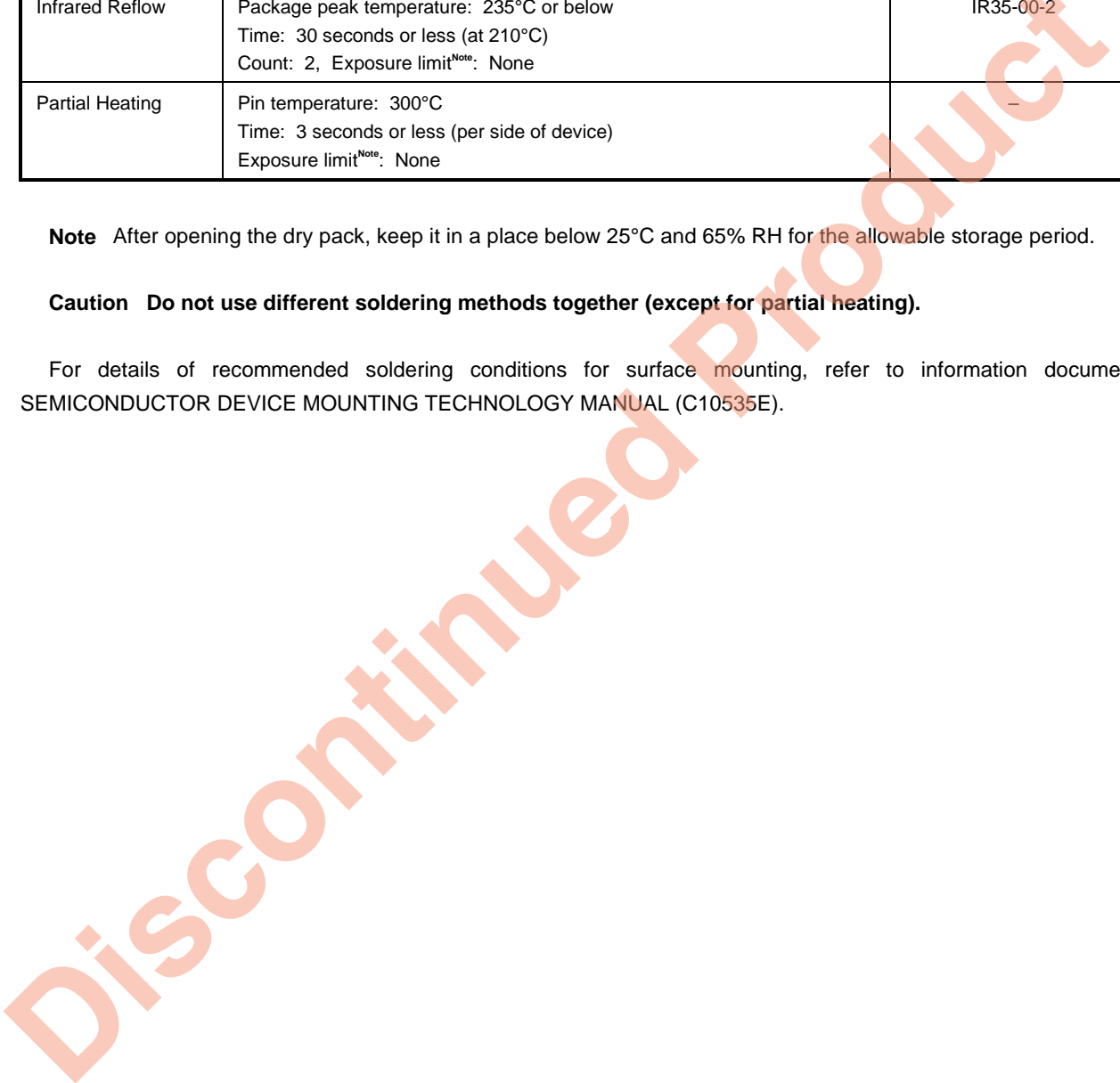
**μPC8158K**

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: 2, Exposure limit <sup>Note</sup> : None	IR35-00-2
Partial Heating	Pin temperature: 300°C Time: 3 seconds or less (per side of device) Exposure limit <sup>Note</sup> : None	-

**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).





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**Special:** Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)

**Specific:** Aircrafts, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, etc.

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