## DATA SHEET

# BIPOLAR ANALOG INTEGRATED CIRCUIT $\mu \mathrm{PC} 2781 \mathrm{GR}$ 

## DESCRIPTION

The $\mu \mathrm{PC} 2781 \mathrm{GR}$ is Silicon monolithic IC designed for use as IQ demodulator in digital communication systems. This IC consists of AGC amplifier, dual balanced mixers (DBM), oscillator, quadrature phase shifter and I \& Q output buffer amplifiers.

The package is 20-pin SSOP (shrink small outline package) suitable for high-density surface mount.

## FEATURES

- On chip quadrature $\left(90^{\circ}\right)$ phase shifter
- IQ phase and amplitude balance Amplitude Balance $\pm 0.5 \mathrm{~dB}$
- Low distortion $\mathrm{IM}_{3} 40 \mathrm{dBc}$
- Supply Voltage 5 V
- Packaged in 20-pin SSOP suitable for high-density surface mount


## ORDERING INFORMATION

| PART NUMBER | PACKAGE | PACKAGE STYLE |
| :--- | :--- | :--- |
| $\mu$ PC2781GR-E1 | 20-pin plastic SSOP <br> $(225$ mil) | Embossed tape 12 mm wide. $2.5 \mathrm{k} /$ REEL <br> Pin 1 indicates pull-out direction of tape |

For evaluation sample order, please contact your local NEC office. (Part number for sample order: $\mu$ PC2781GR)

INTERNAL BLOCK DIAGRAM AND PIN CONFIGURATION (Top View)


## PIN FUNCTIONS

\begin{tabular}{|c|c|c|c|c|}
\hline \begin{tabular}{l}
PIN \\
No.
\end{tabular} \& PIN NAME \& \begin{tabular}{l}
PIN \\
VOLTAGE \\
TYP. (V)
\end{tabular} \& FUNCTION AND EXPLANATION \& EQUIVALENT CIRCUIT \\
\hline 1 \& GND (IQ) \& 0.0 \& Ground pin of IQ outputs block. \& \\
\hline 2 \& Vcc (I) \& 5.0 \& Power supply pin of I-output. \& \\
\hline 3 \& Vagc \& 0 to 4 \& \begin{tabular}{l}
Gain control pin. \\
- @ measurement circuit 1 \\
\(\mathrm{V}_{\mathrm{AGC}}=0 \mathrm{~V}\) : Full gain \\
\(V_{\mathrm{AGC}}=4 \mathrm{~V}\) : Full reduction \\
- @ measurement circuit 2 \\
\(\mathrm{V}_{\mathrm{AGC}}=0 \mathrm{~V}\) : Full gain \\
\(V_{A G C}=5 \mathrm{~V}\) : Full reduction
\end{tabular} \&  \\
\hline 4 \& GND (IF) \& 0.0 \& Ground pin of IF, MIX, REG block. \& \\
\hline 5 \& IFin

IFin \& 2.2 \& IF input pins. In case of single input, 5 pin or 6 pin should be grounded through capacitor. \&  <br>
\hline 7 \& GND (IQ) \& 0.0 \& Ground pin of IQ outputs block. \& <br>
\hline 8 \& Vcc (IF) \& 5.0 \& Power supply pin of IF, MIX, REG block. \& <br>
\hline 9 \& Vcc (Q) \& 5.0 \& Power supply pin of Q-output. \& <br>
\hline 10 \& Vcc (PS) \& 5.0 \& Power supply pin of Phase Shifter block. \& <br>
\hline 11 \& Qout

$\overline{\text { Qout }}$ \& $$
2.7
$$

$$
2.7
$$ \& Q-signal output pin. 11 pin and 12 pin are balance outputs. \&  <br>

\hline
\end{tabular}

\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \[
\begin{aligned}
\& \text { PIN } \\
\& \text { No. }
\end{aligned}
\] \& PIN NAME \& \begin{tabular}{l}
PIN \\
VOLTAGE \\
TYP. (V)
\end{tabular} \& \multicolumn{2}{|l|}{FUNCTION AND EXPLANATION} \& \multicolumn{2}{|r|}{EQUIVALENT CIRCUIT} \\
\hline 13 \& GND (PS) \& 0.0 \& \multicolumn{2}{|l|}{Ground pin of Phase Shifter block.} \& \& \\
\hline \& \& \& External local \& \multicolumn{2}{|r|}{SAW (single)} \& SAW (balance) \\
\hline 14 \& OSC-B1 \& 3.1 \& Oscillator signal input pin. In case of single input, 14 pin or 17 pin should be grounded through capacitor. \& \multicolumn{2}{|r|}{Grounded through 1000 pF capacitor.} \& Connected to SAW resonator through capacitor. \\
\hline 15 \& OSC-C2 \& 3.7 \& OPEN \& \multicolumn{2}{|r|}{Connected to SAW resonator through capacitor.} \& Connected capacitor between 14 pin and 15 pin to oscillate with active feedback loop. \\
\hline 16 \& OSC-C1 \& 3.7 \& OPEN \& \multicolumn{2}{|l|}{OPEN} \& Connected capacitor between 16 pin and 17 pin to oscillate with active feedback loop. \\
\hline 17 \& OSC-B2 \& 3.1 \& Oscillator signal input pin. In case of single input, 14 pin or 17 pin should be grounded through capacitor. \& \multicolumn{2}{|r|}{Connected to SAW resonator through capacitor.} \& Connected to SAW resonator through capacitor. \\
\hline \& \multicolumn{4}{|l|}{\begin{tabular}{l}
<External Local> \\
<SAW resonator (balance)> \\
R: Resistor to adjust oscillator power.
\end{tabular}} \& \multicolumn{2}{|l|}{} \\
\hline 18 \& \[
\begin{aligned}
\& \text { OSC } \\
\& \text { OUT }
\end{aligned}
\] \& 3.7 \& \multicolumn{2}{|l|}{Oscillator signal output pin.} \& \& \\
\hline 19 \& lout

lout \& | 2.7 |
| :--- |
| 2.7 | \& \multicolumn{2}{|l|}{I-signal output pin. 19 pin and 20 pin are balance outputs.} \& \multicolumn{2}{|l|}{} <br>

\hline
\end{tabular}

## ABSOLUTE MAXIMUM RATINGS ( $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$ unless otherwise specified)

| PARAMETER | SYMBOL | TEST CONDITION | RATING | UNIT |
| :--- | :---: | :---: | :---: | :---: |
| Supply Voltage | $\mathrm{V}_{\mathrm{Cc}}$ |  | 6.0 | V |
| Power Dissipation 1 | PD 1 | $\mathrm{~T}_{\mathrm{A}}=75^{\circ} \mathrm{C}, \mathrm{V} \mathrm{CC}=5.25 \mathrm{~V}^{\circ}{ }^{\circ}$ | 500 | mW |
| Operating Ambient Temperature 1 | $\mathrm{~T}_{\mathrm{A} 1}$ |  | -40 to +75 | ${ }^{\circ} \mathrm{C}$ |
| Storage Temperature Range | $\mathrm{T}_{\mathrm{stg}}$ |  | -55 to +150 | ${ }^{\circ} \mathrm{C}$ |


| PARAMETER | SYMBOL | TEST CONDITION | RATING | UNIT |
| :---: | :---: | :---: | :---: | :---: |
| Supply Voltage | Vcc |  | 6.0 | V |
| Power Dissipation 2 | Pd2 | $\mathrm{T}_{\mathrm{A}}=80^{\circ} \mathrm{C}, \mathrm{V}_{\mathrm{Cc}}=5.15 \mathrm{~V}^{*}$ | 467 | mW |
| Operating Ambient Temperature 2 | TA2 |  | -40 to +80 | ${ }^{\circ} \mathrm{C}$ |
| Storage Temperature Range | $\mathrm{T}_{\text {stg }}$ |  | -55 to +150 | ${ }^{\circ} \mathrm{C}$ |

*1 Mounted on $50 \times 50 \times 1.6 \mathrm{~mm}$ double epoxy glass board.
RECOMMENDED OPERATING RANGE

| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Supply Voltage 1 | Vcc1 |  | 4.75 | 5.0 | 5.25 | V |
| Operating Ambient Temperature 1 | TA1 |  | -40 | +25 | +75 | ${ }^{\circ} \mathrm{C}$ |
| IF Input Level Range | PIF | Vout $=1 \mathrm{VP-P}$ | -45 | - | -25 | dBm |
| Gain Control Voltage Range 1 | Vagc1 | *1 | 0.0 | - | 4.0 | V |
| Gain Control Voltage Range 2 | VAGc2 | *2 | 0.0 | - | 5.0 | V |


| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Supply Voltage 2 | Vcc2 |  | 4.75 | 5.0 | 5.15 | V |
| Operating Ambient Temperature 2 | TA2 |  | -40 | +25 | +80 | ${ }^{\circ} \mathrm{C}$ |
| IF Input Level Range | PIF | Vout $=1 \mathrm{~V}$ p-p | -45 | - | -25 | dBm |
| Gain Control Voltage Range 1 | Vagc1 | *1 | 0.0 | - | 4.0 | V |
| Gain Control Voltage Range 2 | VAGC2 | *2 | 0.0 | - | 5.0 | V |

*1 By measurement circuit 1 External Resistance: $100 \Omega$
*2 By measurement circuit 2 External Resistance: $4.7 \mathrm{k} \Omega+22 \mathrm{k} \Omega$

ELECTRICAL CHARACTERISTICS $\left(\mathrm{TA}_{\mathrm{A}}=25^{\circ} \mathrm{C}, \mathrm{Vcc}=5 \mathrm{~V}\right.$, Zin =50 $\Omega$, Zout $=1 \mathrm{k} \Omega$ )

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN. | TYP. | MAX. | UNIT |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Circuit Current | Icc | No input signal | 52.0 | 70.0 | 88.0 | mA |
| IF Input Frequency | $\mathrm{fiF}^{\text {F }}$ | $\mathrm{fiQ}=10 \mathrm{MHz}, \mathrm{fiF}>$ fosc $\quad * \mathbf{1 , 2}$ | 440 | 480 | 520 | MHz |
| IQ Output Frequency | fio | $\begin{aligned} & \text { fif }>\text { fosc, Vout }=1 \text { Vp-p, Posc }=-8 \\ & \mathrm{dBm}, \mathrm{CG}(@ f \mathrm{IQ}=10 \mathrm{MHz}) \pm 1 \mathrm{~dB} * 1,2 \end{aligned}$ | 0.3 | - | 20 | MHz |
| AGC Gain Control Range 1 | GCR1 | $\begin{aligned} & \mathrm{fiF}=480 \mathrm{MHz}, \mathrm{PIF}=-40 \mathrm{dBm}, \\ & \mathrm{fosc}=470 \mathrm{MHz}, \text { Posc }=-8 \mathrm{dBm}, \\ & \mathrm{fiQ}_{\mathrm{I}}=10 \mathrm{MHz}, \text { VAGC }=0 \text { to } 4 \mathrm{~V} \end{aligned}$ | 15 | 20 | - | dB |
| AGC Gain Control Range 2 | GCR2 | $\begin{aligned} & \mathrm{fiF}_{\mathrm{I}}=480 \mathrm{MHz}, \text { PIF }=-40 \mathrm{dBm}, \\ & \mathrm{fosc}=470 \mathrm{MHz}, \text { Posc }=-8 \mathrm{dBm}, \\ & \mathrm{fiQ}_{\mathrm{IQ}}=10 \mathrm{MHz}, \mathrm{~V}_{\text {AGC }}=0 \text { to } 5 \mathrm{~V} \end{aligned}$ | 15 | 20 | - | dB |
| IQ Phase Balance | $\Delta \Phi$ | $\begin{aligned} & \text { fif }=480 \mathrm{MHz}, \text { fosc }=470 \mathrm{MHz}, \\ & \text { Posc }=-8 \mathrm{dBm}, \mathrm{fiQ}=10 \mathrm{MHz}, \\ & \text { Vout }=1 \mathrm{VP} \cdot \mathrm{P} \end{aligned}$ | -2 | 0 | +2 | deg |
| IQ Amplitude Balance | $\Delta \mathrm{G}$ | $\begin{aligned} & \mathrm{fIF}=480 \mathrm{MHz}, \mathrm{fosc}=470 \mathrm{MHz}, \\ & \text { Posc }=-8 \mathrm{dBm}, \mathrm{fiQ}=10 \mathrm{MHz}, \\ & \text { Vout }=1 \mathrm{VP-P} \end{aligned}$ ${ }^{*} 1,2$ | -0.5 | 0 | +0.5 | dB |
| Output Voltage | Vout | $\mathrm{fiQ}=10 \mathrm{MHz}$ | - | 1.0 | - | Vp.P |

*1 By measurement circuit 1 External Resistance: $100 \Omega$
*2 By measurement circuit 2 External Resistance: $4.7 \mathrm{k} \Omega+22 \mathrm{k} \Omega$

STANDARD CHARACTERISTICS $\left(\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}, \mathrm{Vcc}=5 \mathrm{~V}, \mathrm{Zin}=50 \Omega\right.$, Zout $=1 \mathrm{k} \Omega$ )

| PARAMETER | SYMBOL | TEST CONDITIONS | REFERENCE VALUE | UNIT |
| :---: | :---: | :---: | :---: | :---: |
| Conversion Gain | Gcv | $\begin{align*} & \mathrm{fiF}_{\mathrm{IF}}=480 \mathrm{MHz}, \mathrm{fosc}=470 \mathrm{MHz}, \\ & \text { Posc }=-8 \mathrm{dBm}, \mathrm{fiQ}=10 \mathrm{MHz}, \\ & \mathrm{~V}_{\mathrm{AGC}}=0 \mathrm{~V} \end{align*}$ | 50 | dB |
| Noise Figure (DSB) | NF | $\begin{aligned} & \mathrm{fiF}=480 \mathrm{MHz}, \text { fosc }=470 \mathrm{MHz}, \\ & \mathrm{Posc}=-8 \mathrm{dBm}, \mathrm{fiQ}=10 \mathrm{MHz}, \\ & \mathrm{~V}_{\mathrm{AGC}}=0 \mathrm{~V} \end{aligned}$ | 13 | dB |
| Third Intermodulation Distortion | $1 \mathrm{M}_{3}$ | $\begin{aligned} & \text { fif } 1=480 \mathrm{MHz}, \text { fiF2 }=481 \mathrm{MHz}, \\ & \text { fosc }=470 \mathrm{MHz} \text {, Posc }=-8 \mathrm{dBm}, \\ & 0.708 \mathrm{~V} \text { P-P/tone } \end{aligned}$ | 40 | dBc |
| LO to IF Isolation | Iso (LO-IF) | $\begin{aligned} & \text { fosc }=440 \text { to } 520 \mathrm{MHz}, \\ & \text { Posc }=-8 \mathrm{dBm} \end{aligned} \quad \text { *1, 2 }$ | 50 | dB |
| LO to IQ Isolation | Iso (LO-IQ) | $\begin{aligned} & \text { fosc }=440 \text { to } 520 \mathrm{MHz}, \\ & \text { Posc }=-8 \mathrm{dBm} \end{aligned} \quad \text { *1, 2 }$ | 20 | dB |
| Maximum Output Power | Po (sat) | Posc $=-8 \mathrm{dBm}, \mathrm{fiQ}=10 \mathrm{MHz} \quad * 1,2$ | 0 | dBm |
| IQ Output Impedance | Zo (IQ) | $\mathrm{fio}=300 \mathrm{kHz}$ to 20 MHz | 30 | $\Omega$ |
| IF Input Impedance | Zin (IF) | $\mathrm{fiF}^{\prime}=480 \mathrm{MHz}$, no tuning | 160-j30 | $\Omega$ |
| IF Input Return Loss | RL (IF) | $\mathrm{fiF}=480 \mathrm{MHz}$, no tuning | 5 | dB |

*1 By measurement circuit 1 External Resistance: $100 \Omega$
*2 By measurement circuit 2 External Resistance: $4.7 \mathrm{k} \Omega+22 \mathrm{k} \Omega$
*3 By measurement circuit 3

## TYPICAL CHARACTERISTICS





## TYPICAL CHARACTERISTICS



## Amplitude Balance



## Amplitude Balance vs. fıQ




Phase Balance


Phase Balance vs. fio


## STANDARD CHARACTERISTICS

Pout Vs. Pin

$\mathrm{IM}_{3}$

$\mathrm{IM}_{3}$


Pout vs. Pin

$\mathrm{IM}_{3}$


## IF INPUT IMPEDANCE



## IQ OUTPUT IMPEDANCE (Vcc = 5 V )



## MEASUREMENT CIRCUIT 1


*1 In the case of measurement of IM3.
*2 • Vector Signal Analyzer or Vector Voltage Meter @ measurement of IQ phase balance and IQ amplitude balance.

- Spectrum Analyzer @ measurement of bandwidth and IM3.


## MEASUREMENT CIRCUIT 2


*1 In the case of measurement of IM3.
*2 • Vector Signal Analyzer or Vector Voltage Meter @ measurement of IQ phase balance and IQ amplitude balance.

- Spectrum Analyzer @ measurement of bandwidth and IM3.


## MEASUREMENT CIRCUIT 3



## APPLICATION CIRCUIT EXAMPLE



The application circuits and their parameters are for reference only and are not intended for use in actual design-ins.

## ILLUSTRATION OF THE APPLICATION CIRCUIT ASSEMBLED ON EVALUATION BOARD


$\begin{aligned} & \text { NOTES } \text { - } \\ & \square \text { shows short circuited strip for ground } \\ & \text { - } \\ & \text { Pattern should be removed on this application } \\ & \text { shows through holes }\end{aligned}$

## PACKAGE DIMENSIONS

## 20 PIN PLASTIC SSOP (225 mil) <br> (UNIT: mm)



## note

Each lead centerline is located within 0.12 mm ( 0.005 inch) of its true position (T.P.) at maximum material condition.

| ITEM | MILLIMETERS | INCHES |
| :---: | :--- | :--- |
| A | 7.00 MAX. | 0.276 MAX. |
| B | 0.575 MAX. | 0.023 MAX. |
| C | $0.65(\mathrm{T.P})$ | 0.026 (T.P) |
| D | $0.22_{-0.05}^{+0.10}$ | $0.009_{-0.004}^{+0.002}$ |
| E | $0.1 \pm 0.1$ | $0.004 \pm 0.004$ |
| F | 1.8 MAX. | 0.071 MAX. |
| G | $1.5 \pm 0.1$ | $0.058 \pm 0.004$ |
| H | $6.4 \pm 0.2$ | $0.253 \pm 0.008$ |
| I | $4.4 \pm 0.1$ | $0.174 \pm 0.004$ |
| J | 1.0 | 0.040 |
| K | $0.15_{-0.05}^{+0.10}$ | $0.060_{-0.002}^{+0.004}$ |
| L | $0.5 \pm 0.2$ | $0.020_{-0.004}^{+0.008}$ |
| M | 0.10 | 0.004 |
| N | 0.15 | 0.006 |
| P | $3^{\circ}{ }_{-3^{\circ}}$ | $3^{\circ}{ }_{-3^{\circ}}$ |

## RECOMMENDED SOLDERING CONDITIONS

The following conditions (see table below) must be met when soldering this product.
Please consult with our sales officers in case other soldering process is used or in case soldering is done under different conditions.

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

## $\mu$ PC2781GR

| Soldering process | Soldering conditions | Symbol |
| :---: | :---: | :---: |
| Infrared ray reflow | Peak package's surface temperature: $235^{\circ} \mathrm{C}$ or below, Reflow time: 30 seconds or below ( $210^{\circ} \mathrm{C}$ or higher), Number of reflow process: 3, Exposure limit ${ }^{\text {Note }}$ : None | IR35-00-3 |
| VPS | Peak package's surface temperature: $215^{\circ} \mathrm{C}$ or below, Reflow time: 40 seconds or below ( $200^{\circ} \mathrm{C}$ or higher), Number of reflow process: 3, Exposure limit ${ }^{\text {Note }}$ : None | VP15-00-3 |
| Wave soldering | Solder temperature: $260^{\circ} \mathrm{C}$ or below, <br> Reflow time: 10 seconds or below, <br> Number of reflow process: 1, Exposure limit ${ }^{\text {Note }}$ : None | WS60-00-1 |
| Partial heating method | Terminal temperature: $300^{\circ} \mathrm{C}$ or below, Flow time: 3 seconds or below, Exposure limit ${ }^{\text {Note }}$ : None |  |

Note Exposure limit before soldering after dry-pack package is opened.
Storage conditions: $25^{\circ} \mathrm{C}$ and relative humidity at $65 \%$ or less.

## Caution Do not apply more than single process at once, except for "Partial heating method".

[MEMO]

The application circuits and their parameters are for reference only and are not intended for use in actual design-ins.

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