

Advanced Dual PWM and Dual Linear Power Controller

General Description

The RT9229 is a 4-in-one power controller optimized for high-performance microprocessor and computer applications. The IC integrates two PWM controllers, a linear regulator and a linear controller as well as monitoring and protection functions into a 28-pin SOP package. The first PWM controller regulates the microprocessor core voltage with a synchronous buck converter, while the second PWM controller supplies the 3.3V power with a standard buck converter. The linear regulator provides power for the clock driver circuit and the linear controller regulates power for the GTL bus.

The RT9229 features an Intel-compatible, TTL 5-bit programmable DAC that adjusts the core voltage from 2.1V to 3.5V in 0.1V increments and from 1.3V to 2.05V in 0.05V steps. The second PWM controller is user-adjustable for output level between 3.0V and 3.5V with $\pm 2.5\%$ accuracy. The 5-bit DAC has a typical $\pm 1\%$ tolerance. The linear regulator uses an internal drive device to provide 2.5V $\pm 2.5\%$ output voltage. The linear controller drives an external N-channel MOSFET or a low cost NPN bipolar transistor to provide 1.5V $\pm 2.5\%$.

The RT9229 monitors all the output voltages. A Power-good signal is issued when the core voltage is within $\pm 10\%$ of the DAC setting and the other levels are above their under-voltage levels. Additional build-in over-voltage protection for the core output uses the lower MOSFET to prevent output voltage above 115% of the DAC setting. The PWM over-current function monitors the output current using the voltage drop across the upper MOSFET's $R_{DS(ON)}$ which eliminates the need for a current sensing resistor.

Ordering Information

RT9229□□

- Package type
S : SOP-28
- Operating temperature range
C : Commercial standard

Features

- 4-in-one Regulated Voltages for Microprocessor Core, I/O, Clock, and GTL
- Compatible with HIP6019B
- Power-Good Output Voltage Monitor

Switching section

- 5-bit DAC Programmable from 1.3V to 3.5V
- $\pm 1\%$ DAC Accuracy
- Fast Transient Response
- Full 0% to 100% Duty Cycle Driver
- Fixed 200kHz Switching Frequency
- Adaptive Non-overlapping Gate Driver
- Over-current Monitor Uses MOSFET $R_{DS(ON)}$
- Over-voltage Protection Uses Lower MOSFET

Linear Section

- User-adjustable Linear Regulator Output Voltage
- MOSFET or NPN Driving Capability
- Ultra Fast Response Speed
- Under-voltage Protection
- Internal Thermal Shutdown

Applications

- Full Motherboard Power Regulation for Computer
- Low-voltage Distributed Power Supplies

Pin Configurations

| Part Number | Pin Configurations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------------------------------|--|--------|--------|----|-----|--------|---|----|--------|------|---|----|--------|------|---|----|--------|------|---|----|------|------|---|----|--------|------|---|----|-------|-------|---|----|-----|--------|---|----|-----|-----|----|----|-----|-----|----|----|-------|----|----|----|-----|-------|----|----|-------|-----|----|----|-------|--|
| RT9229CS (Plastic SOP-28) | TOP VIEW | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | <table border="0"> <tr><td>UGATE2</td><td>1</td><td>28</td><td>VOC</td></tr> <tr><td>PHASE2</td><td>2</td><td>27</td><td>UGATE1</td></tr> <tr><td>VID4</td><td>3</td><td>26</td><td>PHASE1</td></tr> <tr><td>VID3</td><td>4</td><td>25</td><td>LGATE1</td></tr> <tr><td>VID2</td><td>5</td><td>24</td><td>PGND</td></tr> <tr><td>VID1</td><td>6</td><td>23</td><td>OCSET1</td></tr> <tr><td>VID0</td><td>7</td><td>22</td><td>VSEN1</td></tr> <tr><td>PGOOD</td><td>8</td><td>21</td><td>FB1</td></tr> <tr><td>OCSET2</td><td>9</td><td>20</td><td>NC1</td></tr> <tr><td>FB2</td><td>10</td><td>19</td><td>FB3</td></tr> <tr><td>NC2</td><td>11</td><td>18</td><td>GATE3</td></tr> <tr><td>SS</td><td>12</td><td>17</td><td>GND</td></tr> <tr><td>FAULT</td><td>13</td><td>16</td><td>VOUT4</td></tr> <tr><td>FB4</td><td>14</td><td>15</td><td>VSEN2</td></tr> </table> | UGATE2 | 1 | 28 | VOC | PHASE2 | 2 | 27 | UGATE1 | VID4 | 3 | 26 | PHASE1 | VID3 | 4 | 25 | LGATE1 | VID2 | 5 | 24 | PGND | VID1 | 6 | 23 | OCSET1 | VID0 | 7 | 22 | VSEN1 | PGOOD | 8 | 21 | FB1 | OCSET2 | 9 | 20 | NC1 | FB2 | 10 | 19 | FB3 | NC2 | 11 | 18 | GATE3 | SS | 12 | 17 | GND | FAULT | 13 | 16 | VOUT4 | FB4 | 14 | 15 | VSEN2 | |
| UGATE2 | 1 | 28 | VOC | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PHASE2 | 2 | 27 | UGATE1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VID4 | 3 | 26 | PHASE1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VID3 | 4 | 25 | LGATE1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VID2 | 5 | 24 | PGND | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VID1 | 6 | 23 | OCSET1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VID0 | 7 | 22 | VSEN1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PGOOD | 8 | 21 | FB1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OCSET2 | 9 | 20 | NC1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FB2 | 10 | 19 | FB3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NC2 | 11 | 18 | GATE3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SS | 12 | 17 | GND | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FAULT | 13 | 16 | VOUT4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FB4 | 14 | 15 | VSEN2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Absolute Maximum Ratings

| | | |
|---|-------|-----------------------------------|
| • Supply Voltage | ..... | +15V |
| • PGOOD, FAULT and GATE Voltage | ..... | GND-0.3V to V _{OC} +0.3V |
| • Input, Output or I/O Voltage | ..... | GND-0.3V to 7V |
| • Ambient Temperature Range | ..... | 0°C to +70°C |
| • Junction Temperature Range | ..... | 0°C to +125°C |
| • Storage Temperature Range | ..... | -65°C to +150°C |
| • Lead Temperature (Soldering, 10 sec.) | ..... | 300°C |
| • Package Thermal Resistance | | |
| SOP-28, θ_{JA} | ..... | 60°C/W |

Recommended Operating Conditions

| | | |
|------------------------------|-------|----------------|
| • Supply Voltage | ..... | +12V \pm 10% |
| • Ambient Temperature Range | ..... | 0°C to 70°C |
| • Junction Temperature Range | ..... | 0°C to 125°C |

CAUTION:

Stresses beyond the ratings specified in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Electrical Characteristics

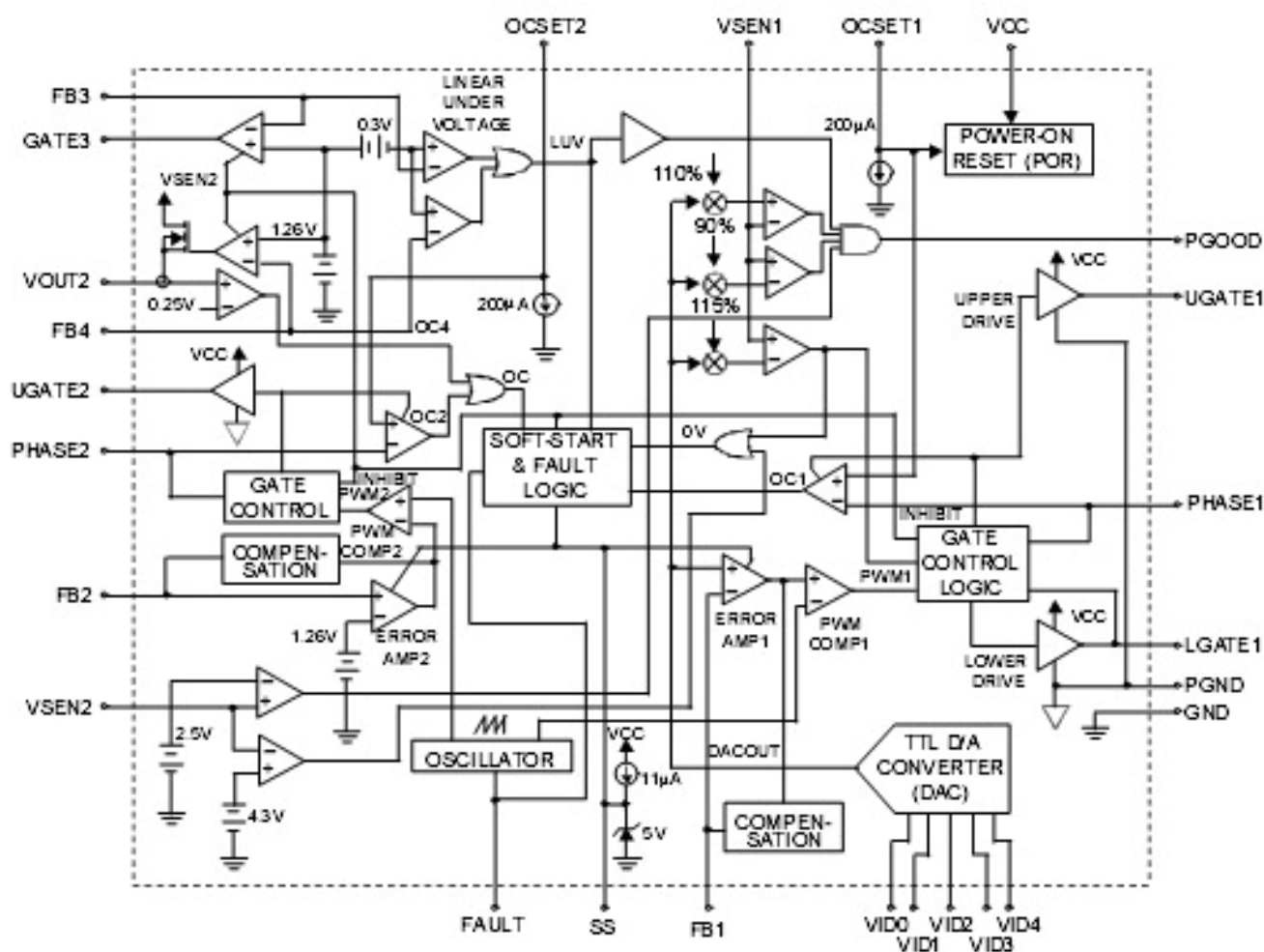
(V_{CC} = 12V, PGND = 0V, T_A = 25°C, unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|------------------|--|-------|-------|-------|-------|
| VCC Supply Current | | | | | | |
| Nominal Supply Current | I _{OC} | UGATE1, GATE2, GATE3, LGATE1, and VOUT4 Open | - | 10 | -- | mA |
| Power-on Reset | | | | | | |
| VCC Rising Threshold | | V _{OCSET} = 4.5V | 7.5 | - | 9.5 | V |
| VCC Falling Threshold | | V _{OCSET} = 4.5V | 7 | - | 9 | V |
| Rising V _{OCSET} 1 (and 2) Threshold | | | - | 1.25 | -- | V |
| Reference and DAC | | | | | | |
| DAC (VID0 – VID4) Input Low Voltage | | | - | - | 0.8 | V |
| DAC (VID0 – VID4) Input High Voltage | | | 2.0 | - | -- | V |
| DACOUT Voltage Accuracy | | DACOUT = 2.05 ~ 3.50V | -1 | - | 1 | % |
| DACOUT Voltage Accuracy | | DACOUT = 1.30 ~ 2.00V | -1% | - | 20mV | - |
| Reference Voltage (Pin FB2 and FB3) | V _{REF} | | 1.240 | 1.265 | 1.290 | V |

To be continued

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|---------------------|--|------|-----|-----|------------------|
| Oscillator | | | | | | |
| Free Running Frequency | | | 180 | 200 | 225 | kHz |
| Ramp Amplitude | ΔV_{OSC} | | – | 1.9 | -- | V _{p-p} |
| Linear Regulator | | | | | | |
| Regulation | | 10mA < I _{OUT2} < 150mA | -2.5 | – | 2.5 | % |
| Under-voltage Level | | FB4 Rising | – | 75 | 87 | % |
| Under-voltage Hysteresis | | | – | 100 | -- | mV |
| Over-current Protection | I _{OV} | | 180 | 230 | -- | mA |
| Over-current Protection During Start-up | | | – | 700 | -- | mA |
| Linear Controller | | | | | | |
| Regulation | | VSEN3 = GATE3 0 < I _{GATE3} < 20mA | -2.5 | – | 2.5 | % |
| Under-voltage Level | | FB3 Rising | – | 75 | 87 | % |
| Under-voltage Hysteresis | | | – | 100 | -- | mV |
| Output Drive Current | | VIN2 – VOUT3 > 1.5V | 20 | 40 | -- | mA |
| PWM Controller Error Amplifier | | | | | | |
| DC Gain | | | – | 65 | -- | dB |
| PWM Controller Gate Driver | | | | | | |
| UGATE 1 (and 2) Source | R _{UGATE} | VCC = 12V VCC - V _{UGATE} = 1V | – | 3 | 7 | Ω |
| UGATE 1 (and 2) Sink | R _{UGATE} | V _{UGATE} = 1V | – | 3 | 7 | Ω |
| LGATE Source | I _{LGATE1} | VCC = 12V, V _{LGATE1} = 2V | – | 1 | -- | A |
| LGATE Sink | R _{LGATE1} | V _{LGATE1} = 1V | – | 2 | 6 | Ω |
| Protection | | | | | | |
| V _{OUT1} Over-voltage Trip | | VSEN1 Rising | 112 | 115 | 118 | % |
| V _{OUT2} Over-voltage Trip | | VSEN2 Rising | 4.1 | 4.3 | 4.5 | V |
| FAULT Sourcing Current | | V _{FAULT} = 8V | 10 | 14 | -- | mA |
| OCSET1 (and 2) Current Source | I _{OCSET} | V _{OCSET} = 4.5V _{DC} | 170 | 200 | 230 | μA |
| Soft-start Current | I _{SS} | V _{SS} = 1V | – | 11 | -- | μA |
| Power Good | | | | | | |
| V _{OUT1} Upper Threshold | | VSEN1 Rising | 108 | – | 112 | % |
| V _{OUT1} Under Voltage | | VSEN1 Rising | 90 | – | 94 | % |
| V _{OUT1} Hysteresis (VSEN1/DACOUT) | | Upper/Lower Threshold | – | 2 | -- | % |
| PGOOD Voltage Low | V _{PGOOD} | I _{PGOOD} = -4mA | – | – | 0.5 | V |

Function Block Diagram



Functional Pin Description

UGATE1, UGATE2 (Pins 27 and 1)

Connect UGATE pins to the respective PWM converter's upper MOSFET gate. This pin provides the gate drive for the upper MOSFETs.

PHASE1, PHASE2 (Pins 26 and 2)

Connect the PHASE pins to the PWM converter's upper MOSFET source. These pins are used to monitor the voltage drop across the upper MOSFETs for over-current protection.

VID0, VID1, VID2, VID3, VID4 (Pin 7, 6, 5, 4, and 3)

VID0~4 are the input pins to the 5-bit DAC. The states of these five pins program the internal voltage reference, DACOUT. The level of DACOUT sets the core converter output voltage (VOUT1). It also sets the core PGOOD and OVP thresholds. Table 1 specifies the DACOUT voltage of 32 combinations of VID levels.

PGOOD (Pin 8)

PGOOD is an open collector output used to indicate the status of the PWM converter output voltage. This pin is pulled low when the core output is not within $\pm 10\%$ of the DACOUT reference voltage, or when any of the other outputs are below their under-voltage thresholds. The PGOOD output is open for '11111'VID code. See table 1.

FB1, FB2 (21 and 10)

FB1, 2 are the available external pins of the PWM error amplifiers. Both the FB pins are the inverting input of the error amplifiers.

OCSET1, OCSET2 (Pins 23 and 9)

Connect a resistor (R_{OCSET}) from this pin to the drain of the upper MOSFET. R_{OCSET} , an internal $200\mu A$ current source (I_{OCSET}), and the upper MOSFET on-resistance ($R_{DS(ON)}$) set the converter over-current (OC) trip point according to the following equation:

$$I_{PEAK} = \frac{I_{OCSET} \times R_{OCSET}}{R_{DS(ON)}}$$

An over-current trip cycles the soft-start function. Sustaining an over-current for 2 soft-start intervals shuts down the controller.

SS (Pin 12)

Connect a capacitor from this pin to ground. This capacitor, along with an internal $11\mu A$ ($V_{SS} > 1V$) current source, sets the soft-start interval of the converter.

Pulling this pin low with an open drain signal will shut down the IC.

FAULT (Pin 13)

This pin is low during normal operation, but it is pulled to about 8V ($V_{CC} = 12V$) in the event of an over-voltage or over-current condition.

FB4 (Pin 14)

Connect this pin to a resistor divider to set the linear regulator output.

VSEN1, VSEN2 (Pins 22 and 15)

These pins are connected to the PWM converters' output voltage. The PGOOD and OVP comparator circuits use these signals to report output voltage status and for over-voltage protection. VSEN2 provides the input power to the integrated linear regulator.

VOUT4 (Pin 16)

Output of the linear regulator. Supplies current up to 230mA.

GATE3 (Pin 18)

Connect this pin to the gate of an external MOSFET or the base of a NPN. This pin provides the drive for the linear controller's pass transistor.

FB3 (Pin 19)

Connect this pin to a resistor divider to set the linear controller output voltage.

PGND (Pin 24)

This is the power ground of UGATE1, LGATE1, and UGATE2. Tie the synchronous PWM converter's lower MOSFET source to this pin.

LGATE1 (Pin 25)

Connect LGATE1 to the synchronous PWM converter's lower MOSFET gate. This pin provides the gate drive for the lower MOSFET.

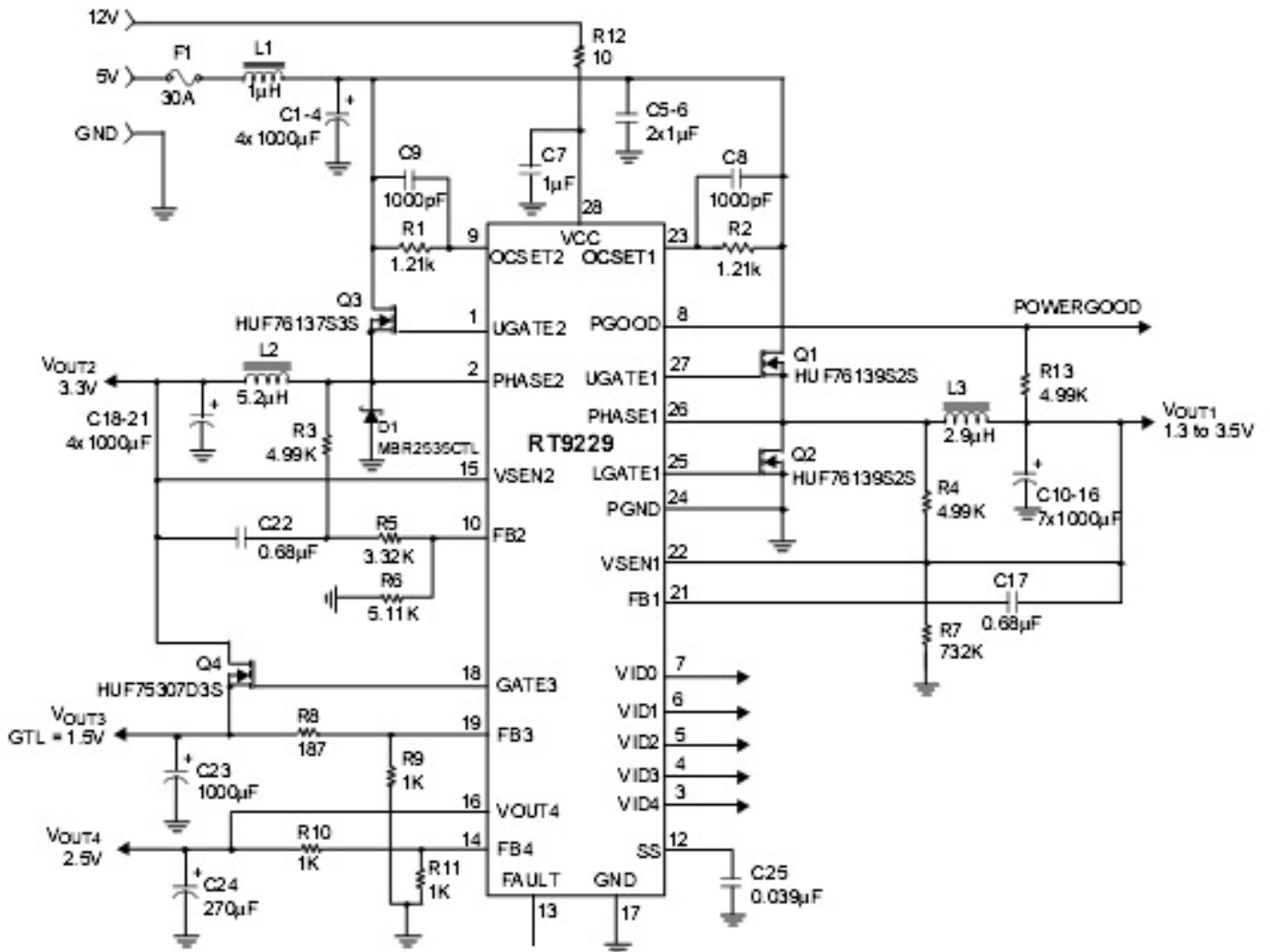
VCC (Pin 28)

Provide a 12V bias supply for the IC to this pin. This pin also provides the gate bias charge for all the MOSFETs controlled by the IC.

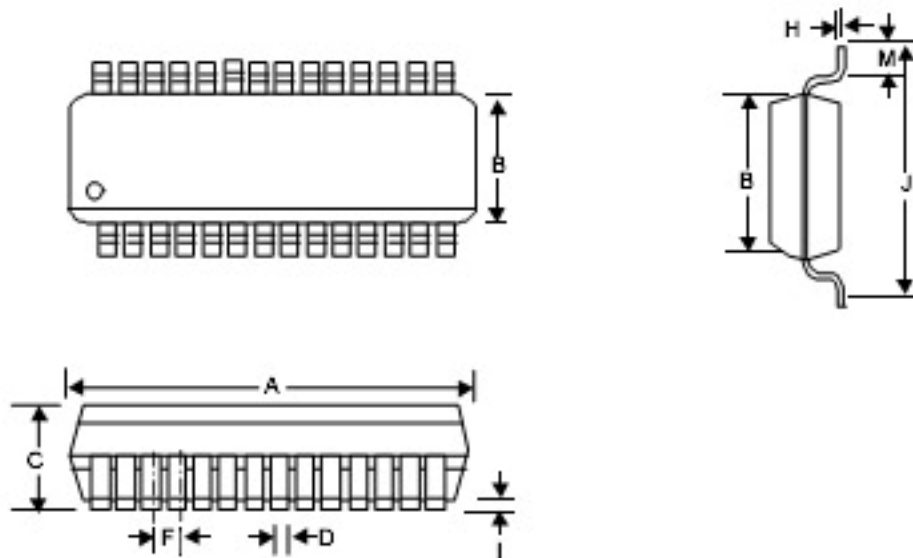
Table 1. VOUT1 Voltage Program

| Pin Name | | | | | Normal OUT1 Voltage DACOUT |
|----------|------|------|------|------|-------------------------------|
| VID4 | VID3 | VID2 | VID1 | VID0 | |
| 0 | 1 | 1 | 1 | 1 | 1.30 |
| 0 | 1 | 1 | 1 | 0 | 1.35 |
| 0 | 1 | 1 | 0 | 1 | 1.40 |
| 0 | 1 | 1 | 0 | 0 | 1.45 |
| 0 | 1 | 0 | 1 | 1 | 1.50 |
| 0 | 1 | 0 | 1 | 0 | 1.55 |
| 0 | 1 | 0 | 0 | 1 | 1.60 |
| 0 | 1 | 0 | 0 | 0 | 1.65 |
| 0 | 0 | 1 | 1 | 1 | 1.70 |
| 0 | 0 | 1 | 1 | 0 | 1.75 |
| 0 | 0 | 1 | 0 | 1 | 1.80 |
| 0 | 0 | 1 | 0 | 0 | 1.85 |
| 0 | 0 | 0 | 1 | 1 | 1.90 |
| 0 | 0 | 0 | 1 | 0 | 1.95 |
| 0 | 0 | 0 | 0 | 1 | 2.00 |
| 0 | 0 | 0 | 0 | 0 | 2.05 |
| 1 | 1 | 1 | 1 | 1 | INHIBIT |
| 1 | 1 | 1 | 1 | 0 | 2.10 |
| 1 | 1 | 1 | 0 | 1 | 2.20 |
| 1 | 1 | 1 | 0 | 0 | 2.30 |
| 1 | 1 | 0 | 1 | 1 | 2.40 |
| 1 | 1 | 0 | 1 | 0 | 2.50 |
| 1 | 1 | 0 | 0 | 1 | 2.60 |
| 1 | 1 | 0 | 0 | 0 | 2.70 |
| 1 | 0 | 1 | 1 | 1 | 2.80 |
| 1 | 0 | 1 | 1 | 0 | 2.90 |
| 1 | 0 | 1 | 0 | 1 | 3.00 |
| 1 | 0 | 1 | 0 | 0 | 3.10 |
| 1 | 0 | 0 | 1 | 1 | 3.30 |
| 1 | 0 | 0 | 1 | 0 | 3.30 |
| 1 | 0 | 0 | 0 | 1 | 3.40 |
| 1 | 0 | 0 | 0 | 0 | 3.50 |

Typical Application Circuit



Package Information



| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|---------------------------|--------|----------------------|-------|
| | Min | Max | Min | Max |
| A | 17.704 | 18.110 | 0.697 | 0.713 |
| B | 7.391 | 7.595 | 0.291 | 0.299 |
| C | 2.362 | 2.642 | 0.093 | 0.104 |
| D | 0.330 | 0.508 | 0.013 | 0.020 |
| F | 1.194 | 1.346 | 0.047 | 0.053 |
| H | 0.229 | 0.330 | 0.009 | 0.013 |
| I | 0.102 | 0.305 | 0.004 | 0.012 |
| J | 10.008 | 10.643 | 0.394 | 0.419 |
| M | 0.381 | 1.270 | 0.015 | 0.050 |