RC5055

Programmable Synchronous DC-DC Converter Controller for Low Voltage Microprocessors, Vtt and Clock Linear Regulator

Features

- Current Sensing is achieved using MOSFET $R_{DS(ON)}$
- Programmable output from 1.3V to 3.5V using an integrated 5-bit DAC
- 85% efficiency typical at full load
- Adjustable operation from 100KHz to 1MHz
- Integrated Power Good and Enable/Soft Start functions
- Overvoltage protection pin controls external SCR
- Short circuit protection with current limiting
- Drives N-channel MOSFETs
- 24 pin SSOP and SOIC package
- Meets Intel Pentium II specifications using minimum number of external components
- On board Linear regulator for GTL termination
- On board fixed linear regulator for Clock power supply
- TTL Compatible inputs

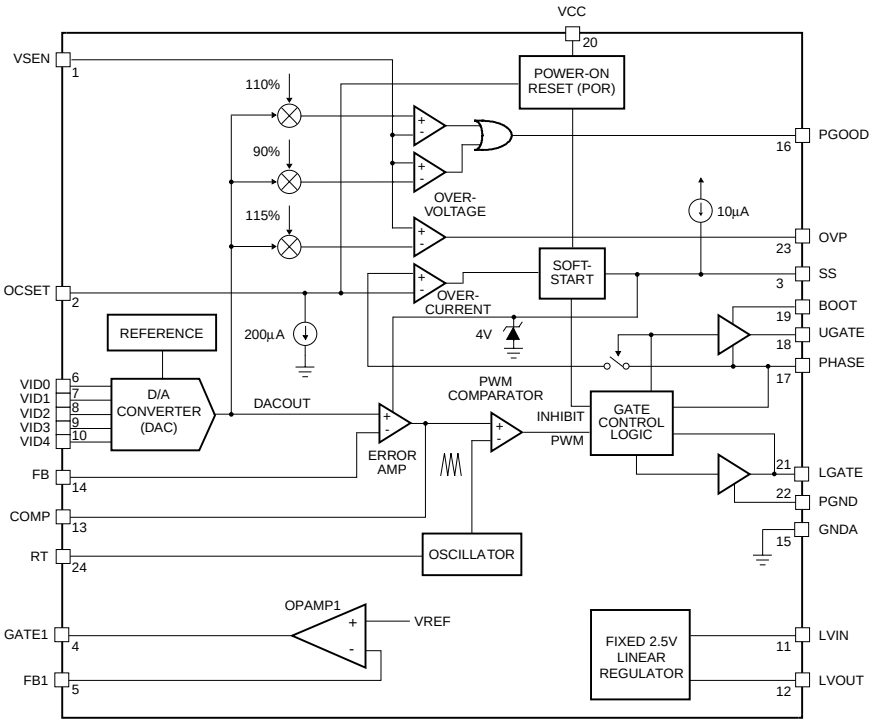
Applications

- Power supply for Pentium® II
- VRM for Pentium II processor
- Programmable step-down power supply

Description

The RC5055 is a triple combo combining a synchronous DC-DC controller with a fixed 2.5V output linear regulator and an adjustable linear regulator. The synchronous mode DC-DC controller provides an accurate, programmable output voltage for all Pentium II CPU applications. It uses a 5-bit D/A converter to program the output voltage from 1.3V to 3.5V and uses a high level of integration to deliver load currents in excess of 17A from a 5V source with minimal external circuitry. Synchronous-mode operation offers optimum efficiency over the entire specified output voltage range, and the internal oscillator can be programmed from 100KHz to 1MHz for additional flexibility in choosing external components. An on-board precision low TC reference achieves tight tolerance voltage regulation without expensive external components. The RC5055 also offers integrated functions including Power Good, Output Enable/Soft Start, over-voltage protection and current limiting.

Block Diagram



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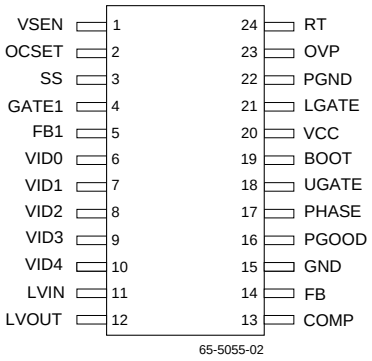
Pin Assignments



Pin Definitions

Pin Number	Pin Name	Pin Function Description
1	VSEN	This pin is connected to the converter's output voltage. The PGOOD and OVP comparator circuits use this signal to report output voltage status and for overvoltage protection.
2	OCSET	Connect a resistor (ROCSET) from this pin to the drain of the upper MOSFET. An internal 200µA current source (Iocs) and the upper MOSFET $R_{DS(ON)}$ set the converter peak over-current trip point: $$I_{PEAK} = \frac{I_{OCS} \bullet R_{OCSET}}{R_{DS(ON)}}$$
3	SS	Soft Start. A capacitor from this point to ground together with an internal 10µA will cause the output duty cycle to increase slowly
4	GATE1	Linear Regulator Error Amplifier Output.
5	FB1	Linear Regulator Error Amplifier Inverting Input. When FB1 and GATE1 are tied together the Output Voltage = Vref
6-10	VID0-4	DAC inputs. Used to adjust the output voltage to the voltage required by the processor.
11	LVIN	Input for fixed linear regulator
12	LVOUT	2.5V fixed output from fixed linear regulator
13	COMP	PWM Loop Error Amplifier output.
14	FB	PWM Loop Voltage Feedback. Inverting input of Error Amplifier.
15	GND	Analog Ground.
16	PGOOD	Power good. This pin is pulled low when any of the regulator's output is not within the spec.
17	PHASE	Connect the PHASE pin to the upper MOSFET source. This pin is used to monitor the voltage drop across the MOSFET for over-current protection. This pin also provides the return path for the upper gate drive.
18	UGATE	Upper MOSFET gate driver
19	BOOT	Upper MOSFET bootstrap.
20	VCC	12V bias supply.
21	LGATE	Low MOSFET gate driver.
22	PGND	Power ground.
23	OVP	Over-voltage Protection. This pin drives an external SCR.
24	RT	Oscillator switching frequency adjust according to the following equations: $$F_S = 200kHz + \frac{3.5 \times 10^6 [KHz \times Kohm]}{R_T[Kohm]} \quad (R_T \text{ to GND})$$ $$F_S = 200kHz - \frac{3 \times 10^5 [KHz \times Kohm]}{R_T[Kohm]} \quad (R_T \text{ to 12V})$$

Absolute Maximum Ratings

Parameter	Min.	Max.
Power Input Voltage, Vin		6V
Supply Voltage Vcc		13.5V
Boot Voltage, V_{BOOT}-V_{PHASE}		13.5V
I/O Voltages	GND-0.3V	Vin+0.3V
ESD Classification		Class 2

Operating Conditions

Parameter	Min.	Max.
Supply Voltage	+12V -10%	+12+10%
Ambient Temperature	0°C	70°C
Junction Temperature	0°C	125°C

Thermal Information

Parameter	Conditions	Min.	Typ.	Max.
Thermal Resistance, Θ_{JA}	SOIC SSOP		80 89	°C/W
Maximum Junction Temperature				150°C
Storage Temperature		-65°C		150°C
Maximum Lead Temperature	Soldering 10 Seconds			300°C

Electrical Specifications

(V_{CC}=12V, F_{OSC}=200KHz and T_A=25°C using circuit in figure 1, unless otherwise noted)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
PWM Section						
VCC Supply Current						
Nominal Supply	I_{CC}	UGATE and LGATE Open	–	24	35	mA
Power-On Reset						
Rising VCC Threshold		V_{OCSET} = 4.5V	–	–	10.4	V
Falling VCC Threshold		V_{OCSET} = 4.5V	8.8	–	–	V
Rising V_{OCSET} Threshold			–	1.26	–	V
Oscillator						
Free Running Frequency	F_S	RT = OPEN	185	200	215	kHz
Ramp Amplitude	ΔV_{OSC}	RT = OPEN	–	1.9	–	V_{P-P}
Reference and DAC						
Input Voltage Setpoint		I_{LOAD} = 0.8A, V_{OUT}=2.000V VOUT=1.550V	1.980 1.534	2.000 1.550	2.020 1.566	V V
Error Amplifier						
DC Gain	A_{DC}		–	88	–	dB
Gain-Bandwidth Product	GBW		–	15	–	MHz
Slew Rate	SR	COMP = 10pF	–	6	–	V/µs

Electrical Specifications (continued)

(V_{CC}=12V, F_{OSC}=200KHz and T_A=25°C using circuit in figure 1, unless otherwise noted)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Gate Driver						
Upper Gate Source Current	I_{UGATE}	V_{BOOT} - V_{PHASE} = 12V		1	–	A
Lower Gate Source Current	I_{LGATE}	V_{CC} = 12V, V_{LGATE} = 6V		1	–	A
Protection						
Over-Voltage Trip (V_{SEN}/DACOUT)			–	115	120	%
OCSET Current Source	I_{OCSET}	V_{OCSET} = 4.5V_{DC}	170	200	230	µA
OVP Sourcing Current	I_{OVP}	V_{SEN} = 5.5V; V_{OVP} = 0V	60	–	–	mA
Soft Start Current	I_{SS}		–	10	–	µA
Power Good						
Upper Threshold (V_{SEN} /DACOUT)		V_{SEN} Rising	106	–	111	%
Lower Threshold (V_{SEN} /DACOUT)		V_{SEN} Falling	89	–	94	%
Hysteresis (V_{SEN} /DACOUT)		Upper and Lower Threshold	–	2	–	%
PGOOD Voltage Low	V_{PGOOD}	I_{PGOOD} = -5mA	–	0.5	–	V
Adjustable Linear Regulator						
Output Voltage		Set by external resistors	1.3			V
Output Voltage Precision		I_{LOAD} = 50 mAto 5.4A V_{CC} = 12V ± 10% T_A = 0 to 70°C	-2		+2	%
Under Voltage Level		Power good trigger point		60		%
Controller Output Current	GATE 1		20			mA
Output Transient Tolerance		50mA to 4.4 Amp Set by ESR of output caps	-135		135	mV
Bias Current	FB 1			1		µA
Feedback Voltage	FB 1			1.265		V
Fixed Linear Regulator						
Output Voltage	V_{OUT}	$I_{LOAD} \leq$ 100mA V_{CC} = 12V ± 10% V_{IN} = 5V	2.375	2.5	2.625	V
Under Voltage Level		Power good trigger point		60		%
Output Current	I_{OUT}	V_{CC} = 12V ± 10% V_{IN} = 5V	100			mA
Over Current Trip Point		V_{CC} = 12V ± 10% V_{IN} = 5V		150		mA
I_{SC} Foldback		V_{OUT} = 0		25		mA
Input Voltage	V_{IN}	V_{CC} = 12V ± 10%	4.75	5	5.25	V

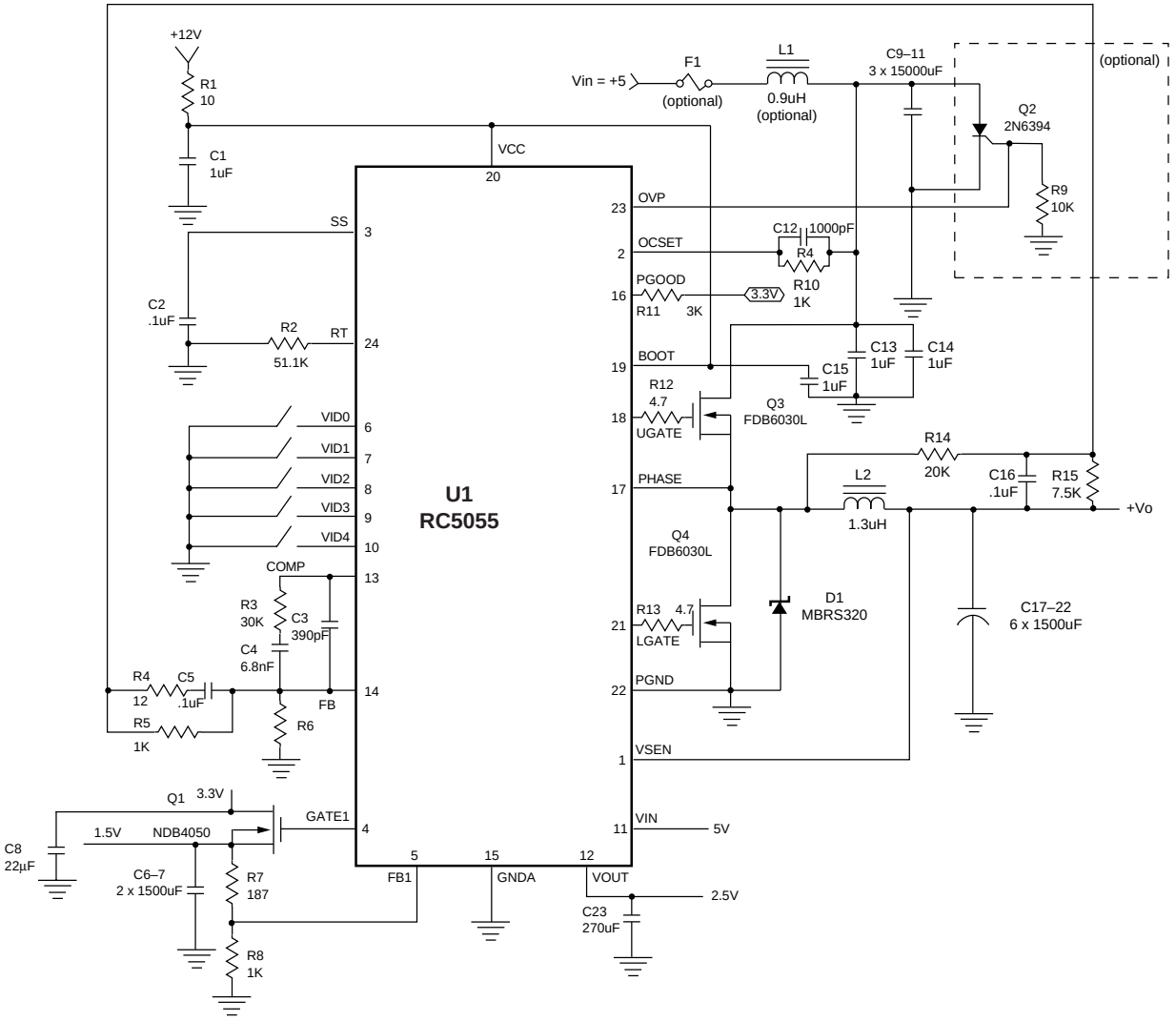


Figure 1. Deschutes 400MHz DC-DC Converter

Table 1. Deschutes 400MHz DC-DC Converter Bill of Materials

Item	Manufacturer Part #	Quantity	Description	Requirements/Comments
C1, C13–15	Any	4	1µF, 16V Capacitor	
C2, C5, C16	Any	3	100nF, 50V Capacitor	
C3	Any	1	390pF, 50V Capacitor	
C4	Any	1	6.8nF, 50V Capacitor	
C6–7, C17–22	Sanyo 6MV1500GX	8	1500µF, 6.3V Electrolytic	ESR ≤ 44MΩ
C8		1	22µF, 16V Capacitor	
C9–11	Sanyo 10MV1200GX	3	1200µF, 10V Electrolytic	I_{RMS} = 2A
C12	Any	1	1nF, 50V Capacitor	
C23	Sanyo 6MV270GX	1	270µF, 6.3V Electrolytic	
D1	Fairchild MBRS320L	1	3A, 20V Schottky Diode	
L1	Any	Optional	0.9µH inductor	See Note 1.
L2	Any	1	1.3µH inductor1.3µH	See Note 2.
Q1	Fairchild NDB4050	1	N-Channel MOSFET	
Q2	Motoraola 2N6394	1	SCR	
Q3–4	Fairchild FDB6030L	2	N-Channel MOSFET	$R_{DS(ON)}$ =20mΩ @ V_{GS} = 4.5V
R1	Any	1	10Ω	
R2	Any	1	51.1KΩ	
R3	Any	1	30.1KΩ	
R4	Any	1	12Ω	
R5, R8, R10	Any	3	1KΩ	
R6	Any	1		Used to adjust output voltage offset.
R7	Any	1	187Ω	
R9	Any	1	10KΩ	
R11	Any	1	3.01KΩ	
R12–13	Any	2	4.7Ω	
R14	Any	1	20KΩ	
R15	Any	1	7.5KΩ	
F1	Littelfuse	1	12A, 32V fast-acting fuse	
U1	Fairchild RC5055M	1	DC/DC Controller	

Notes:

1. 12 turns of 16AWG wire on mocrometals T60-2 core.
2. 9 turns of 16AWG wire on Micrometals T50-8/90 core.

Applications

Increasing the Clock Current

The RC5055 can produce as much as 100mA of current at 2.5V for powering the motherboard's clock chips. If additional current capability is required, an external PNP transistor may be used to enhance the current to 600mA or more, as shown in Figure 2. This circuit also provides a measure of current limit by letting the first 100mA of current be sourced through the 6.8Ω resistor, so that if too much collector, and thus base, current is demanded, the RC5055 cuts off the drive to the base.

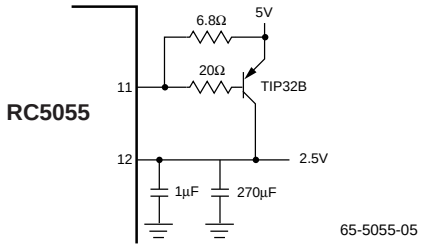


Figure 2. Boosting the Clock Current

Table 2. Output Voltage Table

PIN NAME					NOMINAL OUTPUT VOLTAGE	PIN NAME					NOMINAL OUTPUT VOLTAGE
VID4	VID3	VID2	VID1	VID0		VID4	VID3	VID2	VID1	VID0	
0	1	1	1	1	1.30	1	1	1	1	1	2.0
0	1	1	1	0	1.35	1	1	1	1	0	2.1
0	1	1	0	1	1.40	1	1	1	0	1	2.2
0	1	1	0	0	1.45	1	1	1	0	0	2.3
0	1	0	1	1	1.50	1	1	0	1	1	2.4
0	1	0	1	0	1.55	1	1	0	1	0	2.5
0	1	0	0	1	1.60	1	1	0	0	1	2.6
0	1	0	0	0	1.65	1	1	0	0	0	2.7
0	0	1	1	1	1.70	1	0	1	1	1	2.8
0	0	1	1	0	1.75	1	0	1	1	0	2.9
0	0	1	0	1	1.80	1	0	1	0	1	3.0
0	0	1	0	0	1.85	1	0	1	0	0	3.1
0	0	0	1	1	1.90	1	0	0	1	1	3.2
0	0	0	1	0	1.95	1	0	0	1	0	3.3
0	0	0	0	1	2.00	1	0	0	0	1	3.4
0	0	0	0	0	2.05	1	0	0	0	0	3.5

Note:

1. 0 = connected to GND or V_{SS}, 1 = OPEN

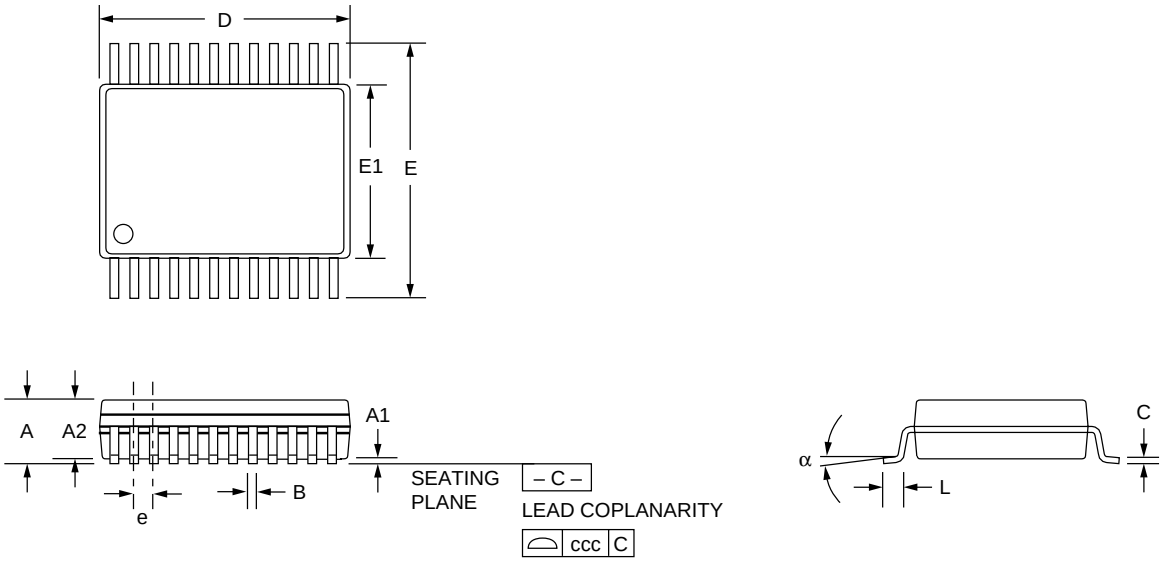
Package Dimensions

24-pin SSOP package

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.078	—	2.00	
A1	.002	—	0.05	—	
A2	.065	.073	1.65	1.85	
b	.010	.015	0.22	0.38	5
c	.0035	.010	0.09	0.25	5
D	.311	.335	7.90	8.50	2, 4
E	.291	.323	7.40	8.20	
E1	.197	.220	5.00	5.60	2
e	.026 BSC		0.65 BSC		
L	.022	.037	0.55	0.95	3
N	24		24		6
α	0°	8°	0°	8°	
ccc	—	.004	—	0.10	

Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .006 inch (0.15mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "b" and "c" dimensions include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.

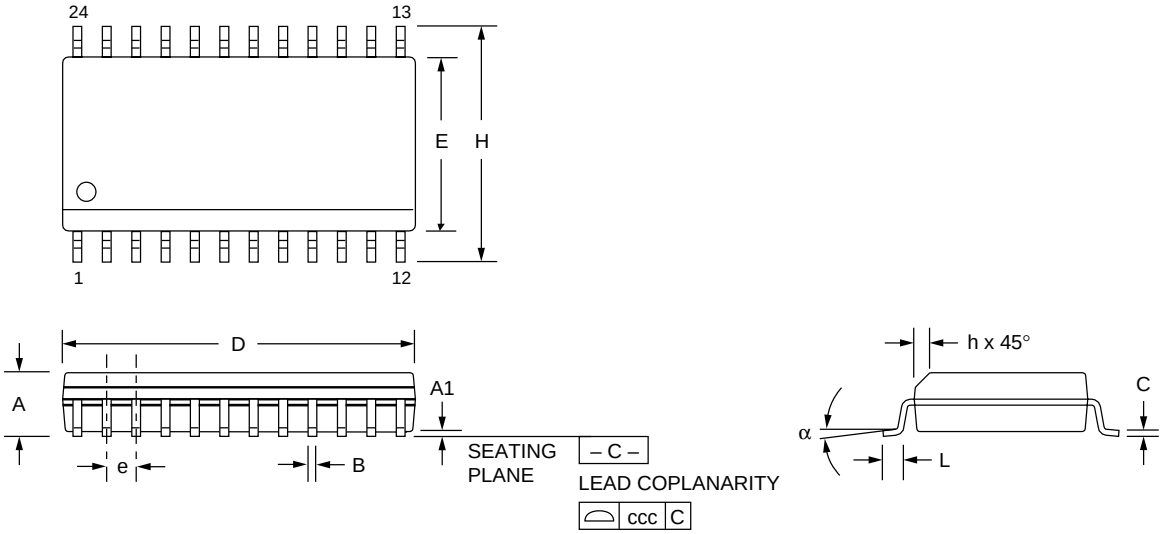


24-pin .300 mil SOIC package

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.093	.104	2.35	2.65	
A1	.004	.012	0.10	0.30	
B	.013	.020	0.33	0.51	
C	.009	.013	0.23	0.32	5
D	.599	.614	15.20	15.60	2
E	.290	.299	7.36	7.60	2
e	.050 BSC		1.27 BSC		
H	.394	.419	10.00	10.65	
h	.010	.020	0.25	0.51	
L	.016	.050	0.40	1.27	3
N	24		24		6
α	0°	8°	0°	8°	
ccc	—	.004	—	0.10	

Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.



Notes

Ordering Information

Product Number	Package
RC5055G	24 pin SSOP
RC5055M	24 pin SOIC