MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MC34063
MC35063
MC33063

3

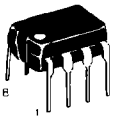
DC-TO-DC CONVERTER CONTROL CIRCUITS

The MC34063 Series is a monolithic control circuit containing the primary functions required for dc-to-dc converters. The device consists of an internal temperature compensated reference, comparator, controlled duty cycle oscillator with an active current limit circuit, driver and high current output switch. This series was specifically designed to be incorporated in Step-Down and Step-Up and Voltage-Inverting applications with a minimum number of external components.

- Operation from 2.5 V to 40 V Input
- Low Standby Current
- Current Limiting
- Output Switch Current of 1.5 A
- Output Voltage Adjustable from 1.25 to 40 V
- Frequency of Operation to 100 kHz

DC-TO-DC CONVERTER CONTROL CIRCUITS

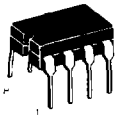
SILICON MONOLITHIC INTEGRATED CIRCUITS



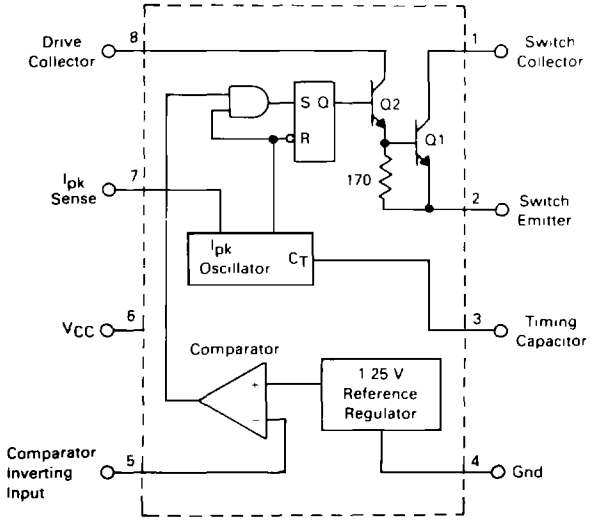
P1 SUFFIX
PLASTIC PACKAGE
CASE 626

"NOT FOR NEW DESIGN-INS"

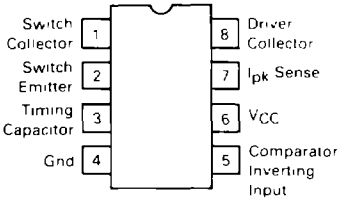
U SUFFIX
CERAMIC PACKAGE
CASE 693



FUNCTIONAL BLOCK DIAGRAM



PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

Device	Temperature Range	Package
MC35063U	−55 to +125°C	Ceramic DIP
MC33063U	−40 to +85°C	Ceramic DIP
MC33063P1		Plastic DIP
MC34063U	0 to +70°C	Ceramic DIP
MC34063P1		Plastic DIP

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{CC}	40	Vdc
Comparator Input Voltage Range	V_{IR}	−0.3 to +40	Vdc
Switch Collector Voltage	$V_{C(switch)}$	40	Vdc
Switch Emitter Voltage	$V_{E(switch)}$	40	Vdc
Switch Collector to Emitter Voltage	$V_{CE(switch)}$	40	Vdc
Driver Collector Voltage	$V_{C(driver)}$	40	Vdc
Switch Current	I_{SW}	1.5	Amps
Power Dissipation and Thermal Characteristics Ceramic Package T_A = +25°C Derate above T_A = +25°C Plastic Package T_A = +25°C Derate above T_A = +25°C	 P_D $1/\theta JA$ P_D $1/\theta JA$	 1.25 10 1.0 10	 W mW/°C W mW/°C
Operating Junction Temperature Ceramic Package Plastic Package	T_J	 +150 +125	°C
Operating Ambient Temperature Range MC35063 MC33063 MC34063	T_A	 −55 to +125 −40 to +85 0 to +70	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, T_A = T_{low} to T_{high} [Note 1] unless otherwise specified.)

Characteristic	Symbol	Min	Typ	Max	Unit
OSCILLATOR					
Charging Current (5.0 V ≤ V_{CC} ≤ 40 V, T_A = 25°C)	I_{chg}	20	35	50	μA
Discharge Current (5.0 V ≤ V_{CC} ≤ 40 V, T_A = 25°C)	I_{dischg}	150	200	250	μA
Voltage Swing (T_A = 25°C)	V_{osc}	—	0.5	—	V_{p-p}
Discharge to Charge Current Ratio ($I_{pk(sense)}$ = V_{CC}, T_A = 25°C)	I_{dischg}/I_{chg}	—	6.0	—	—
Current Limit Sense Voltage I_{chg} = I_{dischg}, T_A = 25°C	$V_{ipk(sense)}$	250	300	350	mV
OUTPUT SWITCH (Note 2)					
Saturation Voltage, Darlington Connection I_{SW} = 1.0 A, $V_{C(driver)}$ = $V_{C(switch)}$	$V_{CE(sat)}$	—	1.0	1.3	V
Saturation Voltage I_{SW} = 1.0 A, $I_{C(driver)}$ = 50 mA, (Forced β = 20)	$V_{CE(sat)}$	—	0.45	0.7	V
DC Current Gain I_{SW} = 1.0 A, V_{CE} = 5.0 V, T_A = 25°C	h_{FE}	35	120	—	—
Collector Off-State Current (V_{CE} = 40 V, T_A = 25°C)	$I_{C(off)}$	—	10	—	nA
COMPARATOR					
Threshold Voltage	V_{th}	1.18	1.25	1.32	V
Threshold Voltage Line Regulation (3.0 V ≤ V_{CC} ≤ 40 V)	Reg_{line}	—	0.04	0.2	mV/V
Input Bias Current (V_{in} = 0 V)	I_{IB}	—	40	400	nA
TOTAL DEVICE					
Supply Current 5.0 V ≤ V_{CC} ≤ 40 V, C_T = 0.001 μF $I_{pk(sense)}$ = V_{CC}, V pin 5 > V_{th}, Pin 2 = Gnd, Remaining pins open	I_{CC}	—	2.4	3.5	mA

NOTES:

1. T_{low} = −55°C for MC35063, −40°C for MC33063, 0°C for MC34063; T_{high} = +125°C for MC35063, +85°C for MC33063, +70°C for MC34063
2. Output switch tests are performed under pulsed conditions to minimize power dissipation

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FIGURE 1 — OUTPUT SWITCH ON-OFF TIME versus OSCILLATOR TIMING CAPACITOR

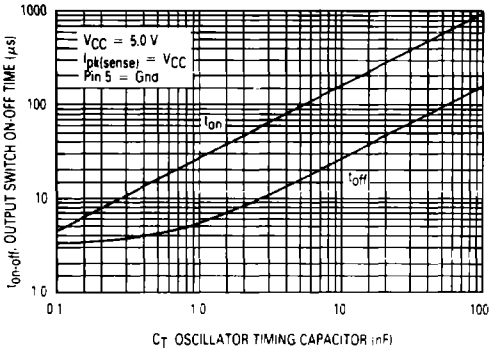


FIGURE 2 — STANDBY SUPPLY CURRENT versus SUPPLY VOLTAGE

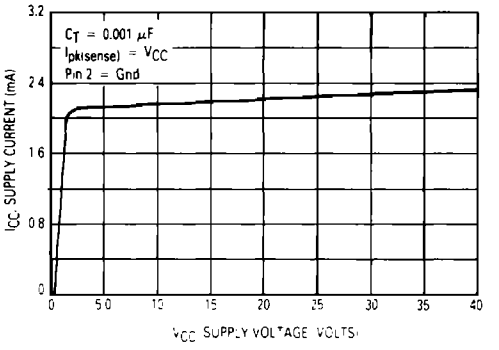


FIGURE 3 — EMITTER-FOLLOWER CONFIGURATION OUTPUT SWITCH SATURATION VOLTAGE versus EMITTER CURRENT

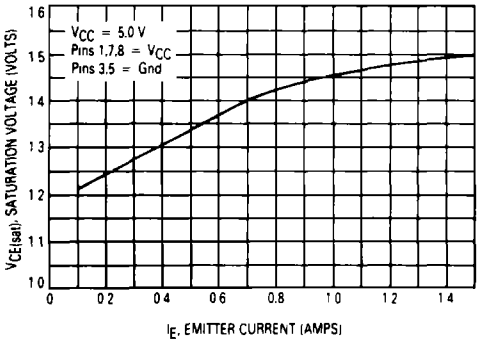


FIGURE 4 — COMMON-EMITTER CONFIGURATION OUTPUT SWITCH SATURATION VOLTAGE versus COLLECTOR CURRENT

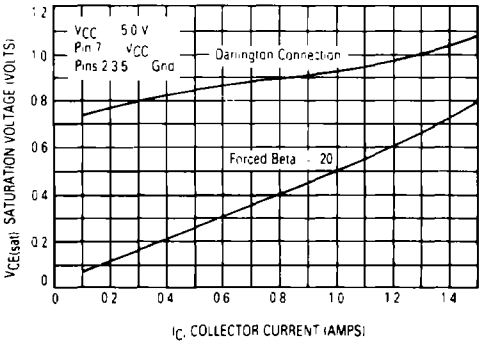
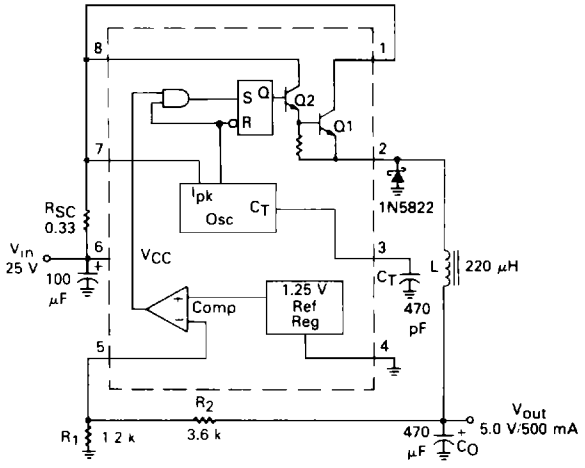


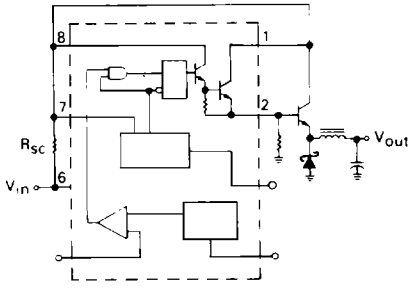
FIGURE 5 — STEP-DOWN CONVERTER



Test	Conditions	Results
Line Regulation	V_{in} = 15 to 25 V, I_O = 500 mA	15 mV
Load Regulation	V_{in} = 25 V, I_O = 50 to 500 mA	5.0 mV
Output Ripple	V_{in} = 25 V, I_O = 500 mA	40 mV_{p-p}
Short Circuit Current	V_{in} = 25 V, R_L = 0.1 Ω	2.3 A
Efficiency	V_{in} = 25 V, I_O = 500 mA	84.7%

FIGURE 6 — EXTERNAL CURRENT BOOST CONNECTIONS FOR I_C PEAK GREATER THAN 1.5 A

6A — EXTERNAL NPN SWITCH



6B — EXTERNAL PNP SATURATED SWITCH

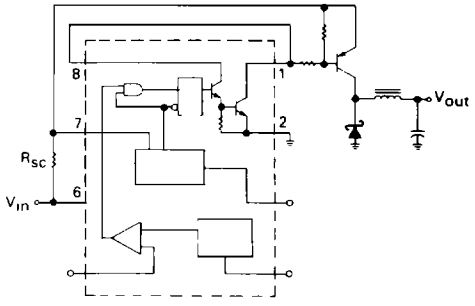


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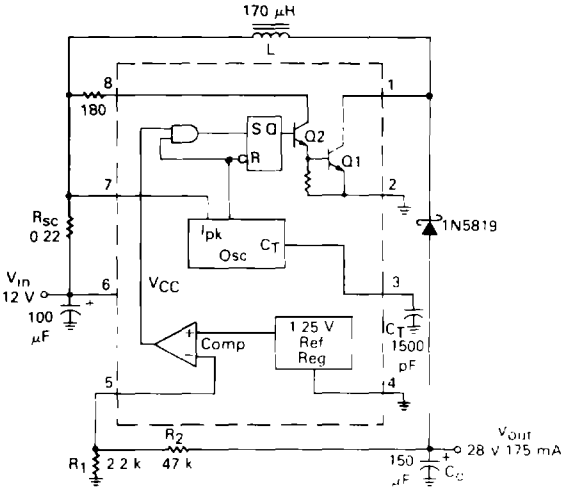
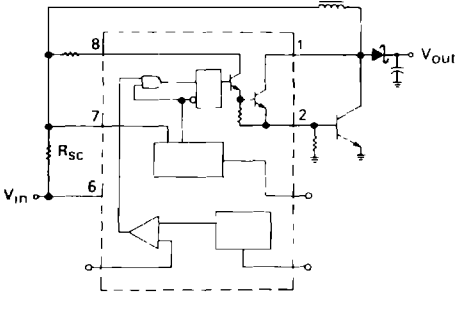
FIGURE 7 — STEP-UP CONVERTER



Test	Conditions	Results
Line Regulation	V_{in} = 8.0 to 16 V, I_O = 175 mA	12 mV
Load Regulation	V_{in} = 12 V, I_O = 75 to 175 mA	45 mV
Output Ripple	V_{in} = 12 V, I_O = 175 mA	150 mV_{p-p}
Efficiency	V_{in} = 12 V, I_O = 175 mA	93%

FIGURE 8 — EXTERNAL CURRENT BOOST CONNECTIONS FOR I_C PEAK GREATER THAN 1.5 A

8A — EXTERNAL NPN SWITCH



8B — EXTERNAL NPN SATURATED SWITCH

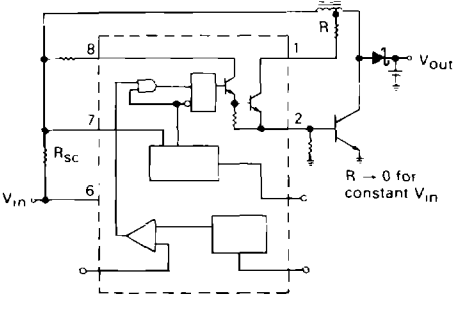


FIGURE 9 — DESIGN FORMULA TABLE

Calculation	Step-Down	Step-Up
$\frac{t_{on}}{t_{off}}$	$\frac{V_{out} + V_F}{V_{in(min)} - V_{sat} - V_{out}}$	$\frac{V_{out} + V_F - V_{in(min)}}{V_{in(min)} - V_{sat}}$
$(t_{on} + t_{off})_{max}$	$\frac{1}{f_{min}}$	$\frac{1}{f_{min}}$
C_T	$4 \times 10^{-5} t_{on}$	$4 \times 10^{-5} t_{on}$
$I_{pk(switch)}$	$2I_{out(max)}$	$2I_{out(max)} \left(\frac{t_{on}}{t_{off}} + 1\right)$
R_{SC}	$0.33/I_{pk(switch)}$	$0.33/I_{pk(switch)}$
$L_{(min)}$	$\left(\frac{V_{in(min)} - V_{sat} - V_{out}}{I_{pk(switch)}}\right) t_{on(max)}$	$\left(\frac{V_{in(min)} - V_{sat}}{I_{pk(switch)}}\right) t_{on(max)}$
C_o	$\frac{I_{pk(switch)} (t_{on} + t_{off})}{8 V_{ripple(p-p)}}$	$\approx \frac{I_{out} t_{on}}{V_{ripple(p-p)}}$

V_{sat} = Saturation voltage of the output switch
V_F = Forward voltage drop of the ringback rectifier

The following power supply characteristics must be chosen:

V_{in} — Nominal input voltage. If this voltage is not constant, then use $V_{in(max)}$ for step-down and $V_{in(min)}$ for step-up converter.

V_{out} — Desired output voltage, $V_{out} = 1.25 \left(1 + \frac{R_2}{R_1}\right)$.

I_{out} — Desired output current.

f_{min} — Minimum desired output switching frequency at the selected values for V_{in} and I_o.

$V_{ripple(p-p)}$ — Desired peak-to-peak output ripple voltage. In practice, the calculated value will need to be increased due to the capacitor's equivalent series resistance and board layout. The ripple voltage should be kept to a low value since it will directly effect the line and load regulation.

Note: For further information refer to application note AN920 Rev. 2.