

# Variable Frequency Micropower Step-up DC-DC Converter

The MC33468 is a micropower step-up switching voltage regulator, specifically designed for handheld and pager applications, to provide a regulated output voltage using a minimum of external parts. This device features a quiescent bias current of 3.0  $\mu$ A typical.

The MC33468 features a highly accurate voltage reference, an error amplifier, an oscillator, a variable frequency modulation (VFM) controller, a drive pin (EXT) for an external transistor, and feedback resistors.

The Vout pin is fixed at 2V in the IC. The output of the converter with an inductor, a diode, a capacitor, a drive transistor, and feed-back resistors can have an output of 30V.

### MC33468 Features:

- Low Quiescent Bias Current of 3.0  $\mu$ A
- High Output Voltage Accuracy of  $\pm 2.5\%$
- Low Startup Voltage of 0.8 V at No Load
- Output Voltage Set With External Resistors
- Operating Temperature Range:  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- Surface Mount Package

### ORDERING INFORMATION

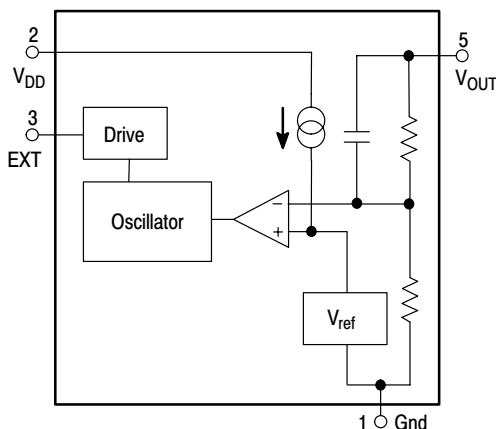
Device	Output Voltage	Marking	Reel Size	Tape Width	Quantity
MC33468SN-20ATR	2.0	0KXX*	7"	8 mm	3000

\* "XX" denotes the lot number.

### PIN DESCRIPTION

Pin No.	Symbol	Description
1	GND	Ground
2	V <sub>DD</sub>	Input
3	EXT	External Transistor Drive
4	NC	No Connection
5	V <sub>OUT</sub>	Voltage Output Pin (Fixed at 2V)

### Representative Block Diagram



# MC33468

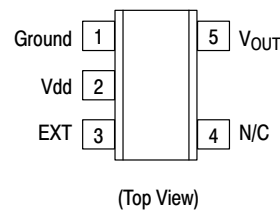
## VARIABLE FREQUENCY MICROPOWER DC-to-DC CONVERTER

### SEMICONDUCTOR TECHNICAL DATA



**N SUFFIX**  
PLASTIC PACKAGE  
CASE 1212  
(SOT-23-5)

### PIN CONNECTIONS



# MC33468

## MAXIMUM RATINGS (T<sub>C</sub> = 25°C, unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Supply Voltage (Transient)	V <sub>DD</sub>	12	V
Power Supply Voltage (Operating)	V <sub>DD</sub>	10	V
External Pin Voltage	V <sub>EXT</sub>	-0.3 to V <sub>DD</sub> + 0.3	V
EXT Pin Source/Sink Current	I <sub>EXT</sub>	50/50	mA
Power Dissipation and Thermal Characteristics N Suffix, Plastic Package Case 1212 (SOT-23-5) Maximum Power Dissipation @ T <sub>A</sub> = 250°C Thermal Resistance, Junction-to-Air	P <sub>D</sub> R <sub>θJA</sub>	150 667	mW °C/W
Operating Junction Temperature	T <sub>J</sub>	125	°C
Operating Ambient Temperature	T <sub>A</sub>	-40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +125	°C

## ELECTRICAL CHARACTERISTICS (V<sub>DD</sub> = 1.9 V, T<sub>A</sub> = 25°C, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit	Note <sup>1</sup>
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### OSCILLATOR

Frequency	f <sub>osc</sub>	-	180	-	kHz	B
Oscillator Minimum Supply Voltage (I <sub>O</sub> = 0 mA)	V <sub>DD</sub>	-	0.7	0.8	V	B
Oscillator Duty Cycle	D	65	75	-	%	B

### EXT OUTPUT

ON State Source Current (V <sub>EXT</sub> = GND)	I <sub>source</sub>	1.5	-	-	mA	C
OFF State Sink Current (V <sub>EXT</sub> = 1.9 V)	I <sub>sink</sub>	1.5	-	-	mA	D

### TOTAL DEVICE

Output Voltage	V <sub>OUT</sub>	1.950	2.000	2.050	V	
Quiescent Bias Current (V <sub>OUT</sub> = 1.9 V, I <sub>O</sub> = 0 mA)	I <sub>Q</sub>	-	15	25	μA	A
Quiescent Bias Current (V <sub>OUT</sub> = 2.1 V, I <sub>O</sub> = 0 mA)	I <sub>Q</sub>	-	3.0	5.0	μA	A
Internal Resistor (V <sub>OUT</sub> to GND)	R <sub>Vout</sub>	2.0	-	-	MΩ	
Output Voltage Temperature Coefficient I <sub>OUT</sub> = 10 mA, -40°C ≤ T <sub>A</sub> ≤ 85°C	$\frac{\Delta V_{OUT}}{\Delta T_A}$	-	±50	-	ppm/oc	E

1. Indicates test circuits shown on next page.

Figure 1. Output Voltage versus Output Current

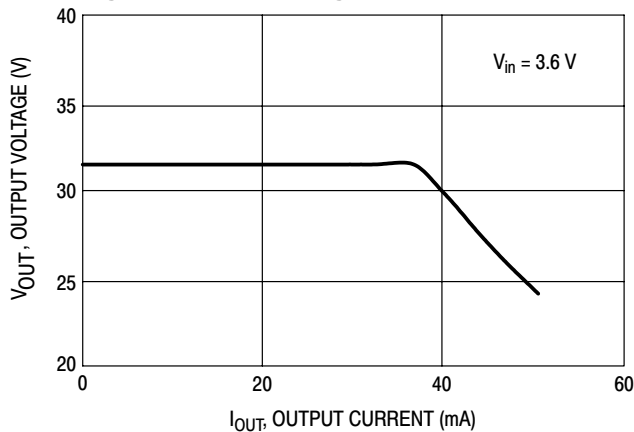
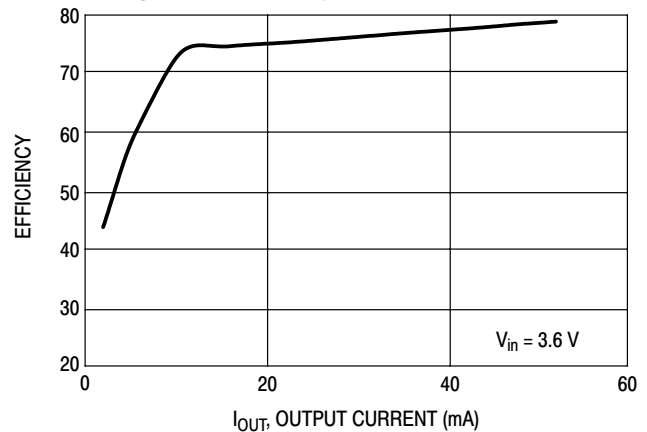


Figure 2. Efficiency versus Output Current



# MC33468

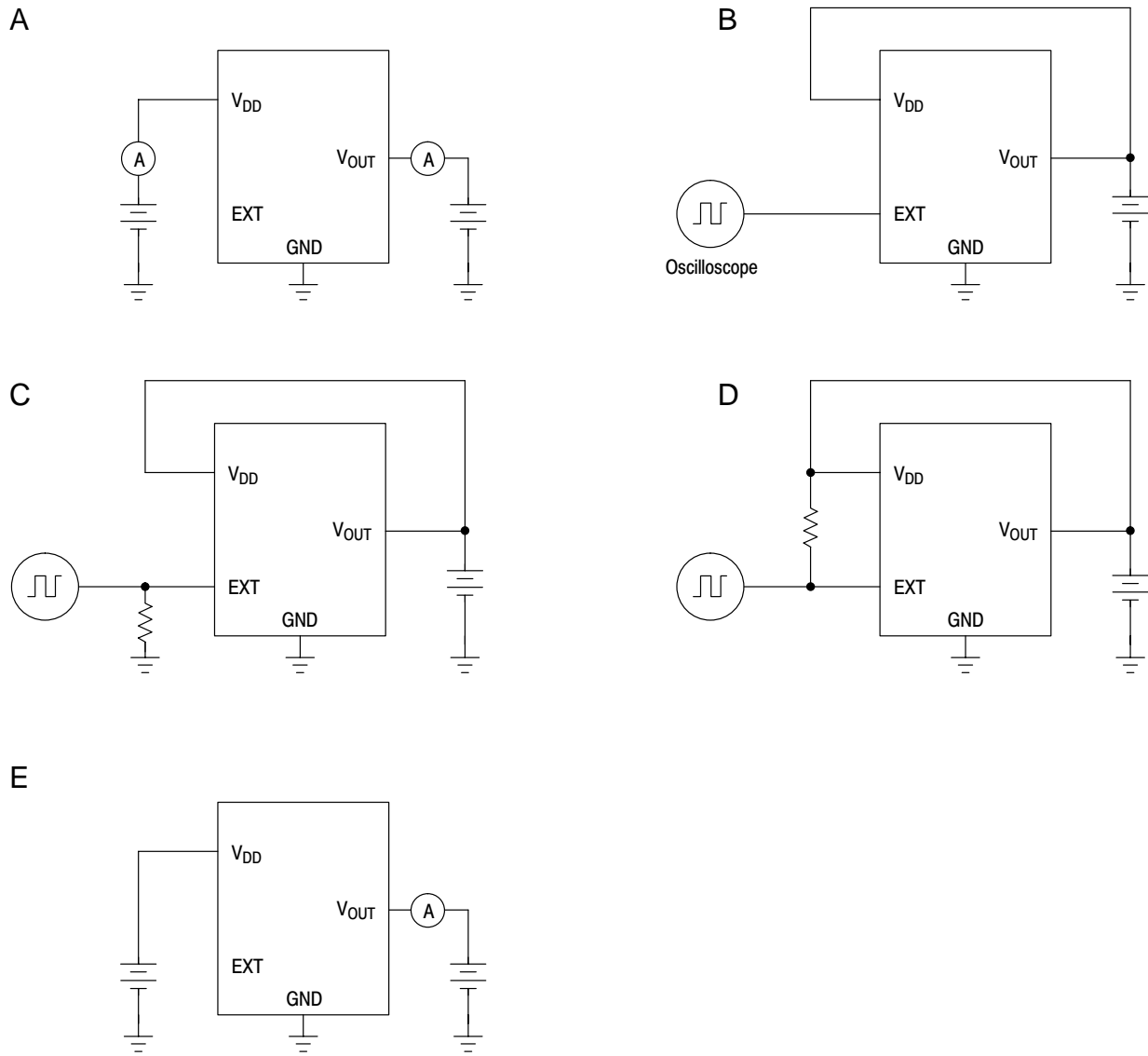


Figure 3. Test Circuit Schematics

**DEFINITIONS**

**Quiescent Bias Current** – Current which is used to operate the switching regulator chip and is not delivered to the load.

**Leakage Current** – Current drawn through a transistor junction, under a specified collector voltage, when the transistor is off.

**FUNCTIONAL DESCRIPTION**

**Introduction**

The MC33468 is a monolithic power switching regulator optimized for dc-to-dc converter applications where power drain must be minimized. The MC33468 uses Variable Frequency Modulation to step up the input DC voltage to a higher accurate output voltage. Potential applications include low power consumer products and battery powered portable products. Typical application circuits are shown in Figure 4.

**Operating Description**

The MC33468 converter operates as a fixed on-time, variable off-time voltage mode ripple regulator. Operation is intended to be in the discontinuous mode, where the inductor current ramps up to a peak value which is greater than or equal to twice the value of the dc input current during

the on-time of the transistor switch. During the off-time of the transistor switch, the inductor current ramps down to zero and remains at zero until another switching cycle begins.

Since the V<sub>DD</sub> pin is connected to the input no external startup circuit is needed.

**Oscillator**

The oscillator frequency, is internally programmed to 180 kHz. The duty ratio of the oscillator is designed for a constant value of 0.75 nominal. Hence the nominal on-time of the power switch is:

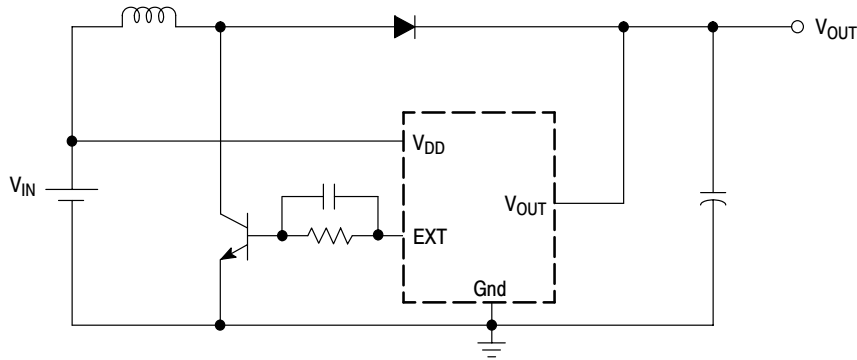
$$t_{on} = \frac{D}{f_{osc}} = \frac{0.75}{(180 \text{ kHz})} = 4.16 \mu\text{s}$$

**Feedback Comparator**

The output voltage is sensed and fed to a high speed comparator noninverting input through an internal resistive divider. The comparator inverting input is connected to an internally trimmed reference.

With a voltage mode ripple converter operating under normal conditions, output switch conduction is initiated and terminated by the oscillator, off-time is controlled by the high speed voltage feedback comparator.

**Figure 4. Typical 2.0 V Application with BJT**



**Figure 5. Design Equations for Step-Up**

Calculation	Equation
$t_{on}$	$\frac{D}{f_{osc}}$
$L$	$< \frac{(n)(V_{in})^2(t_{on})}{P_O}$
$I_{L(avg)}$	$I_{in}$
$I_{L(pk)}$	$\frac{(V_{in} - V_{sat})(t_{on})}{L}$
$V_{ripple(pp)}$	$\approx \frac{(t_{on})(I_O)}{(C_O)}$

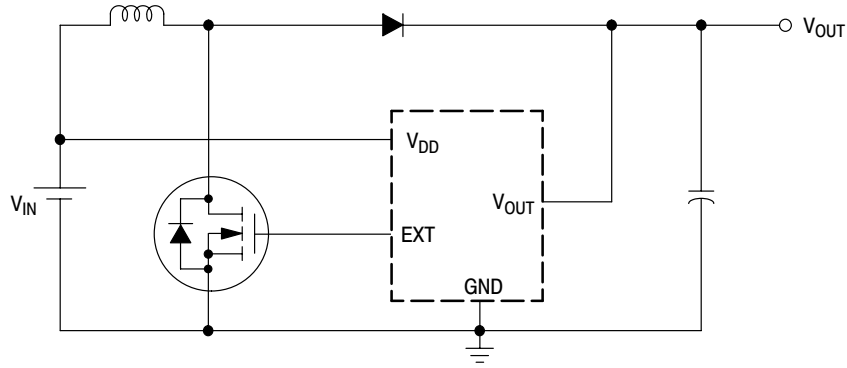
**The following converter design characteristics must be chosen:**

- V<sub>in</sub> – Nominal Operating dc input voltage
- V<sub>O</sub> – Desired dc output voltage
- I<sub>O</sub> – Desired dc output current
- V<sub>ripple(pp)</sub> – Desired peak-to-peak output ripple voltage. For best performance the ripple voltage should be kept to a low value since it directly affects regulation. Capacitor C<sub>O</sub> should have a low equivalent series resistance (ESR).

**NOTE:** 1. V<sub>sat</sub> – Saturation voltage of the switching transistor.  
n – Estimated circuit efficiency.

# MC33468

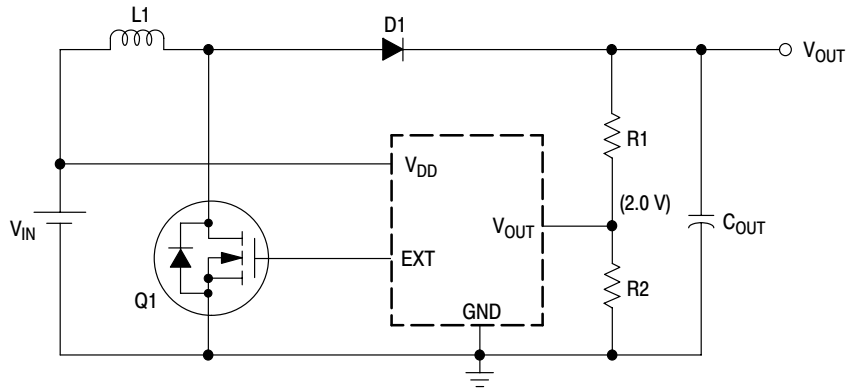
**Figure 6. Typical 2.0 V Application with MOSFET**



If input voltage is high enough, higher efficiency may be obtained by using a MOSFET as the switch transistor, in which no gate resistor or capacitor is needed.

MOSFET and BJT voltage rating ( $V_{DS}$  and  $V_{CE}$ ) should be high enough to allow for spikes in voltage.

**Figure 7. Typical Application for Output Voltages Over 2.0 V**



Inductor (L1)	CD54 (15 $\mu$ H)
Diode (D1)	MBRD540T1
Capacitor (C <sub>OUT</sub> )	47 $\mu$ F (Tantalum type)
Transistor (Q1)	MMFT3055VL
Resistor (R1)	150 k $\Omega$
Resistor (R2)	10 k $\Omega$

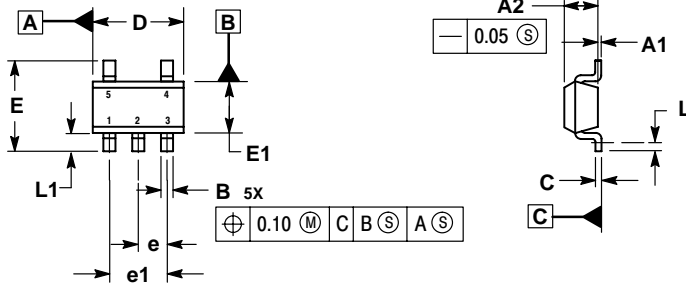
When choosing the output capacitor, ensure that the capacitor voltage is higher than  $V_{out}$ . Select an inductor with low DC resistance and high saturation. A Schottky diode is recommended for a lower voltage drop and faster switching.

Use external resistors that are much smaller resistance than the resistance internal to the IC (minimum of 2 M $\Omega$ ). When R1 is much less than the internal resistance, the error is minimized.

# MC33468

## PACKAGE DIMENSIONS

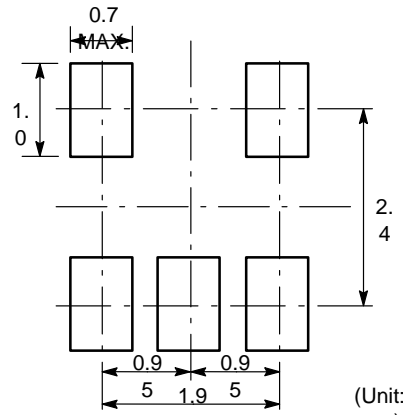
**N SUFFIX**  
 PLASTIC PACKAGE  
 CASE 1212-01  
 (SOT-23)  
 ISSUE O



- NOTES:
1. DIMENSIONS ARE IN MILLIMETERS.
  2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
  3. DATUM C IS A SEATING PLANE.

MILLIMETERS		
DIM	MIN	MAX
A1	0.00	0.10
A2	1.00	1.30
B	0.30	0.50
C	0.10	0.25
D	2.80	3.00
E	2.50	3.10
E1	1.50	1.80
e	0.95 BSC	
e1	1.90 BSC	
L	0.20	---
L1	0.45	0.75

## Recommended Footprint for Surface Mount Applications



**SOT-23-5**

(Unit: mm)

**Notes**

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