Integrated Circuits

LMR64010 PRESENTATION

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LMR64010 SIMPLE SWITCHER

- The LMR64010 switching regulators is a current-mode boost converter operating at a fixed frequency of 1.6 MHz.

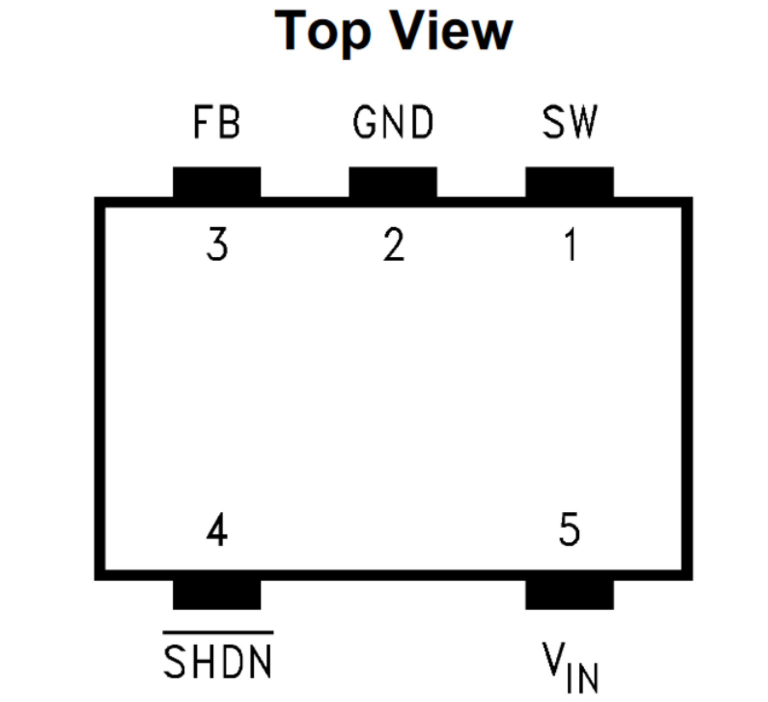
LMR64010 SIMPLE SWITCHER

- Input Voltage Range of 2.7V to 14V
- Output Voltage up to 40V
- Switch Current up to 1A
- 1.6 MHz Switching Frequency
- Low Shutdown Iq, <1 µA
- Great Efficiency up to 90%

DESCRIPTION

- It has a logic-level shutdown pin that can be used to reduce quiescent current and extend battery life.
- The use of SOT-23 package, made possible by the minimal power loss of the internal 1A switch, and use of small inductors and capacitors result in the industry's highest power density. The 40V internal switch makes these solutions perfect for boosting to voltages of 16V or greater.

PIN DESCRIPTIONS



Pin	Name	Function
1	SW	Drain of the internal FET switch.
2	GND	Analog and power ground.
3	FB	Feedback point that connects to external resistive divider
4	SHDN	Shutdown control input.
5	Vin	Analog and power input.

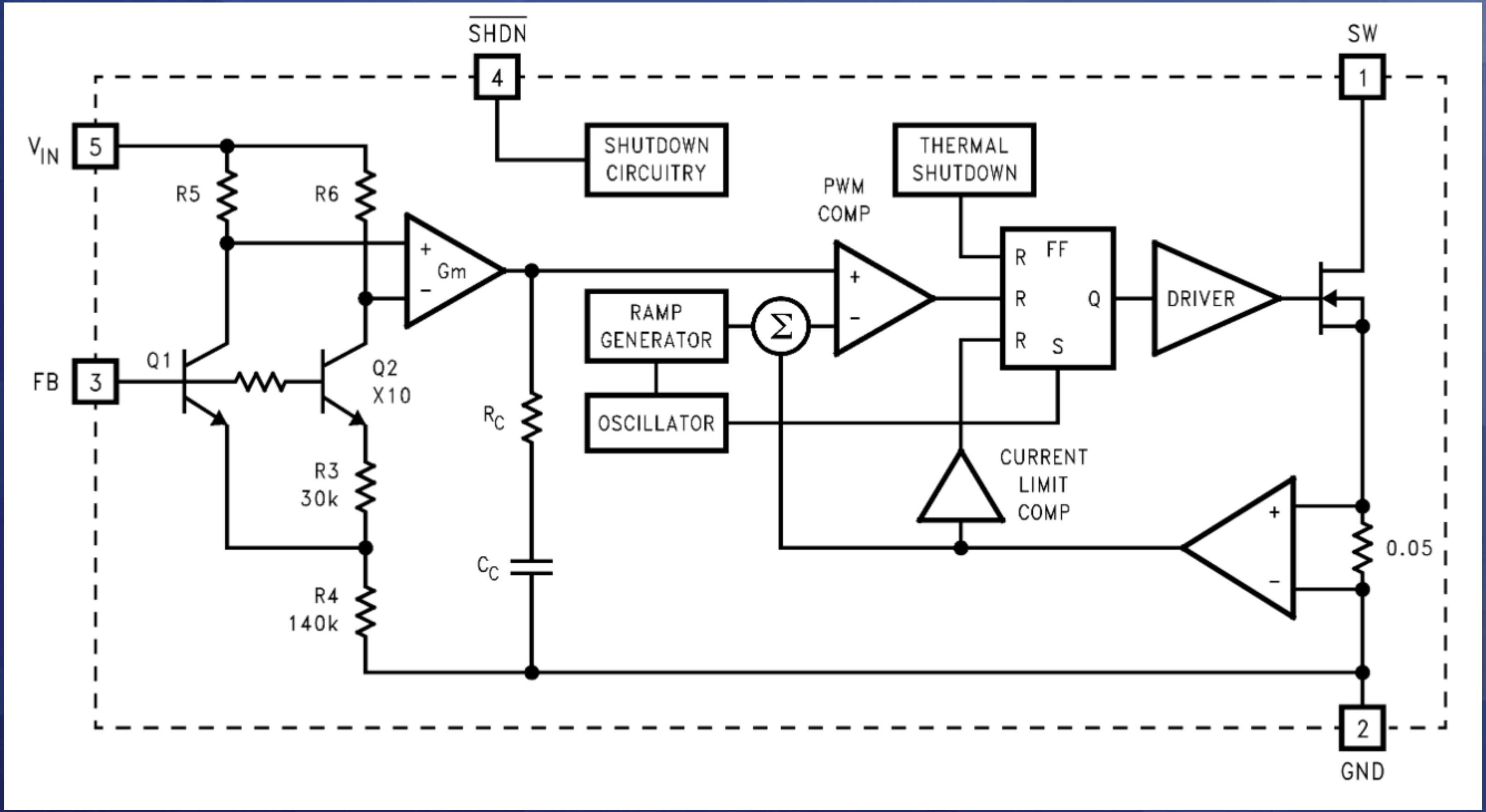
Absolute Maximum Ratings

Storage Temperature Range	−65°C to +150°C
Operating Junction Temperature Range	−40°C to +125°C
Lead Temp. (Soldering, 5 sec.)	300°C
Power Dissipation(3)	Internally Limited
FB Pin Voltage	−0.4V to +6V
SW Pin Voltage	−0.4V to +40V
Input Supply Voltage	−0.4V to +14.5V
SHDN Pin Voltage	−0.4V to VIN + 0.3V
θJ-A (SOT-23-5)	265°C/W

Electrical Characteristics

Parameter		Test Conditions	Min	Typ	Max	Units
V_{IN}	Input Voltage		2.7		14	V
$SHDN_{TH}$	Shutdown Threshold	$V_{SHDN} = 0$		0		
		$V_{SHDN} = 5V$		0	2	µA
V_{FB}	Feedback Pin Reference Voltage	$V_{IN} = 3V$	1.205	1.230	1.255	V
I_{FB}	Feedback Pin Bias Current	$V_{FB} = 1.23V$		60		nA
I_Q	Quiescent Current	$V_{SHDN} = 5V$, Switching		2.1	3	mA
		$V_{SHDN} = 5V$, Not Switching		400	500	µA
		$V_{SHDN} = 0$		0.024	1	
D_{MAX}	Maximum Duty Cycle		87	93		%

Block Diagram



Theory of Operation

The LMR64010 is a switching converter IC that operates at a fixed frequency (1.6 MHz) using current-mode control for fast transient response over a wide input voltage range and incorporates pulse-by pulse current limiting protection. Because this is current mode control, a 50 mΩ sense resistor in series with the switch FET is used to provide a voltage (which is proportional to the FET current) to both the input of the pulse width modulation (PWM) comparator and the current limit amplifier.

Theory of Operation

At the beginning of each cycle, the S-R latch turns on the FET. As the current through the FET increases, a voltage (proportional to this current) is summed with the ramp coming from the ramp generator and then fed into the input of the PWM comparator. When this voltage exceeds the voltage on the other input (coming from the Gm amplifier), the latch resets and turns the FET off. Since the signal coming from the Gm amplifier is derived from the feedback (which samples the voltage at the output), the action of the PWM comparator constantly sets the correct peak current through the FET to keep the output volatge in regulation.

Theory of Operation

Q1 and Q2 along with R3 - R6 form a bandgap voltage reference used by the IC to hold the output in regulation. The currents flowing through Q1 and Q2 will be equal, and the feedback loop will adjust the regulated output to maintain this. Because of this, the regulated output is always maintained at a voltage level equal to the voltage at the FB node "multiplied up" by the ratio of the output resistive divider. The current limit comparator feeds directly into the flip-flop, that drives the switch FET. If the FET current reaches the limit threshold, the FET is turned off and the cycle terminated until the next clock pulse. The current limit input terminates the pulse regardless of the status of the output of the PWM comparator.

SELECTING THE EXTERNAL CAPACITORS

- The best capacitors for use with the LMR64010 are multi-layer ceramic capacitors. They have the lowest ESR (equivalent series resistance) and highest resonance frequency which makes them optimum for use with high frequency switching converters.

- When selecting a ceramic capacitor, only X5R and X7R dielectric types should be used. Other types such as Z5U and Y5F have such severe loss of capacitance due to effects of temperature variation and applied voltage, they may provide as little as 20% of rated capacitance in many typical applications. Always consult capacitor manufacturer's data curves before selecting a capacitor.

SELECTING THE OUTPUT CAPACITOR

A single ceramic capacitor of value 4.7 μF to 10 μF will provide sufficient output capacitance for most applications. For output voltages below 10V, a 10 μF capacitance is required. If larger amounts of capacitance are desired for improved line support and transient response, tantalum capacitors can be used in parallel with the ceramics. Aluminum electrolytics with ultra low ESR such as Sanyo Oscon can be used, but are usually prohibitively expensive. Typical Al electrolytic capacitors are not suitable for switching frequencies above 500 kHz due to significant ringing and temperature rise due to self-heating from ripple current. An output capacitor with excessive ESR can also reduce phase margin and cause instability.

SELECTING DIODES

The external diode used in the typical application should be a Schottky diode. If the switch voltage is less than 15V, a 20V diode such as the MBR0520 is recommended. If the switch voltage is between 15V and 25V, a 30V diode such as the MBR0530 is recommended. If the switch voltage exceeds 25V, a 40V diode such as the MBR0540 should be used. The MBR05XX series of diodes are designed to handle a maximum average current of 0.5A. For applications exceeding 0.5A average but less than 1A, a Toshiba CRS08 can be used.

SETTING THE OUTPUT VOLTAGE

The output voltage is set using the external resistors R1 and R2. A value of approximately 13.3 kΩ is recommended for R2 to establish a divider current of approximately 92 μA. R1 is calculated using the formula:

$$R1 = R2 \times (VOUT/1.23 - 1)$$

DUTY CYCLE

The equation shown for calculating duty cycle incorporates terms for the FET switch voltage and diode forward voltage. The actual duty cycle measured in operation will also be affected slightly by other power losses in the circuit such as wire losses in the inductor, switching losses, and capacitor ripple current losses from self-heating. Therefore, the actual (effective) duty cycle measured may be slightly higher than calculated to compensate for these power losses. A good approximation for effctive duty cycle is :

$$DC(eff) = (1 - Efficiency \times (VIN/VOUT))$$

INDUCTANCE VALUE

The first question we are usually asked is: "How small can I make the inductor?". The answer is not simple and involves tradeoffs in performance. Larger inductors mean less inductor ripple current, which typically means less output voltage ripple. Larger inductors also mean more load power can be delivered because the energy stored during each switching cycle is:

$$E = L/2 \times (Ip)2$$

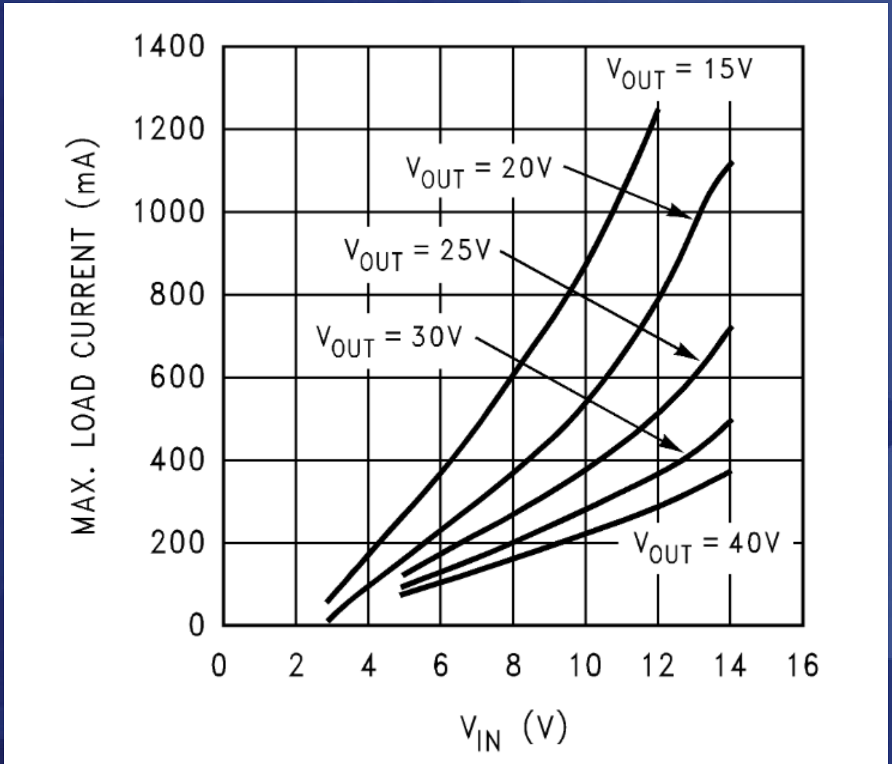
where "Ip" is the peak inductor current.

The LMR64010 will limit its switch current based on peak current. This means that since Ip(max) is fixed, increasing L will increase the maximum amount of power available to the load. Conversely, using too little inductance may limit the amount of load current which can be drawn from the output.

Using the following equation we can calculate the inductance value for a given input voltage (Vin):

$$Vin = L\,(di/dt)$$

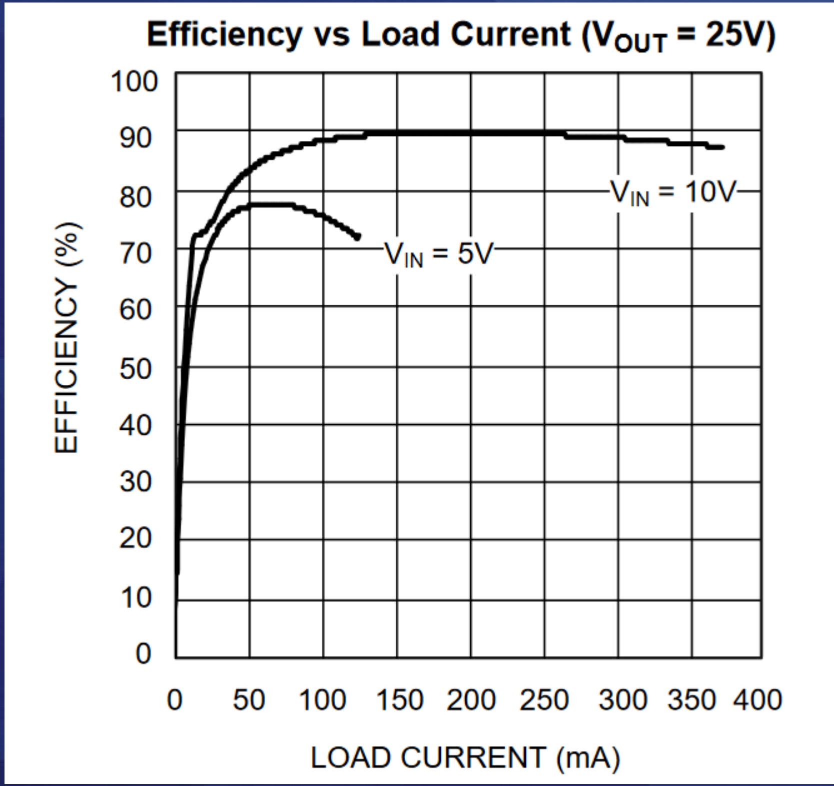
CALCULATING LOAD CURRENT



We can develop an expression which allows the maximum available load current to be calculated:

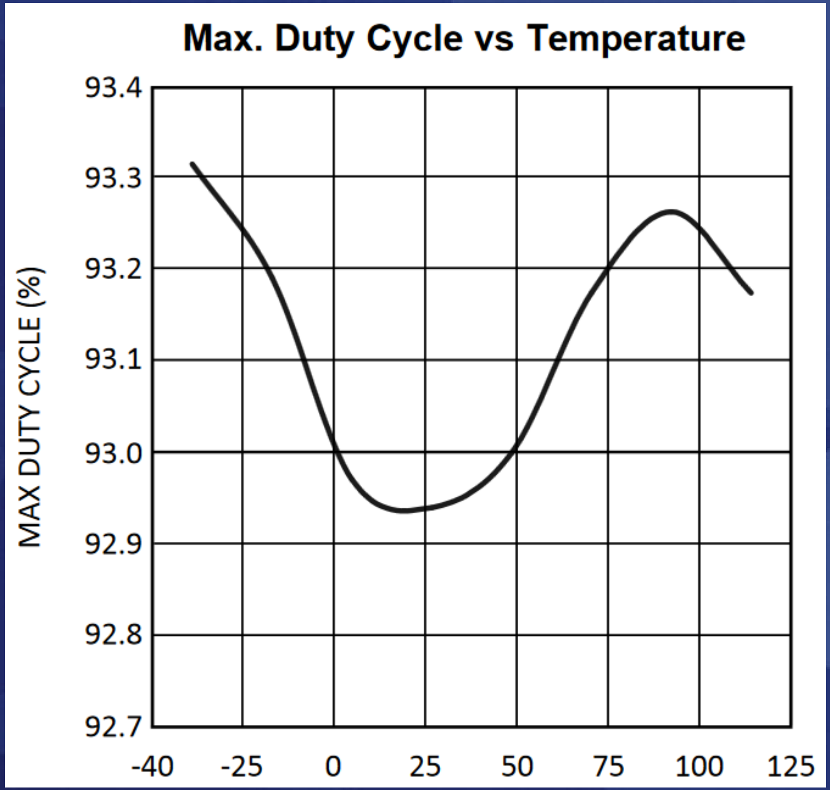
$I_{LOAD(max)} = (1 - DC) \times (I_{SW(max)} - (DC (V_{IN} - V_{SW}))/2fL)$

EFFICIENCY VS LOAD CURRENT



As we want the output voltage to be about 25 Volts we will only discuss this diagram.

THERMAL CONSIDERATIONS

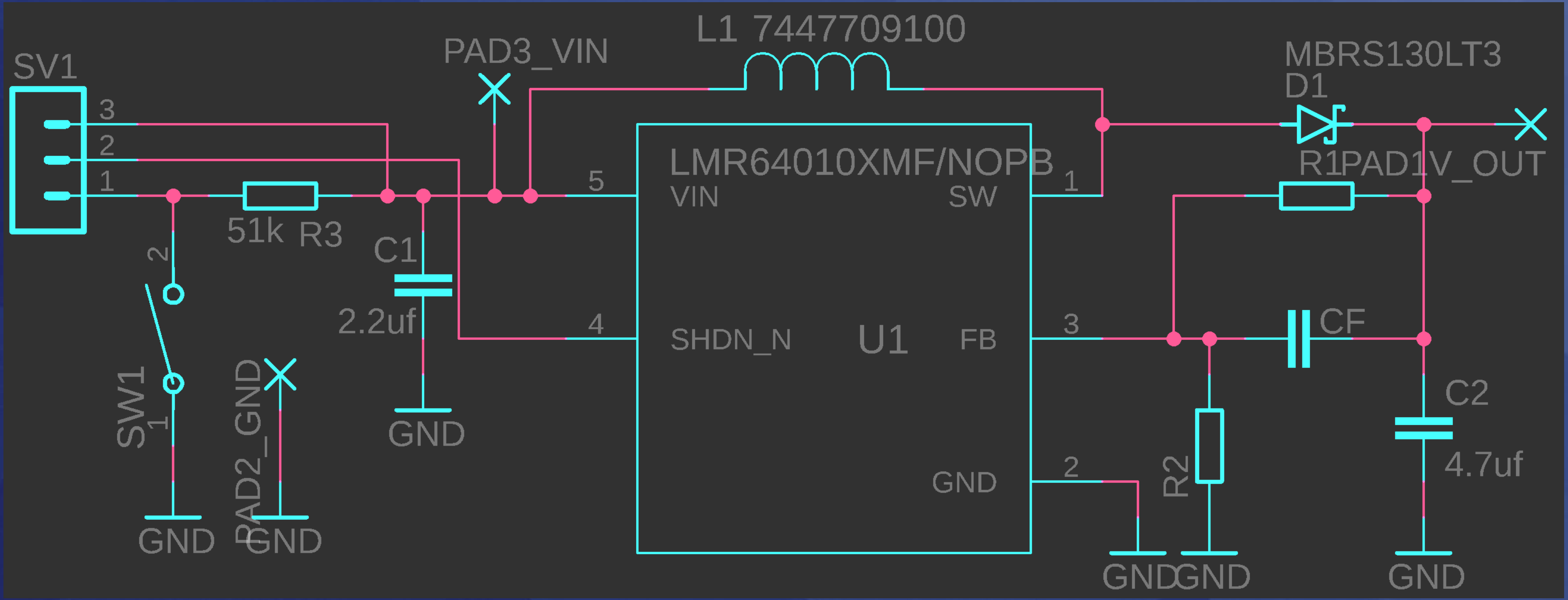


At higher duty cycles, the increased ON time of the FET means the maximum output current will be determined by power dissipation within the LMR64010 FET switch. The switch power dissipation from ON-state conduction is calculated by:

P(SW) = DC x IIND(AVE)2 x RDSON

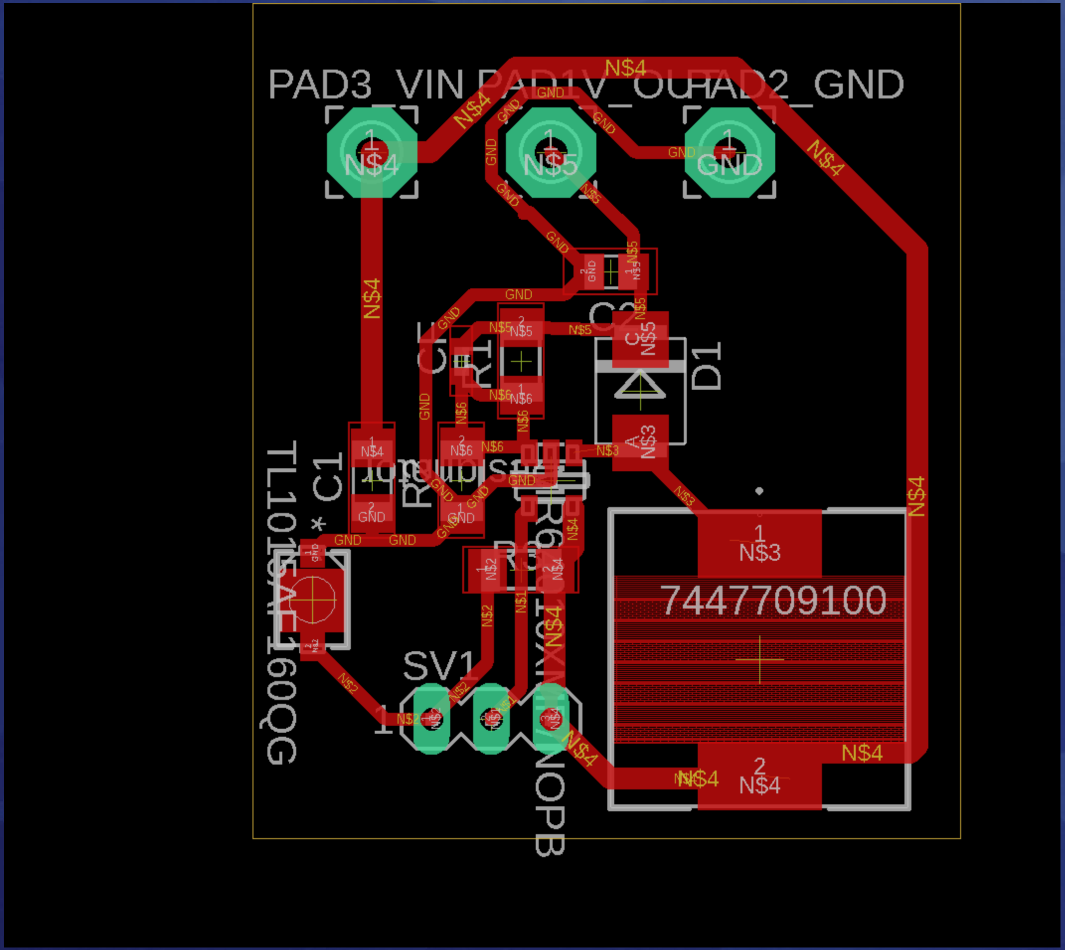
There will be some switching losses as well, so some derating needs to be applied when calculating IC power dissipation.

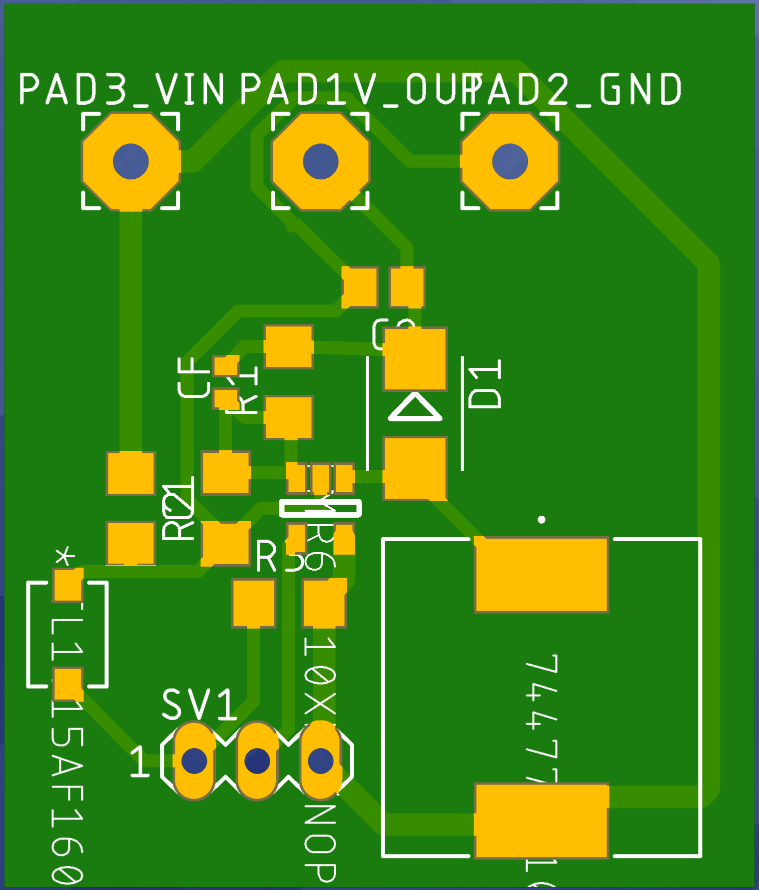
SCHEMATIC



SV1
PAD3_VIN
L1 7447709100
MBRS130LT3
D1
LMR64010XMF/NOPB
VIN
SW
SHDN_N
U1
FB
GND
R1
PAD1
V_OUT
51k
R3
C1
2.2uf
GND
SW1
PAD2_GND
GND
GND
CF
C2
4.7uf
R2
GND
GND
GND

BOARD LAYOUT





APPLICATION

We tried making a small analog speaker amplifier circuit using LMR64010 together with LM384. It will provide sufficient power to drive a 5 W speaker at the output.

LM384 DESCRIPTION

The LM384 is a power audio amplifier for consumer applications. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows ground referenced input signals. The output automatically self-centers to one-half the supply voltage. The output is short-circuit proof with internal thermal limiting.

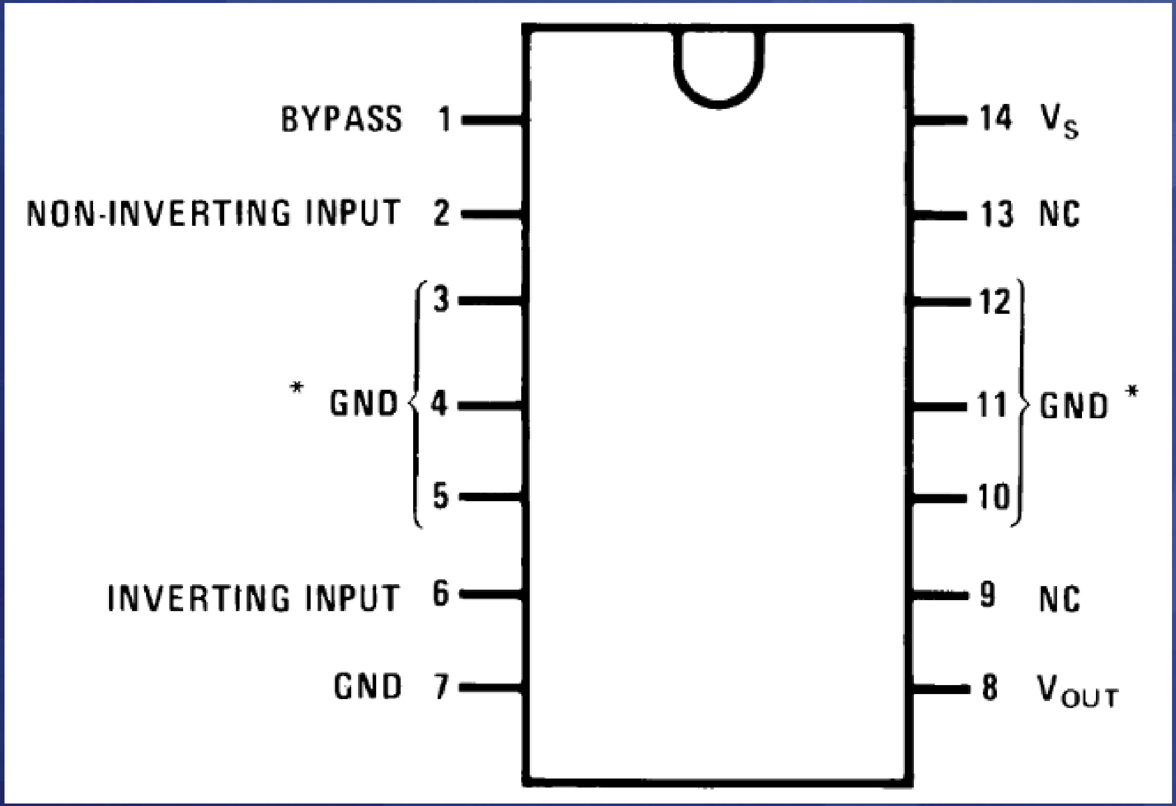
ABSOLUT MAXIMUM RATINGS

Supply Voltage	28V
Peak Current	1.3A
Power Dissipation	1.67W
Input Voltage	±0.5V
Storage Temperature	−65°C to +150°C
Operating Temperature	0°C to +70°C
Lead Temperature (Soldering, 10 sec.)	260°C

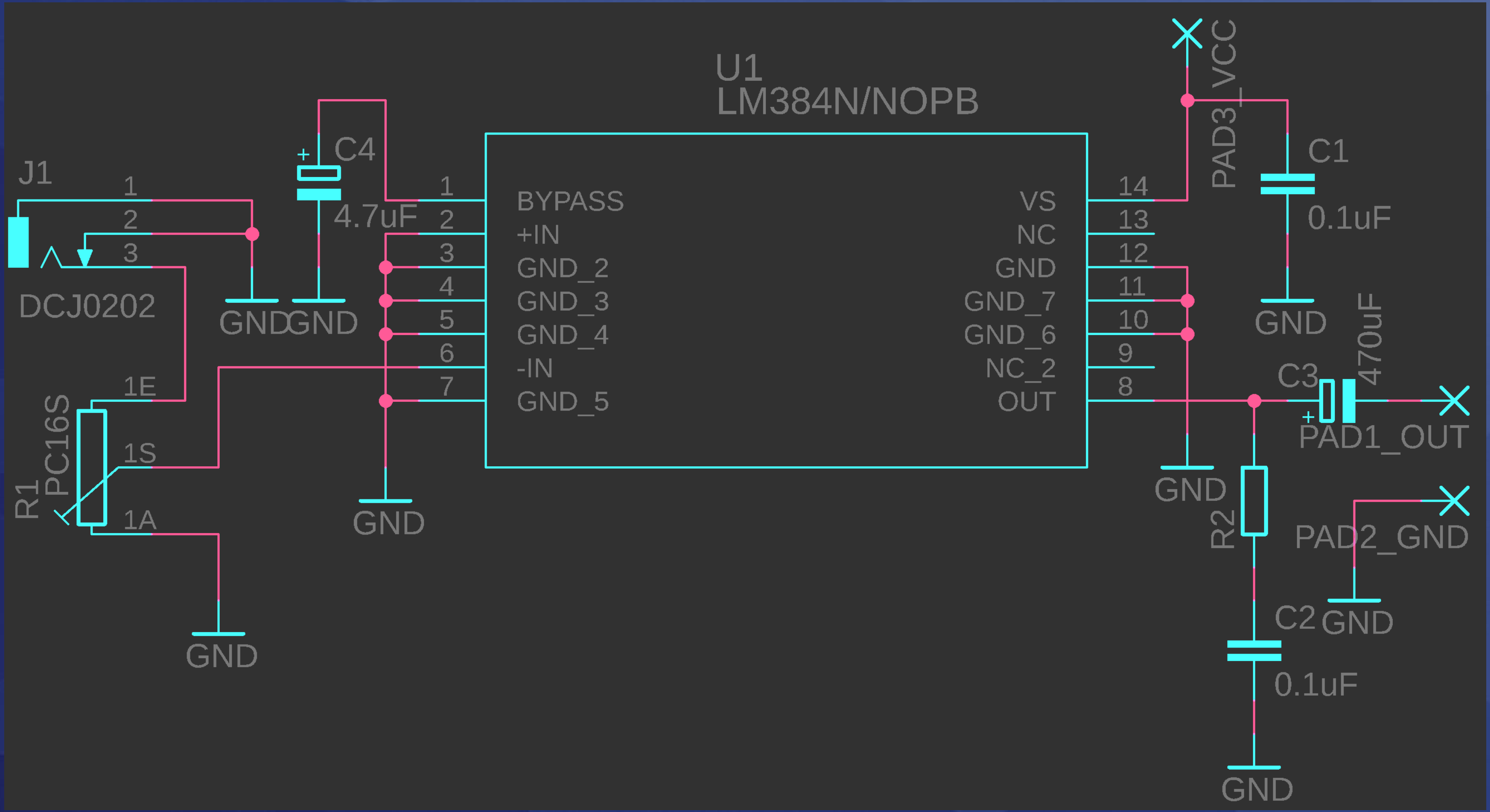
ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Conditions	Min	Typ	Max	Units
AV	Gain		40	50	60	V/V
POUT	Output Power	THD = 10%, RL = 8Ω	5	5.5		W
IQ	Quiescent Supply Current			8.5	25	mA
BW	Bandwidth	POUT = 2W, RL = 8Ω		450		kHz
V+	Supply Voltage		12		26	V
PSRRRTO	Power Supply Rejection Ratio					dB
THD	Total Harmonic Distortion	POUT = 4W, RL = 8Ω		0.25	1.0	%

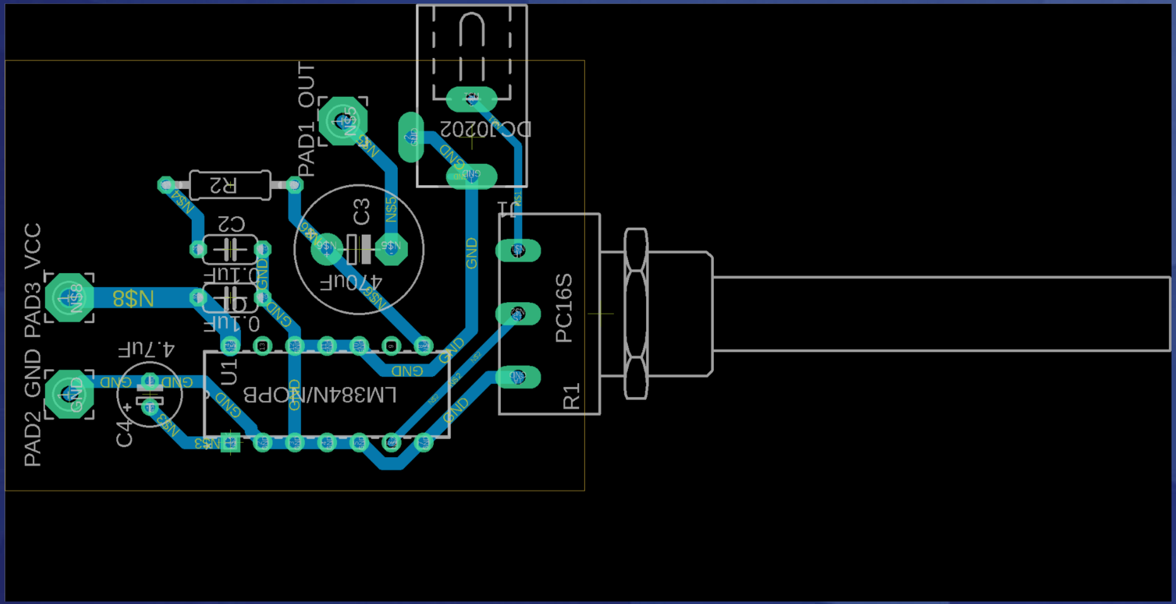
PIN DESCRIPTION



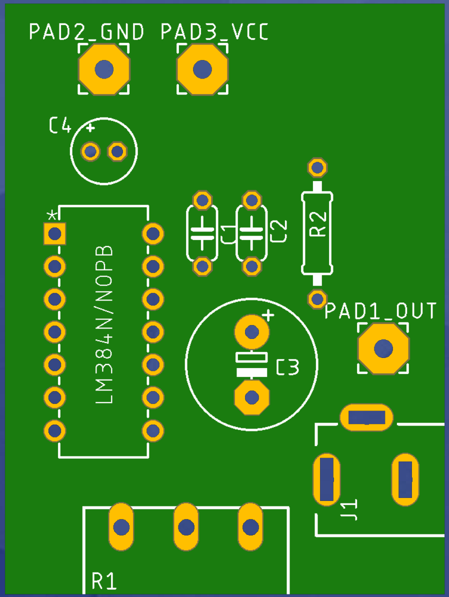
SCHEMATIC


U1
LM384N/NOPB
J1
DCJ0202
C4
4.7uF
BYPASS
+IN
GND_2
GND_3
GND_4
-IN
GND_5
VS
NC
GND
GND_7
GND_6
NC_2
OUT
PAD3_VCC
C1
0.1uF
C3
470uF
PAD1_OUT
PAD2_GND
R1
PC16S
1E
1S
1A
R2
C2
0.1uF
GND

PCB LAYOUT



PAD2_GND
PAD3_VCC
PAD1_OUT
R2
C2
C3
C4
U1
PC16S
R1
DCJ0202



PAD2_GND
PAD3_VCC
C4
R2
C2
C1
LM384N/NOPB
PAD1_OUT
C3
J1
R1

Thank You For Watching

Made by: Παπαδόπουλος Αριστείδης