AN-2266 LM34902/4 Current Limited Power Switch Evaluation Module

1 Introduction

With the advent of new handset, tablet, and notebook devices in smaller and smaller footprints, engineers are facing the challenging task of designing next-generation systems that fit into these smaller form factors. Also, consumers are placing more value on the battery life of their portable devices by seeking longer operation time between charges.

One of the standards that has become a “must have” for these devices is the USB port that enables a user to connect various accessories to their device. However, power transfer from a host device to a downstream accessory needs to be carefully managed to avoid inrush current and/or voltage transient events upon connection. The accessory typically sends a handshake signal to indicate that it is ready to accept downstream power transfer. Only then should the device’s CPU or system controller authorize current flow. Well-defined overload protection is also mandated to reliably manage capacitive loads or accessory fault modes.

With nominal 5 nA shutdown and 47 µA quiescent supply currents, the LM34902/4 current-limited power switch is ideally suited for such applications. Offered in a tiny 6-bump 1.2 mm x 0.8 mm micro SMD package with 0.6 mm height and 0.4 mm pin pitch, the LM34902 and LM34904 are rated for 300 mA and 500 mA continuous load currents, respectively. An input voltage range of 2.8V to 5.3V is provided to cater to 3V and 5V systems. With a low ON resistance, the high-side p-channel MOSFET switch power dissipation is minimized, translating into lower temperature increase—a critical feature in space constrained applications—and longer battery life. Using an integrated sense resistor, the LM34902/4 provides accurate brickwall current limit, protecting the input supply even when the ACC_PWR output is hard-shorted to ground (GND). To assure reliability, thermal shutdown protection is provided if the junction temperature exceeds 135°C (LM34904) or 170°C (LM34902).

2 Evaluation Module Features

- Input voltage operating range: 2.8V to 5.3V.
- Ambient temperature range: -40°C to +85°C.
- Rated load current: 300 mA (LM34902), 500 mA (LM34904).
- PCB size: 1.7” × 1.7” (43 mm × 43 mm).

3 Evaluation Module Operation

As the pinouts and footprints of the LM34902 and LM34904 are identical, the solution presented in this user's guide enables the user to evaluate both power switches. This commonality provides flexibility if the load current specifications evolve during the design process. The schematic in Figure 1 demonstrates how the LM34902/4 switch connects to a device CPU (or an ASIC with embedded µC core) and an accessory load. Presented also is the LM34902/4 truth table operation (Table 1).

When the accessory is connected, it asserts an active-low accessory detect ($\overline{\text{ACC\_DET}}$) control input. The CPU can then selectively turn on (or off) the switch using the ENABLE input, providing power to the accessory (or conserving power when needed). Both the ENABLE and $\overline{\text{ACC\_DET}}$ inputs are 1.8V logic compatible. Both inputs need to be asserted to turn on the MOSFET switch ($\overline{\text{ACC\_DET}}$ first and then ENABLE). Note that the power switch is not bidirectional: the input voltage must therefore be higher than the output voltage under all conditions.

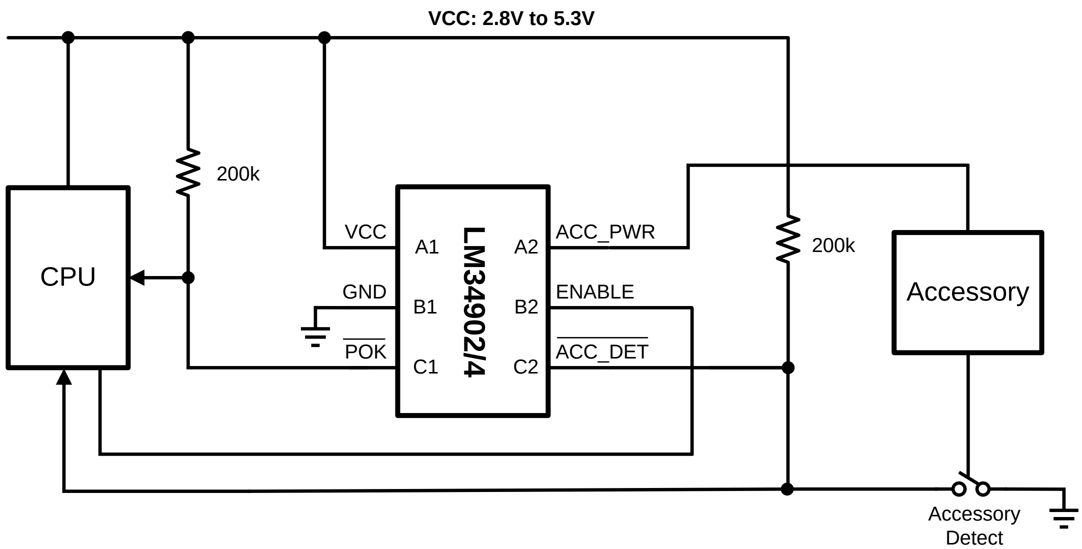

Figure 1. Typical System Schematic

Table 1. Power Switch Truth Table

Input [(1)]					Output	
ENABLE	**$\overline{\text{ACC\_DET}}$**	**Current Limit Detected**	**T_J Limit Exceeded**	**2.8V < VCC < 5.3V**	**PFET Switch Status**	**$\overline{\text{POK}}$**
0	x	No	No	Yes	Open	Open Drain
x	1	No	No	Yes	Open	Open Drain
0 to 1	0	No	No	Yes	On	Grounded
0 to 1	0	Yes	No	Yes	Current Limited	Grounded
x	x	x	Yes	2.2V < VCC < 5.3V	Open	Open Drain
0	x	x	No	2.2V < VCC < 2.8V	Open	Open Drain

(1) x = stands for "don't care".

4 Evaluation Module Schematic

The schematic of the evaluation module is shown in Figure 2. Note that ENABLE and ACC_DET default to their off-states if left open-circuited in this implementation. An active-low open-drain output (POK) provides an indication of switch status to the CPU. As shown in Figure 2, the module provides pullup resistors to VCC for POK and ACC_DET and a pulldown resistor to GND for ENABLE.

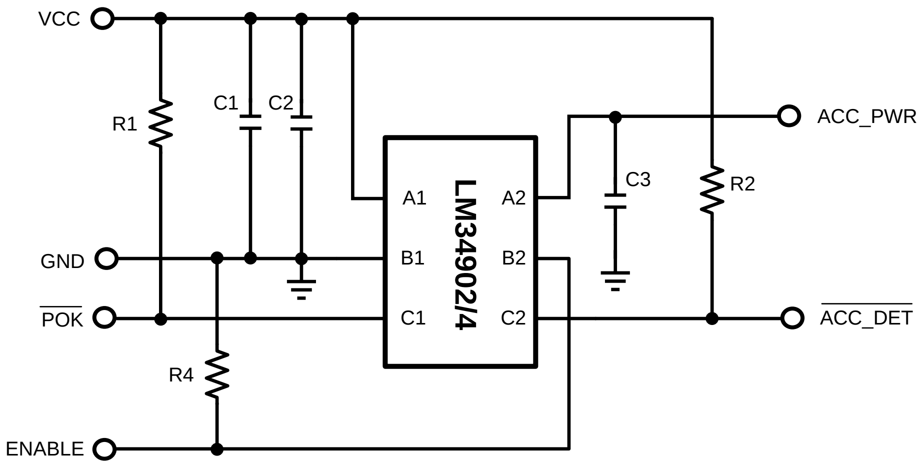

Figure 2. Evaluation Module Schematic

5 Evaluation Module Bill of Materials

Designator	Value	Description	Manufacturer	Part Number	Qty
C1, C2	22 µF	Ceramic, 22µF, X5R, 10V, 10%, 0805	Taiyo Yuden	LMK212BJ226MG-T	2
C3	4.7 µF	Ceramic, 4.7µF, X5R, 25V, 10%, 0805	Murata	GRM21BR61E475KA12L	1
VCC, ACC_PWR		Test Point, TH, Miniature, Red	Keystone Electronics	5000	2
ENABLE, ACC_DET, POK		Test Point, TH, Miniature, White	Keystone Electronics	5002	3
GND		Test Point, TH, Miniature, Black	Keystone Electronics	5001	1
R1, R2, R4	220k	Resistor, 220k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW0603220KFKEA	3
U1		500mA Current Limited Power Switch	Texas Instruments	LM34904	1

6 Evaluation Module Component Selection

Ceramic input and output capacitors are positioned close to the load switch. Specifically, two 22 µF bypass capacitors from VCC to GND minimize input voltage drop during a high current startup event or momentary output short circuit condition. A 1 µF capacitor is usually adequate even though larger capacitance will further reduce the voltage drop. A 4.7 µF decoupling capacitor from ACC_PWR to GND alleviates any negative swing of ACC_PWR induced by parasitic inductance in the load lines as the load current ramps to zero during a turn-off event. Of course, all traces short be kept as short as possible with VCC, ACC_PWR and GND power bus traces kept wide to minimize conduction drop and assist with thermal spreading.

When the output is short-circuited, the input voltage appears across the switch, and the instantaneous power dissipation can be quite high. If the fault condition is not removed, the die temperature may increase to the level where the thermal shutdown protection activates. If the faulted short-circuit condition persists and the device engages thermal shutdown, it latches off. ENABLE can be cycled to initiate a re-start.

7 Evaluation Module Power Up Procedure

Step 1: Apply an input voltage between 2.8V and 5.3V (VCC to GND).

Step 2: Connect $\overline{\text{ACC\_DET}}$ to GND.

Step 3: Connect ENABLE to VCC. The load switch turns on – measure voltage from ACC_PWR to GND.

Step 4: Apply a load current up to the rated current of the device – check voltage from ACC_PWR to GND.

Step 5: Apply and remove an overload or short circuit – confirm recovery from this condition.

Step 6: Cycle ENABLE high and low to assess turn on and turn off wavefroms, respectively.

8 Evaluation Module Performance Characteristics

Using the LM34904 with $\overline{\text{ACC\_DET}}$ and $\overline{\text{POK}}$ pullup resistors connected to a pullup voltage source of 1.8V, various performance characteristics of the evaluation module are presented in Figure 3 through Figure 9.

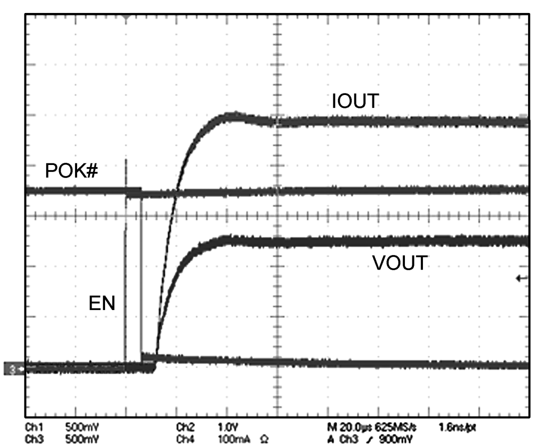

Figure 3. ENABLE Turn On, VCC = 2.8V, IOUT = 0.5A (Resistive Load)

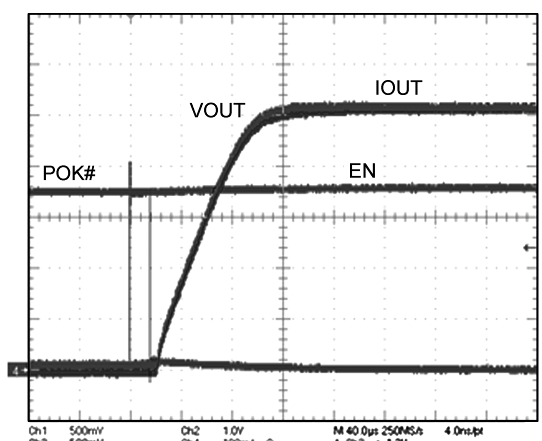

Figure 4. ENABLE Turn On, VCC = 5.3V, IOUT = 0.5A (Resistive Load)

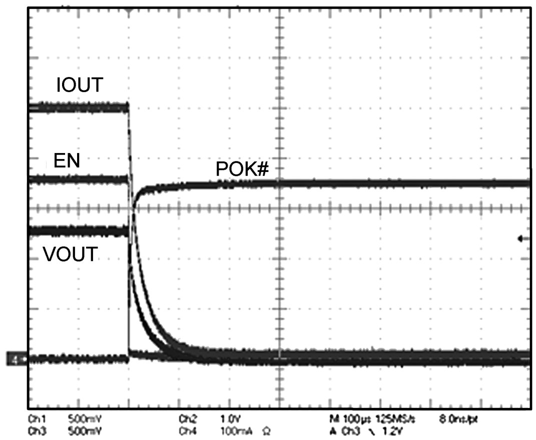

Figure 5. ENABLE Turn Off, VCC = 2.8V, IOUT = 0.5A (Resistive Load)

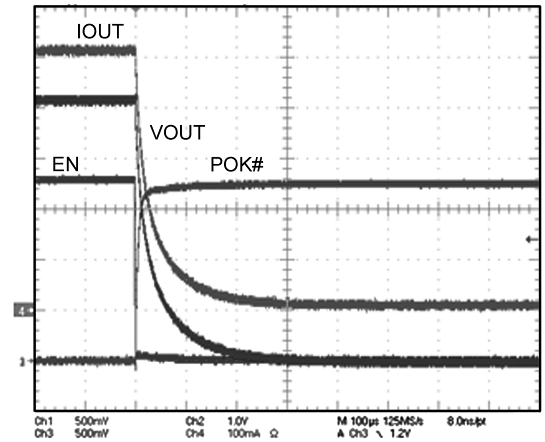

Figure 6. ENABLE Turn Off, VCC = 5.3V, IOUT = 0.5A (Resistive Load)

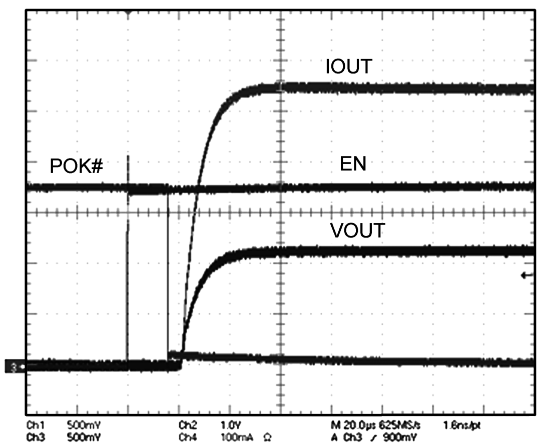

Figure 7. ENABLE Turn On Into An Overload Condition (4Ω Resisitve Load), VCC = 5.3V

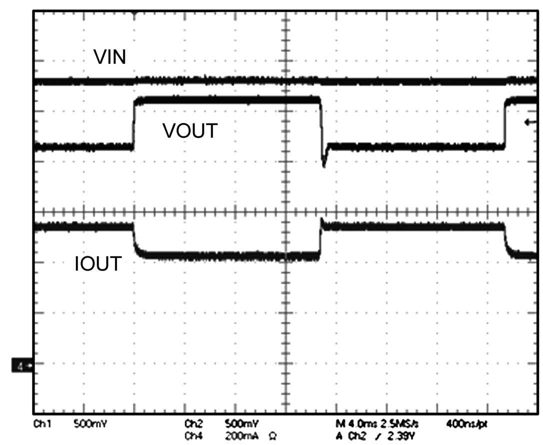

Figure 8. Output Transient Response When Cycling Into and Out Of Current Limit (Electronic Load Output), VCC = 5.3V

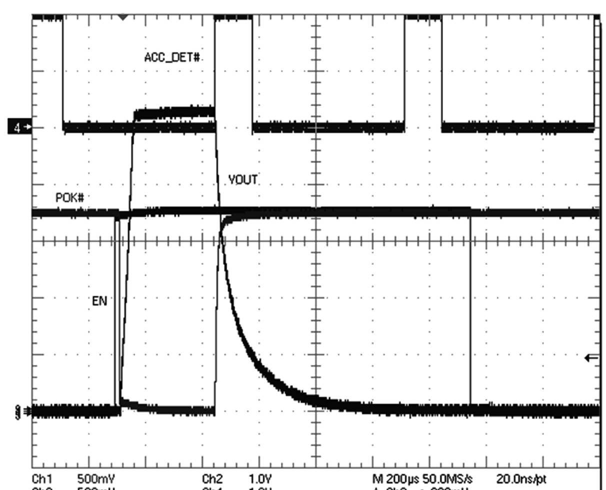

Figure 9. ENABLE and $\overline{\text{ACC\_DET}}$ Cycled Independently, VCC = 5.3V

9 PCB Layout

The LM34902/4 evaluation module uses a two-layer FR4 PCB with terminal connections provided for VCC, ACC_PWR, GND, ENABLE, $\overline{\text{ACC\_DET}}$ and $\overline{\text{POK}}$. The top and bottom side PCB layouts are shown in Figure 10 and Figure 11, respectively.

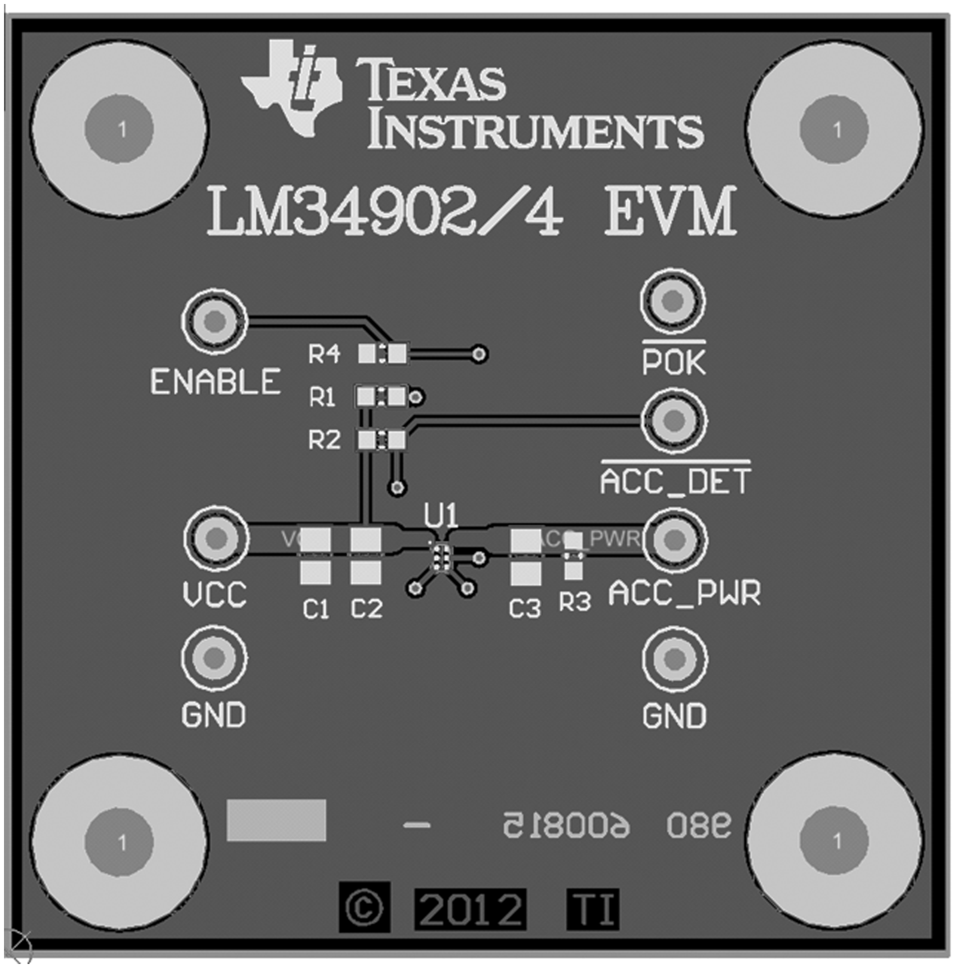

Figure 10. PCB Top Layer

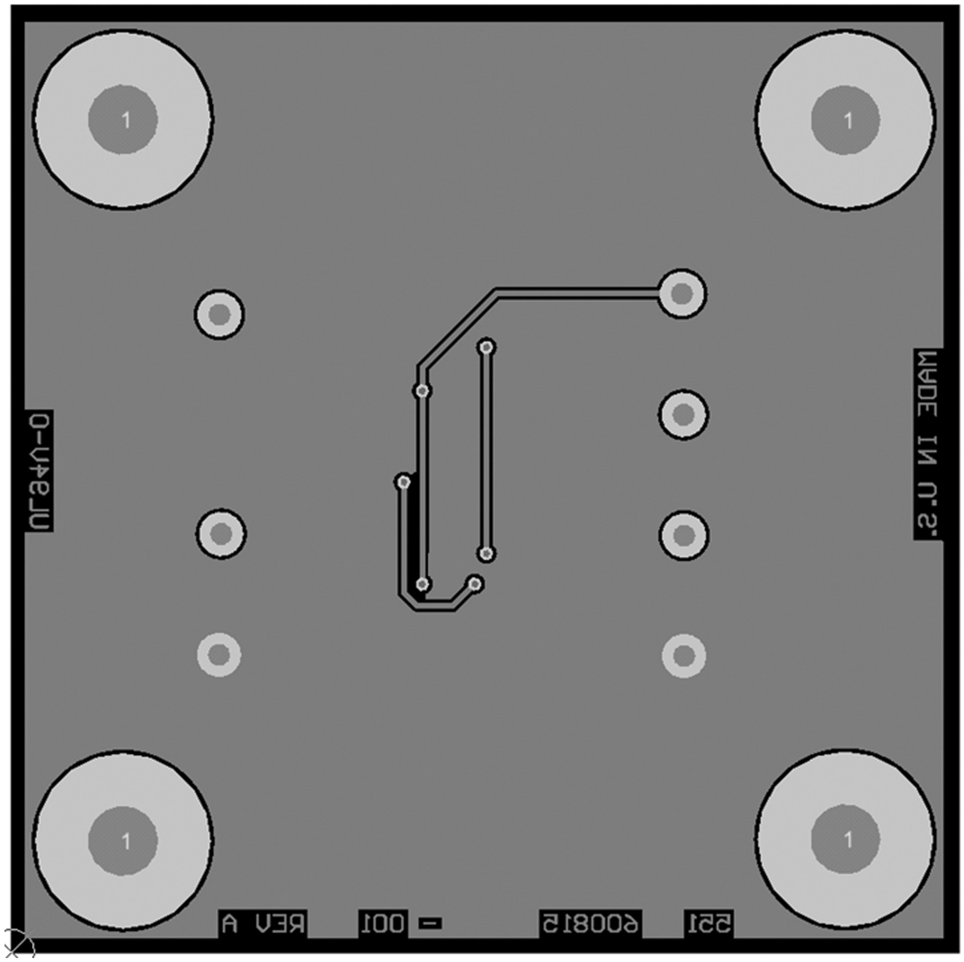

Figure 11. PCB Bottom Layer

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