AN-1409 LP3878-ADJ Evaluation Board

1 Introduction

The LP3878-ADJ is an 800 mA low-dropout linear regulator whose output voltage can be externally set to any value between 1V and 5.5 V using two resistors. This document gives information about the evaluation board supplied to demonstrate the function of this part. This board is designed to handle either the LP3878MR-ADJ (SO PowerPAD-8) or the LP3878SD-ADJ (WSON-8). By default the board is populated with the LP3878MR-ADJ (SO PowerPAD-8) device.

2 Basic Application Circuit

The basic application circuit shown below provides the component designators used on the evaluation board.

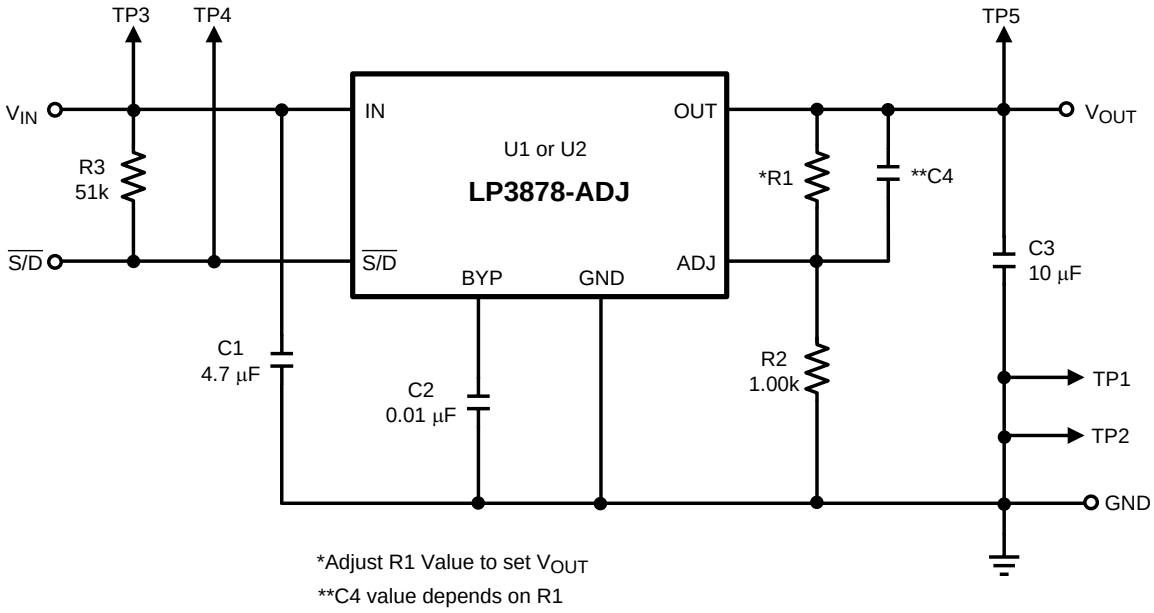

Figure 1. Evaluation Board Schematic

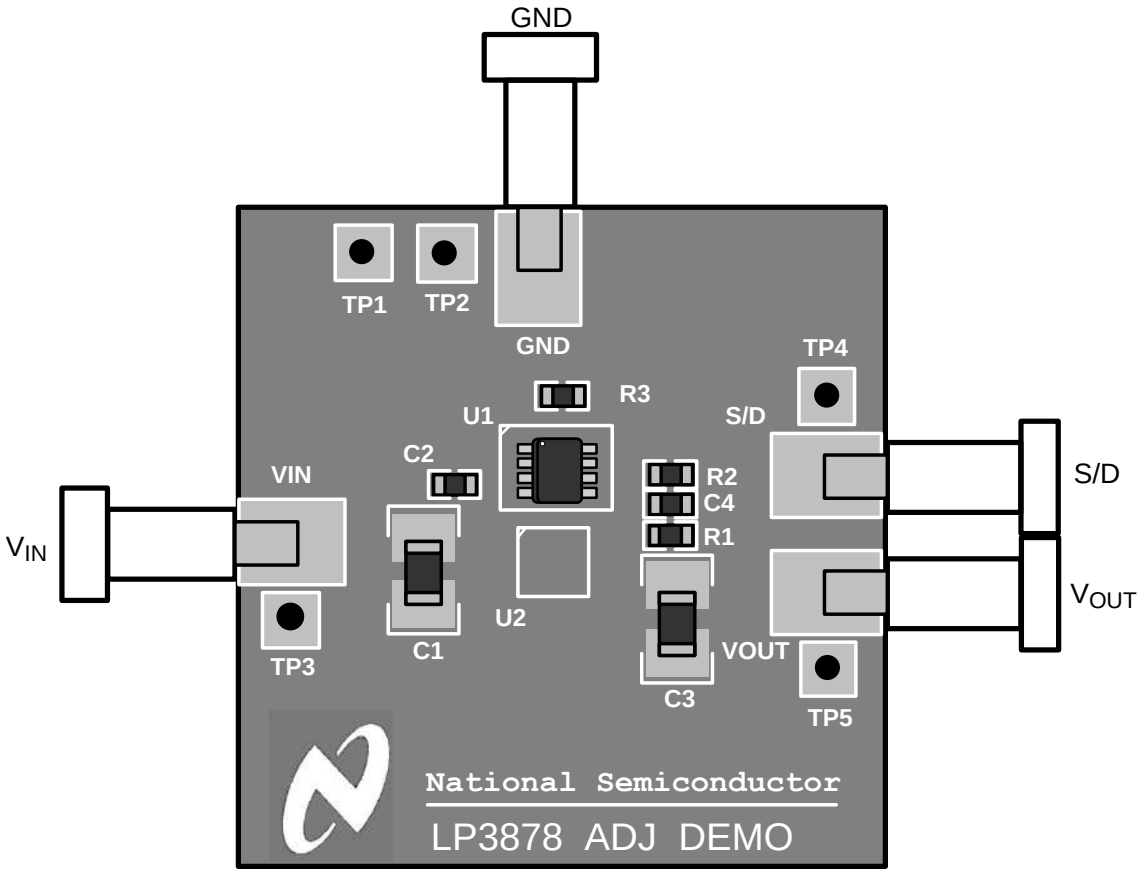

Figure 2. Evaluation Board Component Placement (Top View)

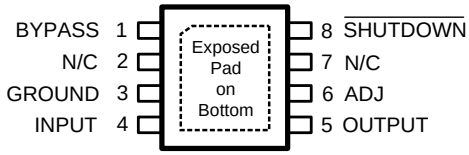

Figure 3. LP3878MR-ADJ Connection Diagram

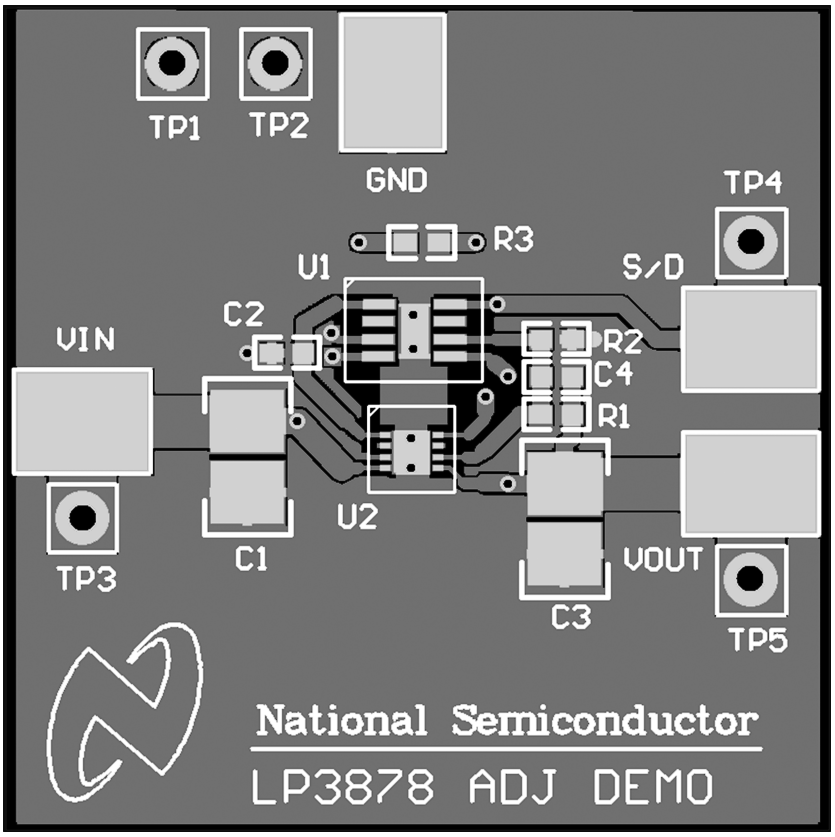

Figure 4. Evaluation Board PCB (Top)

3 Operating Range

The operating range for LP3878-ADJ evaluation board is

- Input Voltage, V_{IN}: 2.50V to 16.0V
- Output Current, I_{OUT}: 0 mA to 800 mA
- Ambient Temperature, T_A: 0°C to 50°C

The LP3878-ADJ evaluation board has the output voltage (V_{OUT}) pre-set to 1.80V. Operating with an elevated input voltage and/or output current can create excessive internal dissipation that will cause the LP3878-ADJ to go into thermal shutdown. The thermal rating (θ_{JA}) for the LP3878MR-ADJ mounted on this evaluation board is approximately 50°C/W. With an ambient temperature (T_A) of 25°C and a maximum operating junction temperature ($T_{J(MAX)}$) of 125°C, the device dissipation (P_{DISS}) should be limited to:

$$P_{DISS} \leq (T_{J(MAX)} - T_A) / \theta_{JA}$$
$$P_{DISS} \leq (125°C - 25°C) / 50°C/W$$
$$P_{DISS} (W) \leq 2.0W$$

The maximum device dissipation ($P_{DISS(MAX)}$) is generally defined as:

$$P_{DISS(MAX)} = (V_{IN(MAX)} - V_{OUT}) \times I_{OUT(MAX)}$$

This means that for given ambient temperature and output voltage, there may be a limitation on the maximum output current and/or maximum input voltage.

4 Setting the Output Voltage

The output voltage is set using the two external resistors R1 and R2:

$$V_{OUT} = V_{ADJ} \times (1 + (R1 / R2))$$

For the LP3878-ADJ, the typical value for V_{ADJ} is 1.00V.

The LP3878-ADJ Eval boards are set to a 1.80V output using a 806Ω resistor for R1, and 1.00 kΩ for R2.

The value of R2 is required to be less than 5 kΩ for stability reasons. Using 1.00 kΩ for R2 and 1.00V for V_{ADJ}, the appropriate value for R1 can be calculated for any value of V_{OUT} between 1V and 5.5V.

$R1 = R2 \times ((V_{OUT} / V_{ADJ}) - 1)$

$R1 = 1000\Omega \times (V_{OUT} / 1.00V) - 1)$

5 Selecting Compensation Capacitor (C4)

The function of C4 is "feedforward" compensation that is to provide a zero in the loop gain, which adds phase lead at the unity gain crossover frequency. The frequency of the zero is given by:

$f_Z = 1 / (2 \times \pi \times R1 \times C4)$

Bench testing was performed that showed the best range for the zero varied slightly based on the output voltage. For best setting time, it is recommended that C4 be selected such that:

$(V_{OUT} > 2.5V) : 20kHz < f_Z < 100kHz$

$(V_{OUT} \leq 2.5V) : 50kHz < f_Z < 200kHz$

The value of C4 can be calculated from the following formula:

$C4 = 1 / (2 \times \pi \times R1 \times f_Z)$

The default installed value for C4 is 3300 pF (i.e. 3.3 nF), and the default installed value for R1 is 806Ω. The zero frequency is:

$f_Z = 1 / (2 \times \pi \times 806 \times 3.30e\text{-}9) = 59837Hz = 59.8\ kHz$

NOTE: Because C4 forms both a pole and zero, it should be made clear that the amount of beneficial phase gain that is possible reduces at lower output voltages. As the value of R1 is reduced, the pole and zero become closer in frequency. At output voltages below about 1.5V, C4 has very little beneficial effect on phase margin (this topic is covered in detail on the LP3878-ADJ datasheet).

6 Components for Alternate Output Voltages

Keeping R2 at the installed valued of 1.00 kΩ and keeping close to a 60 kHz zero frequency from C4, the following values can be used for R1 and C4:

V_{OUT}	R1	R2	C4
1.8V	806Ω	1.00 kΩ	3.3 nF
2.0V	1.00 kΩ	1.00 kΩ	2.7 nF
2.5V	1.50 kΩ	1.00 kΩ	1.8 nF
3.0V	2.00 kΩ	1.00 kΩ	1.5 nF
3.3V	2.32 kΩ	1.00 kΩ	1.2 nF
5.0V	4.02 kΩ	1.00 kΩ	680 pF

Other values of R1 and R2 may produce slightly better results in some cases, as long as R2 is kept at a value less than 5 kΩ and C4 is adjusted accordingly.

7 BYPASS Capacitor (C2)

The BYPASS pin capacitor is at component C2, and the default installed value is 0.01 µF (i.e. 10 nF).

The practical capacitance range for the BYPASS pin capacitor is 1 nF to 100 nF. Below 1 nF there is no meaningful reduction in the output noise. Increasing the value above 100 nF does not provide any significant additional reduction in the output noise.

Since the BYPASS pin capacitor is charged from the band-gap reference circuit, the capacitance value will directly affect the time needed for the output voltage to settle to the final value after power is applied and the output is enabled.

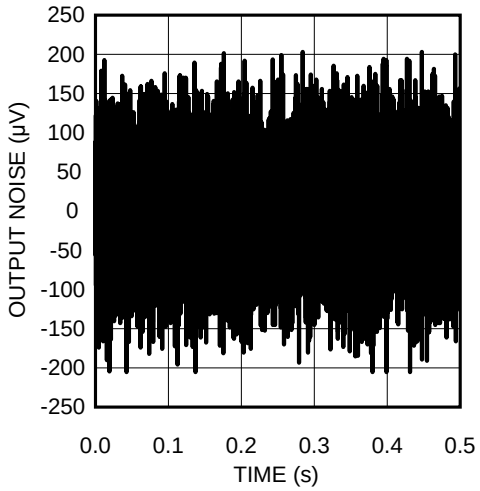

Figure 5. Output Noise With C_{BYPASS} = Open

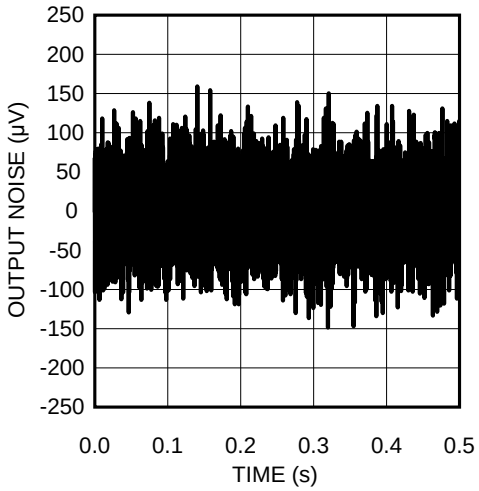

Figure 6. Output Noise With C_{BYPASS} = 1 nF (40 μV_{RMS})

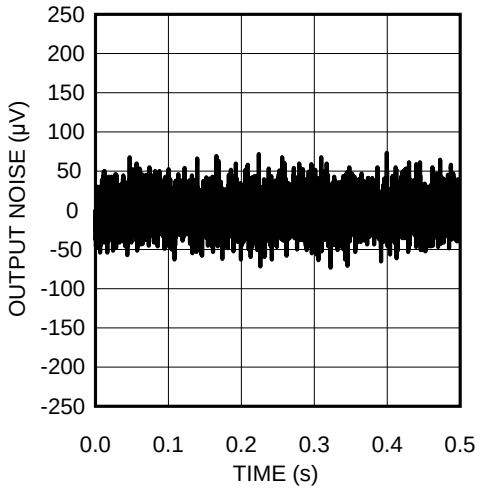

Figure 7. Output Noise With C_{BYPASS} = 10 nF (20 μV_{RMS})

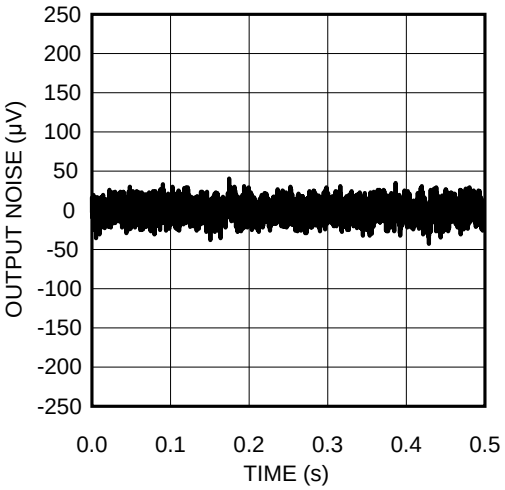

Figure 8. Output Noise With C_{BYPASS} = 100 nF (10 μV_{RMS})

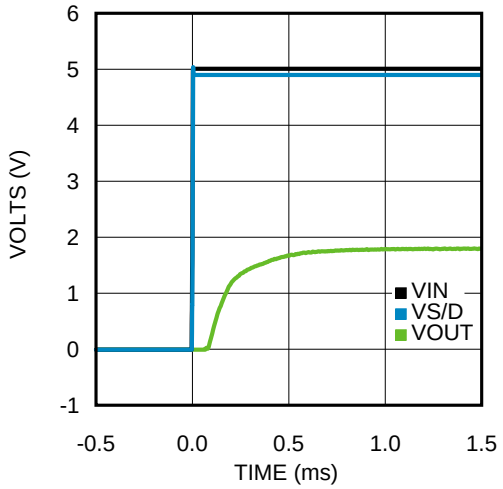

Figure 9. Start-Up With C_{BYPASS} = 10 nF

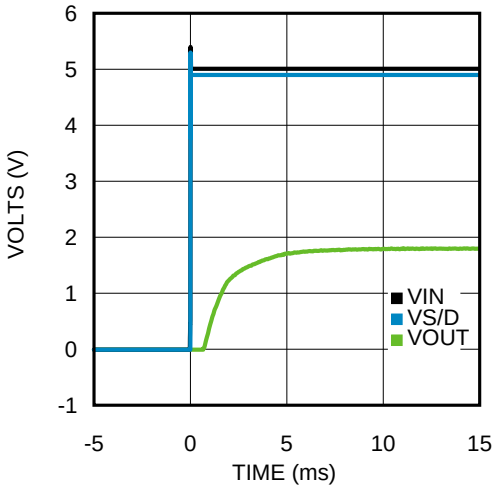

Figure 10. Start-Up With C_{BYPASS} = 100 nF

8 Component List

NOTE: Higher voltage rated capacitors may be substituted, but only X5R or X7R dielectric types may be used.

Table 1. Component List

Item	Description	Part Number
PCB	PCB	980012506-118B
U1	IC, LDO, SO PowerPAD-8	Texas Instruments LP3878
U2	Not Installed	Not Installed
TP1, TP2, TP3, TP4 TP5	Terminal: Turret, Double	Keystone 1573-2
VIN CONNECTOR	Banana Jack: RED	Emerson 108-0902-001
VOUT CONNECTOR	Banana Jack: BLUE	Emerson 108-0910-001
GROUND CONNECTOR	Banana jack, BLACK	Emerson 108-0903-001
$\overline{S/D}$ CONNECTOR	Banana Jack: YELLOW	Emerson 108-0907-001
R1	Resistor: 806Ω, 0.25W, ±1%, 1206	Vishay/Dale CRCW1206806RFKEA
R2	Resistor: 1.00 kΩ, 0.25W, ±1%, 1206	Vishay/Dale CRCW12061K00FKEA
R3	Resistor: 51.0 kΩ, 0.25W, ±1%, 1206	Vishay/Dale CRCW120651K0FKEA
C1	Capacitor: MLCC, 4.7 µF, 25V, X5R, ±10%, 1206	Taiyo Yuden TMK316BJ475KL-T
C2	Capacitor: MLCC, 0.01 µF, 50V, X7R, ±10%, 0805	AVX Corporation 08055C103KAT2A
C3	Capacitor: MLCC, 10 µF, 10V, X5R, ±10%, 0805	Taiyo Yuden LMK212BJ106KG-T
C4	Capacitor: MLCC, 3300 pF, 50V, X7R, ±10%, 0805	AVX Corporation 08055C332KAT2A

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- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
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