

# NCP45491PMNGEVB

## NCP45491 Paired Mode Evaluation Board User's Manual



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### Introduction

This user's manual provides detailed information regarding the configuration and use of the NCP45491PMNGEVB evaluation board. The evaluation board serves as a demonstration of NCP45491 general functionality for *dual* mode chip mode featuring power monitoring of 6 channels. The evaluation board also provides a means of quick prototyping for specific applications.

### Features

- 2 NCP45491 Connected in Paired Mode
- Connectors for 6 High Current Loads and 3 Separate Bus Voltage Supplies
- Configuration Options for Shunt Current and Bus Voltage Gain Settings
- Appropriate Test Points for Easy Evaluation

### Quick Start

#### Recommended Equipment

Before beginning, the following equipment is needed:

- 4 DC Power Supplies (3.3 V VCC Supply, 12 V Bus Voltage, 6 V Bus Supply, 8 V Bus Supply)
- 6 DC loads (Up to at Least 2 A)
- 1 Function Generator
- 1 Oscilloscope
- 1 Digital Multi-meter
- SMA to BNC Cables Recommended for Connection to DIFF\_OUTN, DIFF\_OUTP, and MUX\_SEL

NOTE: Bus voltage supplies need to be capable of sourcing load currents times 2 since each supply sources 2 loads on the default setup.

### Board Setup

The assembled evaluation board targets Bus Voltages and Shunt Currents shown in Tables 1 and 2. VBUS1 ties to both channel 1 and channel 2 bus voltage inputs. VBUS2 ties to both channel 3 and channel 4 bus voltage inputs. VBUS3 ties to both channel 5 and channel 6 bus voltage inputs. Refer to the schematic and layout diagrams found in [Appendix A](#) and [Appendix B](#) respectively as needed.

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Table 1. BUS VOLTAGE SETUP

| Channel   | Target Bus Voltage | Bus Divider |
|-----------|--------------------|-------------|
| 1 (VBUS1) | 12 V               | 1/60 V/V    |
| 2 (VBUS1) | 12 V               | 1/60 V/V    |
| 3 (VBUS2) | 6 V                | 1/30 V/V    |
| 4 (VBUS2) | 6 V                | 1/30 V/V    |
| 5 (VBUS3) | 8 V                | 1/40 V/V    |
| 6 (VBUS3) | 8 V                | 1/40 V/V    |

Table 2. SHUNT CURRENT SETUP

| Channel | Shunt Current Target | Shunt Gain Default Setting |
|---------|----------------------|----------------------------|
| Load 1  | 1 A                  | 400 mV/A                   |
| Load 2  | 0.5 A                | 400 mV/A                   |
| Load 3  | 1 A                  | 400 mV/A                   |
| Load 4  | 0.5 A                | 400 mV/A                   |
| Load 5  | 1 A                  | 400 mV/A                   |
| Load 6  | 0.5 A                | 400 mV/A                   |

The specific resistor configuration populated on the board facilitates these gain settings. The nominal differential amplifier gain is 2 V/V. Therefore, the expected differential output for any channels voltage or current can be calculated as follows:

- For Bus Voltage:  
Diff Output = Bus Voltage × Channel Bus Divider × 2
- For Load Current:  
Diff Output = Load Current × Channel Shunt Gain × 2

The output for each channel is calculated as follows:

$$\text{Diff Output} = \text{Bus Voltage} \times \frac{R4}{R4 + R3} \times 2 \quad (\text{eq. 1})$$

The channel shunt current gain is calculated as follows:

$$\text{Diff Output} = I_{\text{load}} \times \frac{R2 \times R_{\text{sense}}}{R1} \times 2 \quad (\text{eq. 2})$$

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These gain settings can be adjusted by changing the bus divider resistors, and the shunt current network resistors as desired.

### Board Connections & Jumper Settings

The following board to bench equipment connections are required for demonstration of 6 channel power monitoring.

Make all board connections with supplies and loads disabled. Take adequate precautions when working with high current and high voltage applications. Table 3 below defines all default board connections and their purpose.

Table 4 below defines all default jumper connections and their purpose.

**Table 3. EVALUATION BOARD DEFAULT CONNECTIONS**

| Connection           | Connect To...                                | Purpose                                       |
|----------------------|----------------------------------------------|-----------------------------------------------|
| VBUS1 (banana)       | 12 V supply                                  | Provides channel 1 and channel 2 bus voltages |
| VBUS2 (banana)       | 6 V supply                                   | Provides channel 3 and channel 4 bus voltages |
| VBUS3 (banana)       | 8 V supply                                   | Provides channel 5 and channel 6 bus voltages |
| LOAD1 & GND (banana) | 1 A load current                             | Provides channel 1 load current               |
| LOAD2 & GND (banana) | 0.5 A load current                           | Provides channel 2 load current               |
| LOAD3 & GND (banana) | 1 A load current                             | Provides channel 3                            |
| LOAD4 & GND (banana) | 0.5 A load current                           | Provides channel 4 load current               |
| LOAD5 & GND (banana) | 1 A load current                             | Provides channel 5 load current               |
| LOAD6 & GND (banana) | 0.5 A load current                           | Provides channel 6 load current               |
| VCC & GND            | 3.3 V                                        | Provides NCP45491 supply                      |
| MUX_SEL (sma)        | 3.3 V to 0 V signal generator                | Channel mux select input                      |
| EN (sma/header)      | 3.3 V to 0 V signal generator or tied to GND | NCP45491 enable input. Active low             |
| DIFF_OUT_P (sma)     | Oscilloscope                                 | Differential output (positive)                |
| DIFF_OUT_N (sma)     | Oscilloscope                                 | Differential output (negative)                |

1. All connections to the board have an accompanying ground connection. Use all ground connections with the evaluation board being the center of a star ground to avoid ground loops.
2. Connect to DIFF\_OUTN/P signals with either 2 SMA to BNC cables to an oscilloscope (where the subtraction of the 2 signals gives the differential voltage), or connect to the DIFF\_OUT\* test loops with a twisted pair or differential probe. Connecting in this manner mitigates noise via EMI.
3. SH\_INx inputs need to be driven to a voltage between VCC and 26 V, even for unused channels. Jumpers 1, 2, 5, and 8 provide a means to connect unused channels to VCC. If a channel is not in use, the jumper should be switched to the VCC position and the SH\_Ox jumper should be removed to float the SH\_Ox pin.

**Table 4. DEFAULT JUMPER DEFINITION**

| Jumper                     | Default Setting | Function                                                                                                |
|----------------------------|-----------------|---------------------------------------------------------------------------------------------------------|
| J3, J6, J11, J12, J13, J14 | Shorted [1,2]   | Connects channel bus voltages. [2,3] connection sets bus voltage to 3.3 V if that channel is not in use |
| J4, J5, J9, J7, J8, J10    | Shorted         | Connects SH_Ox. Short for all used channels                                                             |
| J2                         | Shorted [1,2]   | SKIP input connection                                                                                   |
| J1                         | Open            | SMD jumper that can be shorted to tie EN to GND                                                         |

4. The number of used channels for each NCP45491 chip must match. The default connects set 3 channels for each chip for a total of 6 channels. Up to 8 can be used.

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### Testing Procedure

The NCP45491PMNGEVB comes fully assembled and tested. Follow the steps below to verify board operation. Refer to the schematic and layout diagrams found in [Appendix A](#) and [Appendix B](#) respectively as needed.

1. Apply power to VBUS inputs (12 V, 6 V, and 8 V supply).
2. Apply load currents for all channels.
3. Apply 3.3 V VCC power.
4. Ensure that EN is held at 0 V.
5. Apply MUX\_SEL signal. (Square wave 50% duty cycle, 100 kHz or faster, VCC to 0 V)
  - a. 12 cycles will read out voltage and current data for all 6 default channels.
  - b. Continuous cycles on MUX\_SEL will read out bus voltage and current data continuously, repeating channels 1–6.
6. Observe the following:
  - a. 1.3 V on BG\_REF\_OUT
  - b. 650 mV on CM\_REF\_IN
  - c. 170 mV on BS\_REF
  - d. Bus voltages and currents represented on DIFF\_OUTP and DIFF\_OUTN with oscilloscope.

### PCB Layout

Care must be taken in PCB layout regarding a few specific nodes for proper operation of the NCP45491. Connections to the external sense resistor for each channel must be treated as a 4 wire Kelvin connection. The SH\_IN\_Nx and the SH\_IN\_Px (connected through R1) must connect directly to the sense resistor leads for each respective channel. These should also be large traces to avoid error in the shunt current measurement. See [Appendix C](#) for the example layout of the evaluation board.

## APPENDIX A: NCP45491 PAIRED MODE EVALUATION BOARD SCHEMATIC



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## APPENDIX B: BILL OF MATERIALS

**Table 5. BILL OF MATERIALS**

| Designator                                                                                                                                                                                                                         | Description                | Value               | Manufacturer              | Manufacturer P/N   | Footprint         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------|---------------------------|--------------------|-------------------|
| BG_REF_OUT, BS_IN1, BS_IN2, BS_IN3, BS_IN4, BS_IN5, BS_IN6, BS_OK, BS_REF, CM_REF_IN, DIFF_OUTN, DIFF_OUTP, GND1, GND2, GND3, GND4, GND5, SH_IN1, SH_IN2, SH_IN3, SH_IN4, SH_IN5, SH_IN6, SH_O1, SH_O2, SH_O3, SH_O4, SH_O5, SH_O6 | Test Points                | n/a                 | Keystone Electronics      | 5009               | Test_Point        |
| C1, C2, C3, C4, C5, C10, C13                                                                                                                                                                                                       | SMD capacitor              | Do not populate     | n/a                       | n/a                | SMD_0805          |
| C6, C7, C8, C11, C12, C14, C15                                                                                                                                                                                                     | SMD capacitor              | 0.1 $\mu$ F         | Murata Electronics        | GCM21BR71H104KA37K | SMD_0805          |
| C9                                                                                                                                                                                                                                 | SMD capacitor              | 0.01 $\mu$ F        | Samsung Electro-Mechanics | CL21B103KBANNNC    | SMD_0805          |
| DIFF_OUT_N, DIFF_OUT_P, EN, MUX_SEL                                                                                                                                                                                                | SMB/SMA Straight Connector | SMA/SMB             | Molex                     | 733910060          | SMB_V-RJ45        |
| GND6, GND7, GND8, GND9, GND10, GND11, GND12, GND13, GND14, GND15, LOAD1, LOAD2, LOAD3, LOAD4, LOAD5, LOAD6, VBUS_A, VBUS_B, VBUS_C, VCC1                                                                                           | Interconnect               | Banana Jack, female | Cinch Connectivity        | 111-2223-001       | Bannana_Connector |
| J1                                                                                                                                                                                                                                 | 10th inch header           | Leave open          | n/a                       | n/a                | SMD_2             |
| J2, J3, J6, J11, J12, J13, J14                                                                                                                                                                                                     | 3 way jumper               | 3 pin 10" header    | Würth Electronics Inc     | 61300311121        | HEADER_3          |
| J4, J5, J7, J8, J9, J10                                                                                                                                                                                                            | 10th inch header           | 2 pin 10" header    | Würth Electronics Inc     | 61300211121        | HEADER_2          |
| R7, R1, R2                                                                                                                                                                                                                         | SMD resistor               | 0 $\Omega$          | Stackpole Electronics     | HCJ1206ZT0R00      | RES1206           |
| Rsense1, Rsense2, Rsense3, Rsense4, Rsense5, Rsense6                                                                                                                                                                               | SMD resistor               | 5 m $\Omega$        | Rohm Semiconductor        | PMR18EZPFU5L00     | RES1206           |
| R29, R16                                                                                                                                                                                                                           | SMD resistor               | 118 k $\Omega$      | Panasonic                 | ERJ-8ENF1183V      | RES1206           |
| R17, R32                                                                                                                                                                                                                           | SMD resistor               | 57.6 k $\Omega$     | Vishay Dale               | CRCW120657K6FKEA   | RES1206           |
| R25, R26                                                                                                                                                                                                                           | SMD resistor               | 78 k $\Omega$       | Yageo                     | RC1206FR-0778K7L   | RES1206           |
| R30, R19, R20, R33, R27, R28                                                                                                                                                                                                       | SMD resistor               | 2 k $\Omega$        | Panasonic                 | ERA-8AEB202V       | RES1206           |
| R10, R11, R18, R12, R13, R21                                                                                                                                                                                                       | SMD resistor               | 100 $\Omega$        | Panasonic                 | ERA-8AEB101V       | RES1206           |
| R8, R9                                                                                                                                                                                                                             | SMD resistor               | 100 k $\Omega$      | Rohm Semiconductor        | ESR18EZPJ104       | RES1206           |
| R3, R4, R5                                                                                                                                                                                                                         | SMD resistor               | 66.5 k $\Omega$     | Yageo                     | RC1206FR-0766K5L   | RES1206           |
| R6                                                                                                                                                                                                                                 | SMD resistor               | 10 k $\Omega$       | Stackpole Electronics     | RNCP1206FTD10K0    | RES1206           |
| R14, R15, R22, R23, R24, R31                                                                                                                                                                                                       | Resistor                   | 2.49 $\Omega$       | Vishay Dale               | CRCW12062R49FKEAHP | RES1206           |
| U1, U2                                                                                                                                                                                                                             | NCP45491                   | NCP45491            | ON Semiconductor          | NCP45491           | RES1206           |

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## APPENDIX C: NCP45491 EVALUATION BOARD LAYOUT

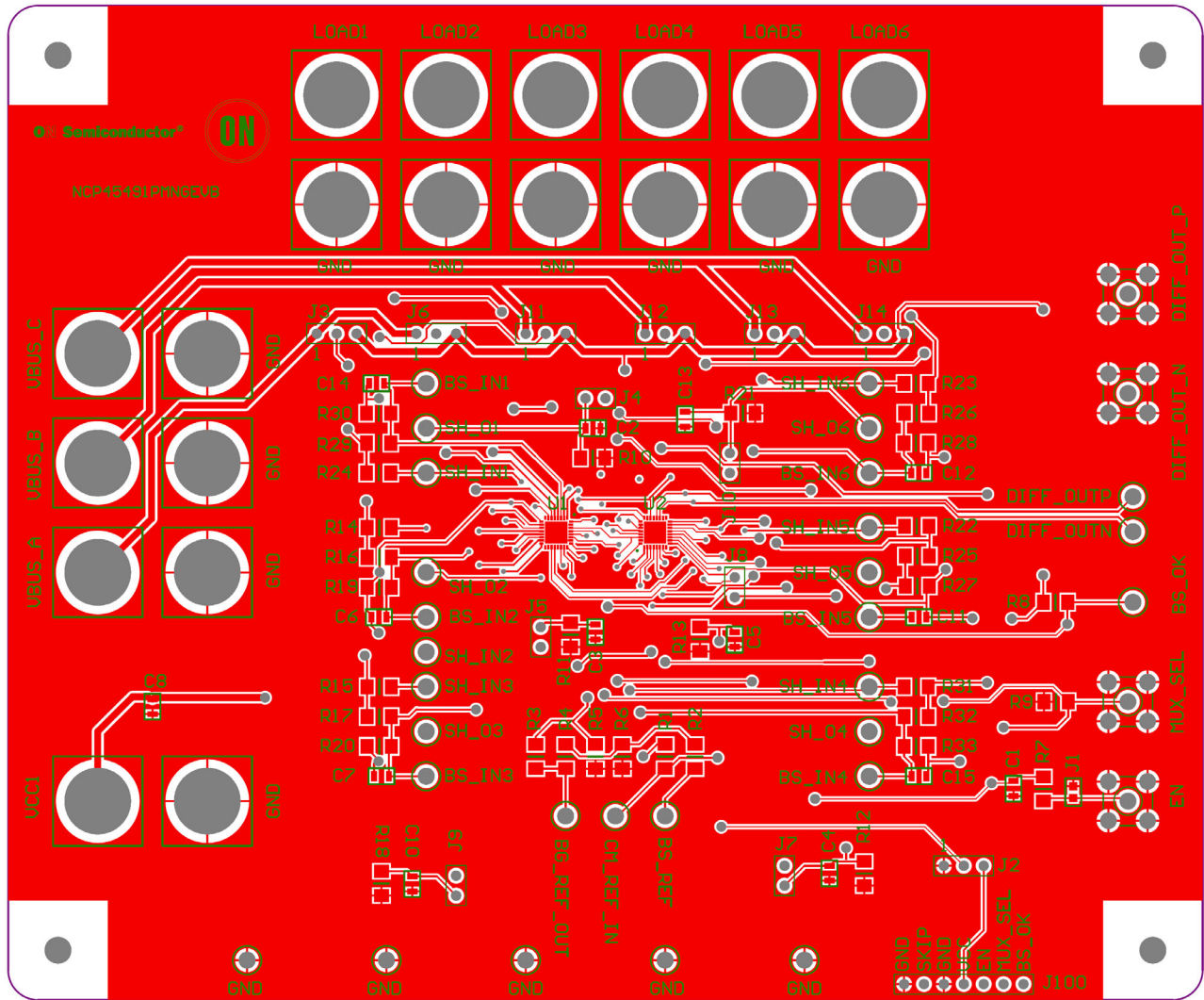


Figure 2. PCB Front (Top Metallization)

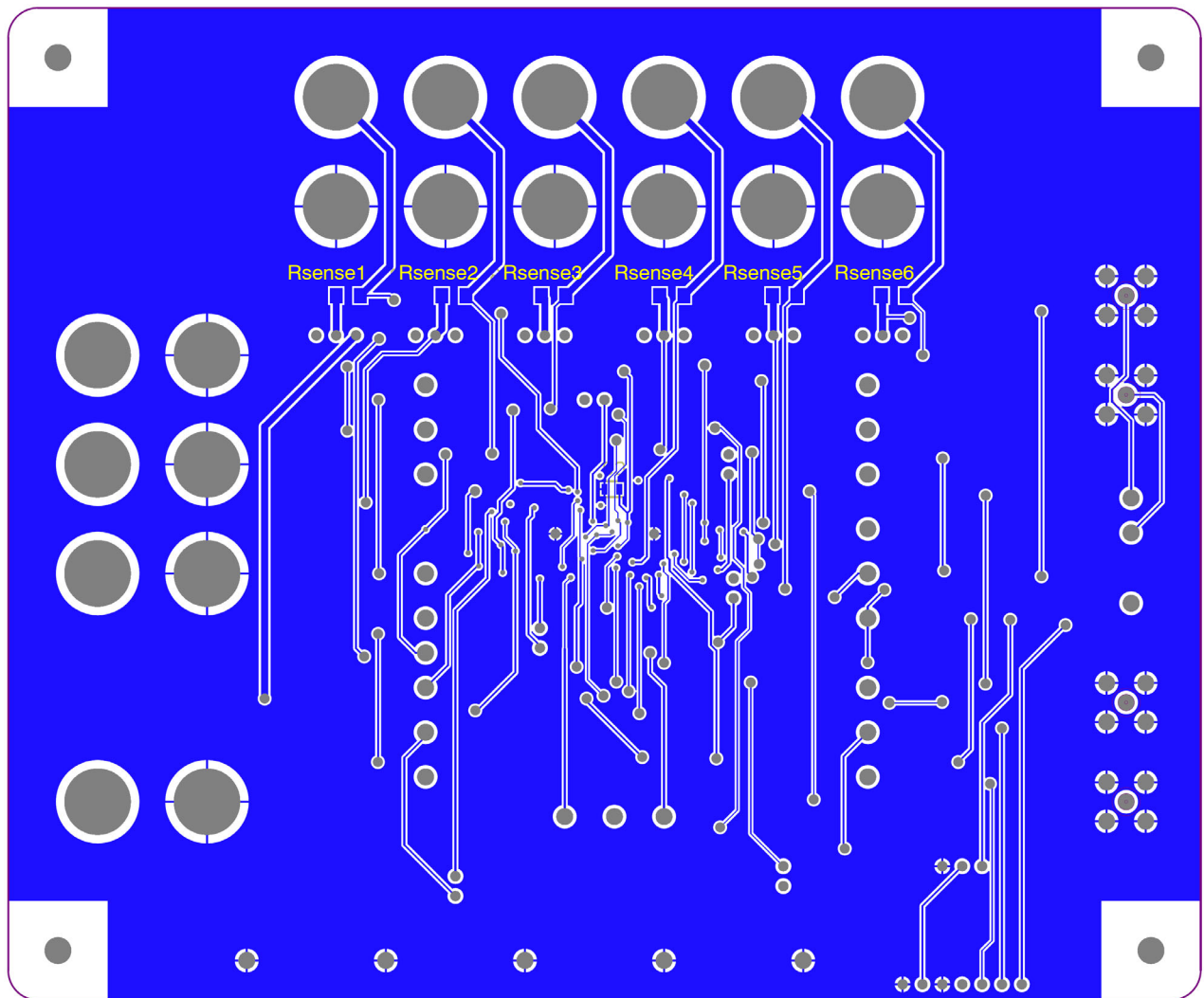


Figure 3. PCB Backside (Bottom Metallization)

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