Test Report: PMP23377

Four-Switch, Buck-Boost DC/DC Converter Reference Design

**TEXAS INSTRUMENTS**

Description

This reference design is a four-switch, buck-boost DC/DC converter used for battery backup unit (BBU) applications, targeting Open Compute Project® (OCP) Open Rack V3 Power BBU specifications. This design has a 1.4kW power capability. The converter works in either buck, buck-boost, or boost mode depending on the V_{in} and V_{out} voltage. The converter transients smoothly between each mode. Peak current mode control is employed in this design, providing a fast load transient response. Relying on the LM51770 features, no extra driver is needed for field-effect transistors.

Features

- 1.4kW power capability per phase then N number of phases can be connected in parallel for higher power battery discharge operation
- Bidirectional conversion under varying V_{in}–V_{out}
- Multimode operation: seamless transitions between buck to buck-boost and buck-boost to boost
- Integrated average input and output current monitor or limiter either in input or output
- Peak efficiency > 98.5%. Exceptional high load efficiency for $V_{in} \cong V_{out}$ over the full range of the output current
- Meets OCP-V3, 50V BBU power conversion function
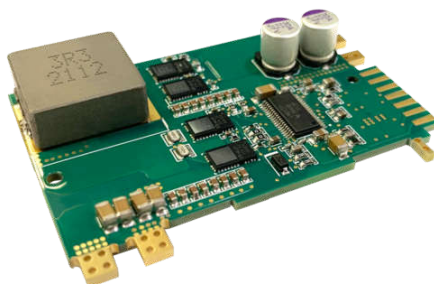
Applications

- Battery backup unit (BBU)
- Rack and server power
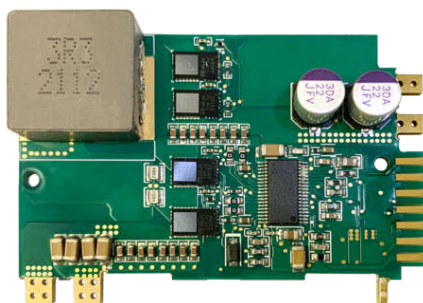
Top of Board
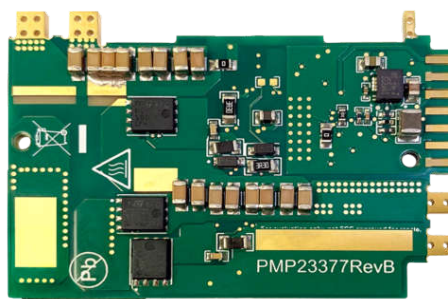
Bottom of Board

Angled Board

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
V_{in} (Battery)	36V to 56V
V_{out} (System)	53V
Switching Frequency	200kHz
Maximum Discharge Current	22.64A
Peak Efficiency	98.5%

1.2 Required Equipment

- DC source: 80V, 50A
- Electronics load: 100V, 300A
- DC source: 12V, 1A
- DC source: 12V, 2A - Fan

1.3 Dimensions

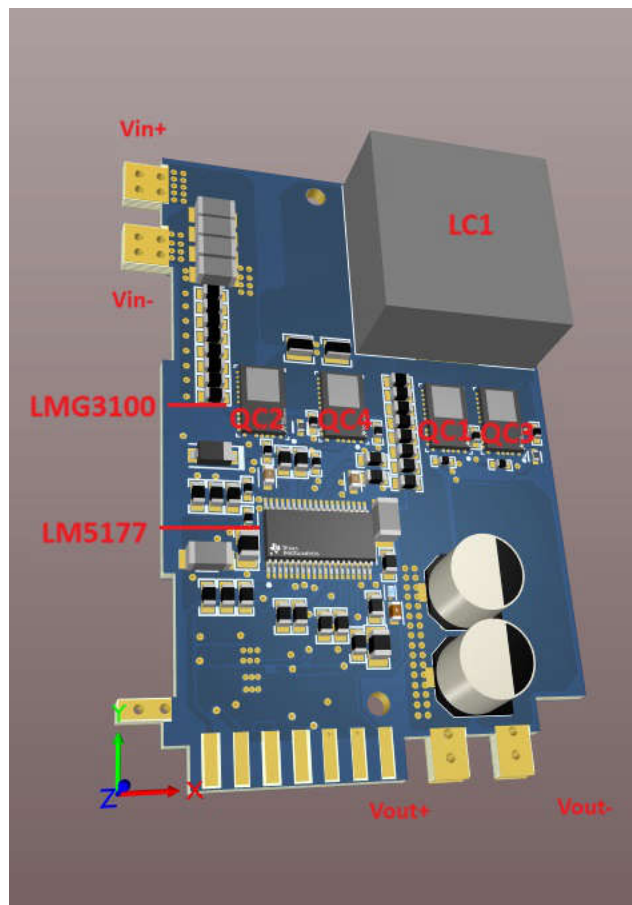Length × width: 58.9mm × 40.5mm; height: 16mm (PCB thickness: 1.6mm).

1.4 Test Setup

Figure 1-1. Test Setup

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in Figure 2-1 through Figure 2-4 for 42V_{in}, 48V_{in}, 53V_{in}, and 58V_{in} to 53V_{out}.
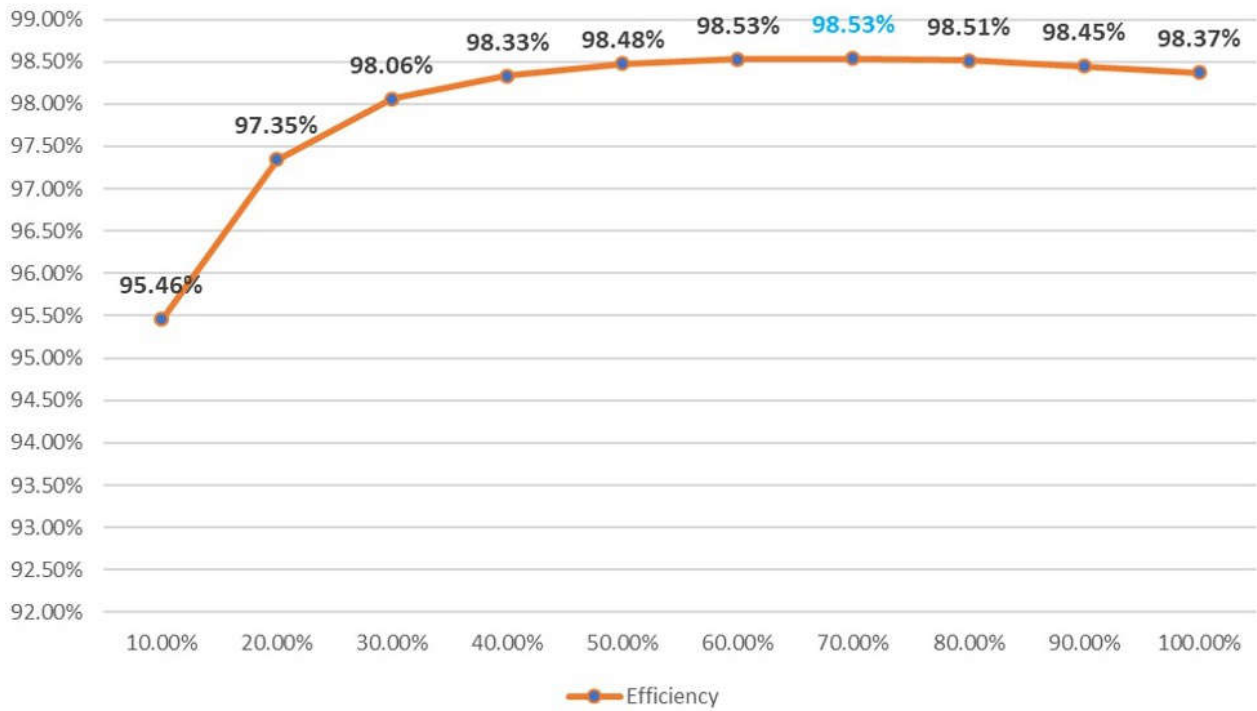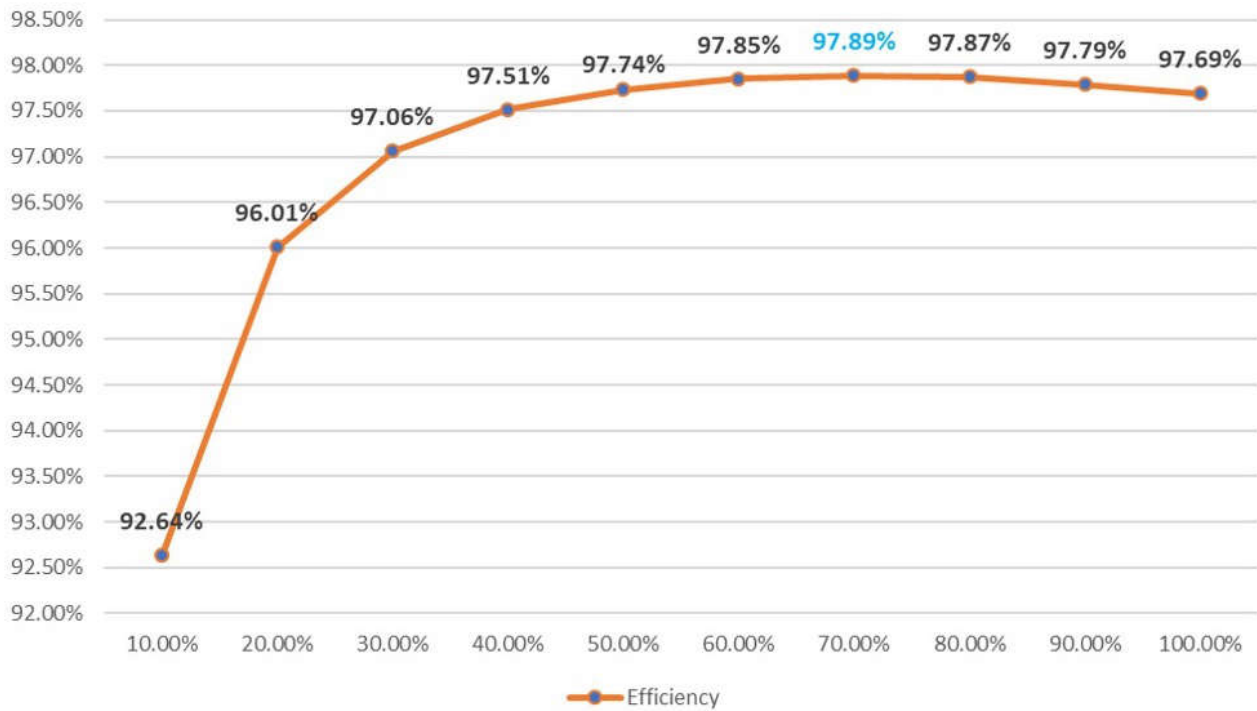

Figure 2-1. Efficiency at V_{in} = 42V, V_{out} = 53V

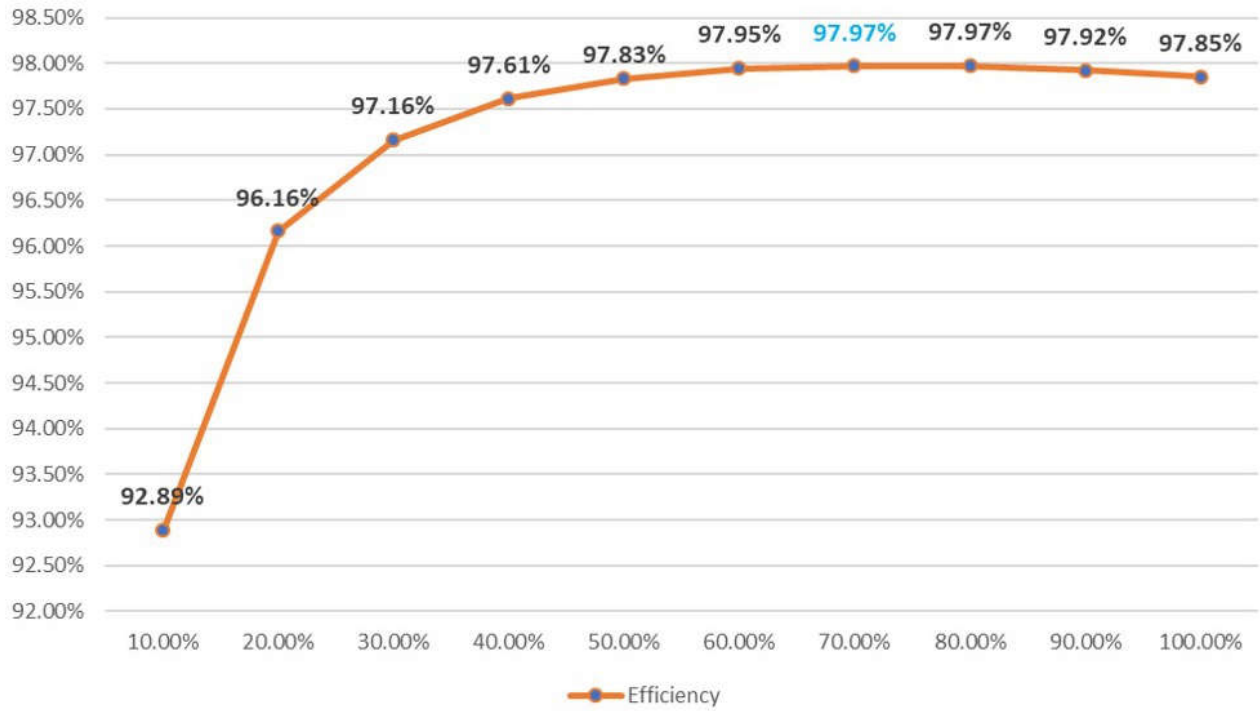**Figure 2-2. Efficiency at V_{in} = 48V, V_{out} = 53V**

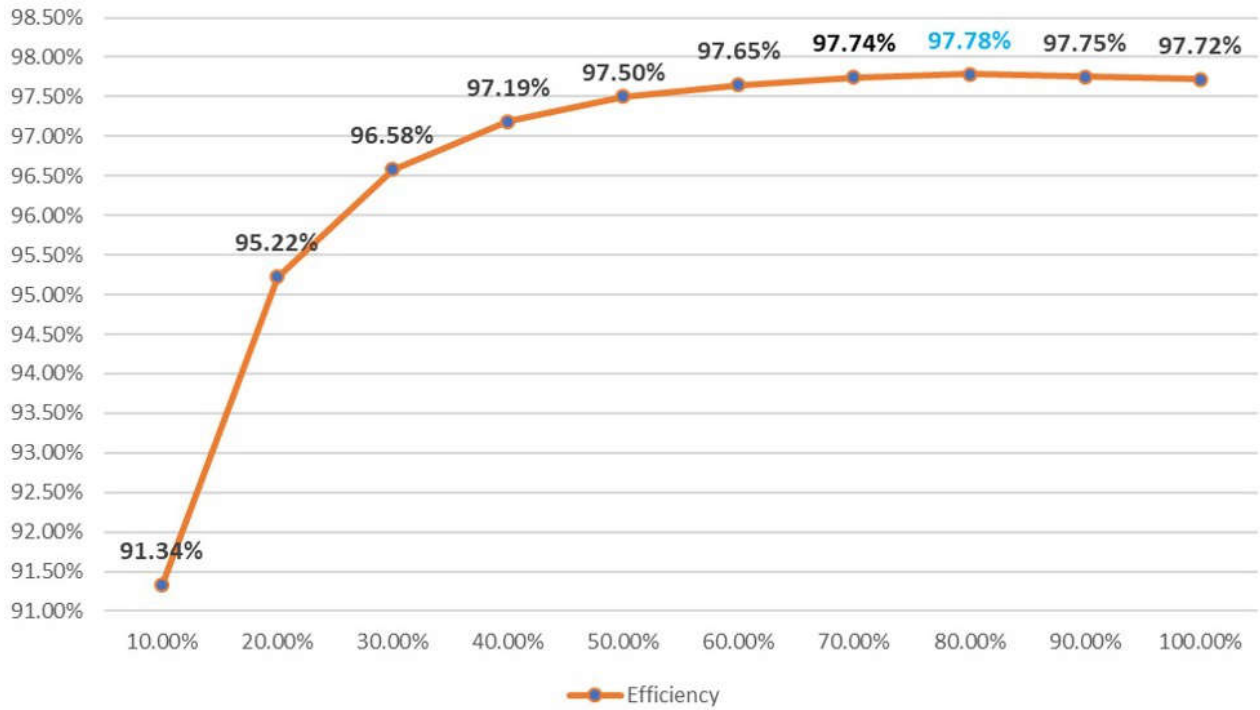**Figure 2-3. Efficiency at V$_{in}$ = 53V, V$_{out}$ = 53V**

Figure 2-4. Efficiency at V$_{in}$ = 58V, V$_{out}$ = 53V

2.2 Efficiency Data

Efficiency data is shown in Table 2-1 through Table 2-4.

Table 2-1. 42V to 53V Efficiency Data

V$_{in}$ (V)	I$_{in}$ (A)	V$_{out}$ (V)	I$_{out}$ (A)	EFFICIENCY (%)	TEMPERATURE (°C)
42.007	2.9964	53.046	2.265	95.46	43.2
42	5.8835	53.043	4.535	97.35	42.2
42.003	8.7631	53.041	6.805	98.06	45.7
42.007	11.653	53.042	9.075	98.33	49.6
42	14.55	53.044	11.345	98.48	52.9
42.003	17.45	53.042	13.615	98.53	61.4
42.004	20.358	53.042	15.885	98.53	66.2
42.005	23.272	53.044	18.155	98.51	72.4
42.007	26.199	53.046	20.425	98.45	80.9
42	29.14	53.049	22.695	98.37	89.2

Table 2-2. 48V to 53V Efficiency data

V$_{in}$ (V)	I$_{in}$ (A)	V$_{out}$ (V)	I$_{out}$ (A)	EFFICIENCY (%)	TEMPERATURE (°C)
48.001	2.7015	53.038	2.27	92.64	49.6
48.009	5.218	53.034	4.54	96.01	55.3
48.005	7.7451	53.031	6.81	97.06	59
48.003	10.28	53.025	9.08	97.51	63.3
48.001	12.823	53.026	11.35	97.74	68.5
48.008	15.37	53.032	13.62	97.85	74.8
48.005	17.927	53.031	15.89	97.89	81.6
48.001	20.494	53.033	18.16	97.87	90.2
48.006	23.079	53.046	20.43	97.79	102.6
48.004	25.677	53.057	22.7	97.69	115.2

Table 2-3. 53V to 53V Efficiency Data

V$_{in}$ (V)	I$_{in}$ (A)	V$_{out}$ (V)	I$_{out}$ (A)	EFFICIENCY (%)	TEMPERATURE (°C)
53.003	2.4395	53.026	2.27	92.89	51.3
53.004	4.7175	53.02	4.54	96.16	54.2
53.004	7.0057	53.017	6.81	97.16	57.5
53.004	9.299	53.015	9.08	97.61	61.4
53.005	11.599	53.015	11.35	97.83	65.7
53.005	13.904	53.018	13.62	97.95	71.7
53.005	16.22	53.023	15.89	97.97	78.5
53.004	18.538	53.025	18.16	97.97	86.1
53.003	20.869	53.03	20.43	97.92	94.9
53.003	23.207	53.034	22.7	97.85	104.9

Table 2-4. 58V to 53V Efficiency Data

V$_{in}$ (V)	I$_{in}$ (A)	V$_{out}$ (V)	I$_{out}$ (A)	EFFICIENCY (%)	TEMPERATURE (°C)
58.006	2.2678	53.047	2.27	91.34	52.6
58.009	4.3548	53.042	4.54	95.22	53.6
58.003	6.4423	53.034	6.81	96.58	57.2
58.006	8.536	53.028	9.08	97.19	61.1
58.01	10.635	53.019	11.35	97.50	65.8
58.001	12.745	53.017	13.62	97.65	71
58.004	14.855	53.019	15.89	97.74	77
58.006	16.971	53.022	18.16	97.78	84.1
58.002	19.102	53.027	20.43	97.75	92.6
58.004	21.234	53.032	22.7	97.72	101.7

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