Test Report: PMP21966

Automotive 1.1-V, 60-A, 3-Phase Synchronous Buck Converter Reference Design

TEXAS INSTRUMENTS

Description

This synchronous buck converter was designed for a high-current automotive Engine Control Unit (ECU). This design combines the TPS59632-Q1, 24-V, 3-phase step-down driverless controller and state-of-the-art automotive DrMOS. The compact size and high efficiency make the design an excellent choice for low-voltage, high-current rails in automotive applications.
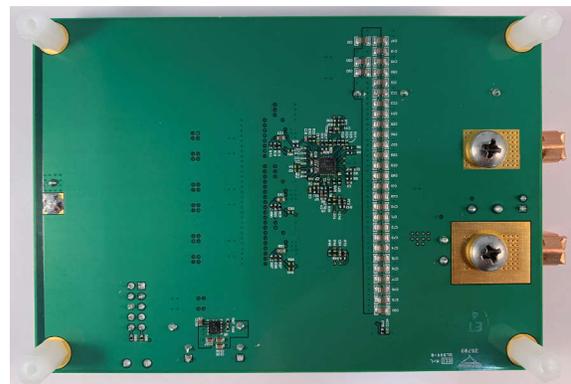
Features

- Automotive input range, 8 V to 18 V
- 0.9 V to 1.1 V, 60-A high current rail
- Peak efficiency 89.6% at 1 MHz
- Compact size 1.2 in × 1.6 in
- Fast dynamic response
- Excellent current sharing

Applications

- Drive assist ECU
- Radar ECU

Top of Board

Bottom of Board

1 Test Prerequisites

1.1 Voltage and Current Requirements

Parameter	Specifications
Input voltage, V_{IN}	8 V to 18 V
Output Voltage, V_{OUT}	0.9 V to 1.1 V, 60 A

1.2 Required Equipment

- Power Supply: 0 V to 30 V, 0 A to 15 A
- Load: 1.1 V, 60 A

2 Testing and Results

2.1 Current Sharing

Table 2-1. Three-Phase Current Sharing Data

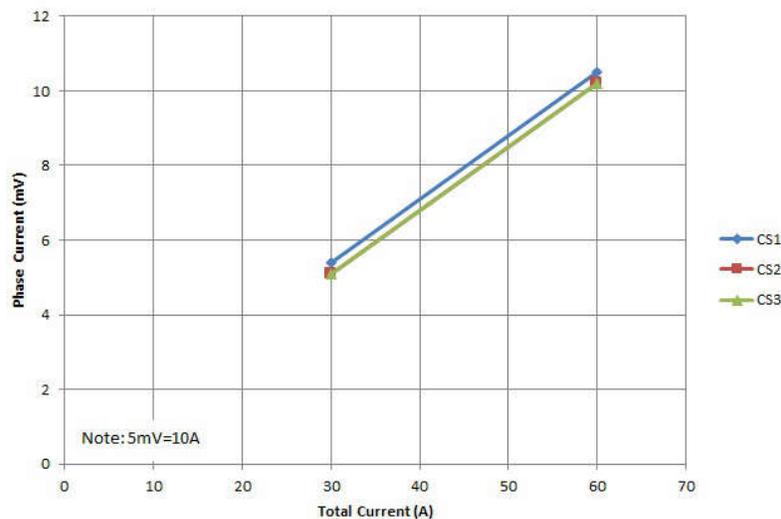|	Phase I	Phase II	Phase III
30 A (Measured across IND)	7.7 mV	7.3 mV	7.3 mV
30 A (Measured across CS capacitor)	5.4 mV	5.1 mV	5.1 mV
60 A (Measured across IND)	15.6 mV	15.6 mV	15.3 mV
60 A (Measured across CS capacitor)	10.5 mV	10.2 mV	10.2 mV

Figure 2-1 shows the current-sharing graph.

Figure 2-1. Current Sharing

2.2 Efficiency Graphs

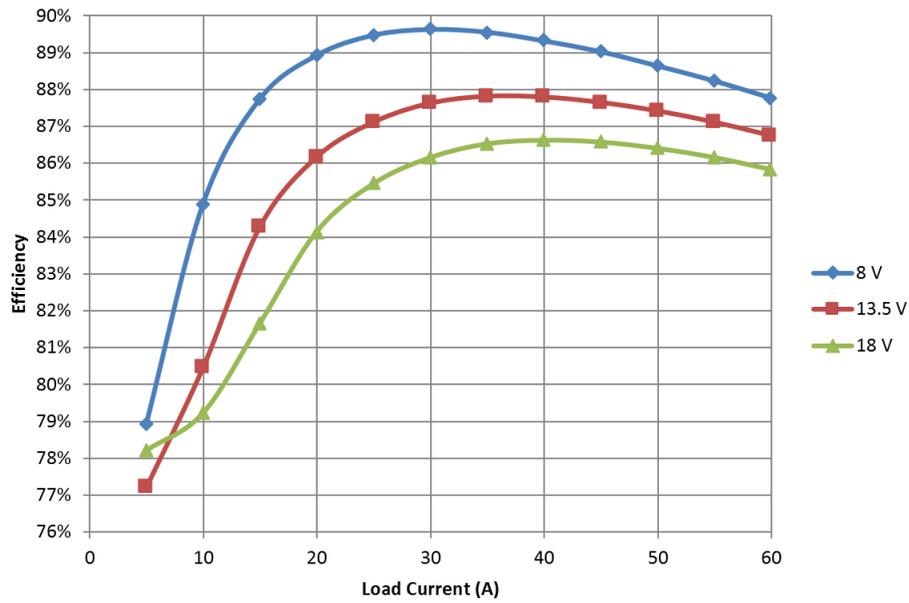shows the PMP21966 efficiency graph at 1.1 V, 1 MHz.

**Figure 2-2. PMP21966 Efficiency Graph at 1.1 V, 1 MHz**

2.3 Efficiency Data

Efficiency data is shown in the following table.

Table 2-2. PMP21966 Test Conditions: 1.1 V_{OUT}, 1000 kHz

V_{IN} (V)	V_{OUT} (V)	V5V	I_{IN}	I_{OUT}	I5v	Efficiency	P_{LOSS}
7.995	1.100	4.947	0.797	4.988	0.118	78.9%	1.47
7.990	1.102	4.944	1.544	9.984	0.125	84.9%	1.96
7.985	1.103	4.944	2.281	14.980	0.125	87.7%	2.31
7.980	1.104	4.944	3.030	19.974	0.126	88.9%	2.75
7.976	1.106	4.944	3.792	24.971	0.126	89.5%	3.25
7.970	1.107	4.944	4.567	29.967	0.126	89.6%	3.84
7.965	1.109	4.944	5.355	34.961	0.127	89.6%	4.52
7.960	1.110	4.943	6.158	39.953	0.128	89.3%	5.30
7.955	1.112	4.943	6.975	44.944	0.128	89.0%	6.16
7.950	1.113	4.943	7.806	49.932	0.129	88.6%	7.12
7.945	1.115	4.943	8.651	54.914	0.130	88.2%	8.16
7.939	1.116	4.943	9.513	59.891	0.130	87.8%	9.31
13.514	1.100	4.959	0.495	4.988	0.084	77.2%	1.62
13.511	1.102	4.947	0.969	9.984	0.119	80.5%	2.67
13.508	1.103	4.946	1.407	14.980	0.122	84.3%	3.09
13.506	1.105	4.946	1.852	19.975	0.122	86.2%	3.55
13.503	1.106	4.946	2.304	24.972	0.122	87.1%	4.09
13.500	1.108	4.945	2.762	29.968	0.122	87.6%	4.69
13.497	1.109	4.945	3.227	34.961	0.123	87.8%	5.39
13.494	1.110	4.945	3.700	39.955	0.123	87.8%	6.17
13.491	1.112	4.945	4.180	44.945	0.124	87.6%	7.05
13.488	1.113	4.945	4.669	49.933	0.124	87.4%	8.01
13.485	1.115	4.944	5.166	54.913	0.125	87.1%	9.06
13.481	1.116	4.944	5.670	59.890	0.126	86.7%	10.21
18.001	1.100	4.970	0.375	4.989	0.054	78.2%	1.53
17.998	1.102	4.954	0.744	9.984	0.098	79.2%	2.88
17.996	1.103	4.950	1.094	14.981	0.111	81.7%	3.71
17.994	1.104	4.949	1.426	19.975	0.111	84.1%	4.16
17.992	1.106	4.949	1.766	24.972	0.112	85.5%	4.70
17.990	1.108	4.949	2.110	29.969	0.113	86.2%	5.33
17.988	1.109	4.949	2.460	34.961	0.113	86.5%	6.03
17.985	1.110	4.949	2.816	39.955	0.114	86.6%	6.84
17.983	1.112	4.948	3.178	44.946	0.115	86.6%	7.74
17.981	1.113	4.948	3.546	49.932	0.115	86.4%	8.74
17.979	1.115	4.948	3.920	54.914	0.116	86.2%	9.83
17.976	1.116	4.948	4.300	59.891	0.117	85.8%	11.03

2.4 Thermal Images

The thermal image is shown in the following figure.
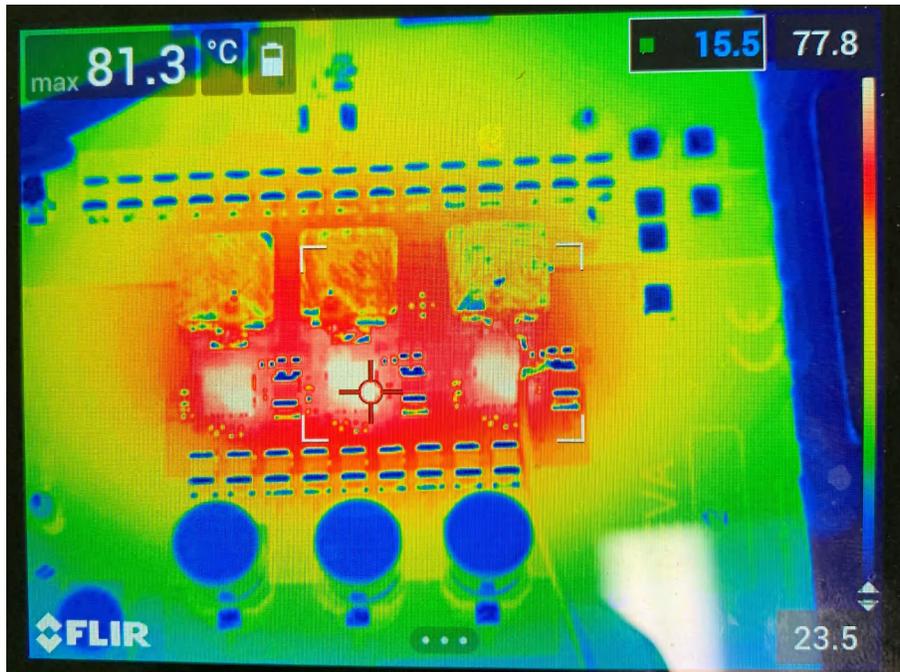
Test conditions: 12 V_{IN}, 1 V, 45 A_{OUT}, 1000 kHz, room temperature, natural convection, T_{FET} = 81.3°C, T_{IND} = 59.2°C

Figure 2-3. Thermal Image

3 Waveforms

3.1 Start-up and Shutdown

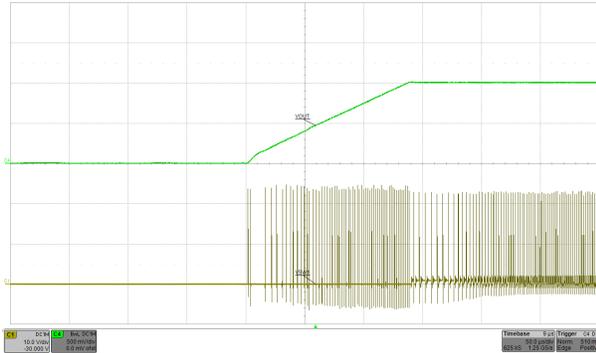Start-up behavior is shown in the following figures.

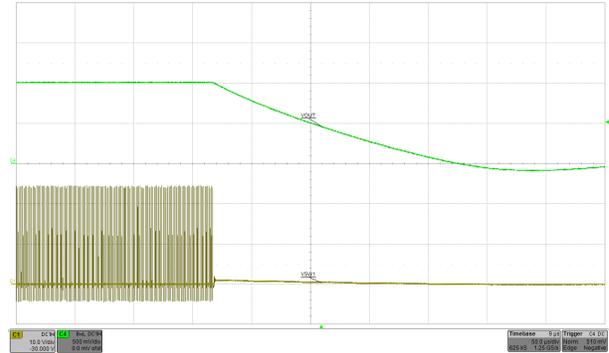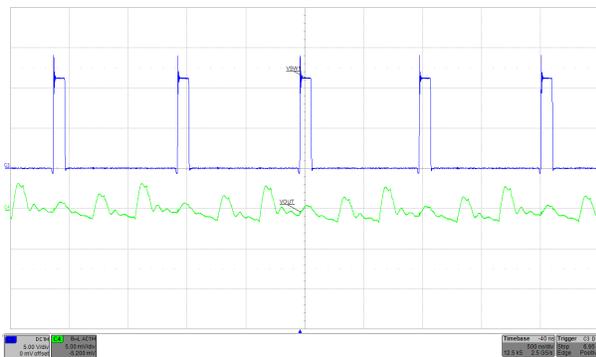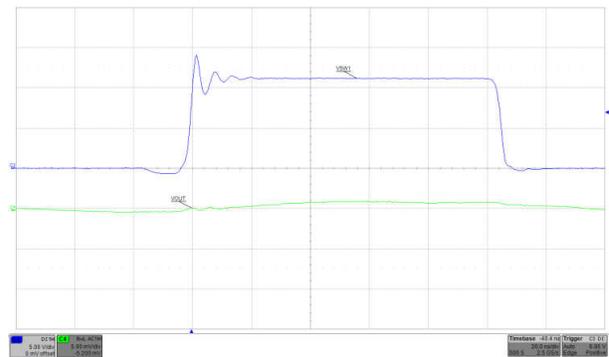**Figure 3-1. Turn-On, 12 V$_{IN}$, 1 V$_{OUT}$, 10 A**

Figure 3-2. Turn-Off, 12 V$_{IN}$, 1 V$_{OUT}$, 10 A

3.2 Ripple and Switching Node

The following images illustrate the ripple and switching node waveforms.

15 × 100 μF, 4 V, 1210 + 30 × 22 μF, 6.3 V, 0805

Figure 3-3. 12 V$_{IN}$, 1.1 V$_{OUT}$, 45-A Load, 5 mV (±0.25%)

15 × 100 μF, 4 V, 1210 + 30 × 22 μF, 6.3 V, 0805

Figure 3-4. 12 V$_{IN}$, 1.1 V$_{OUT}$, 45-A Load, 14 V$_{MAX}$
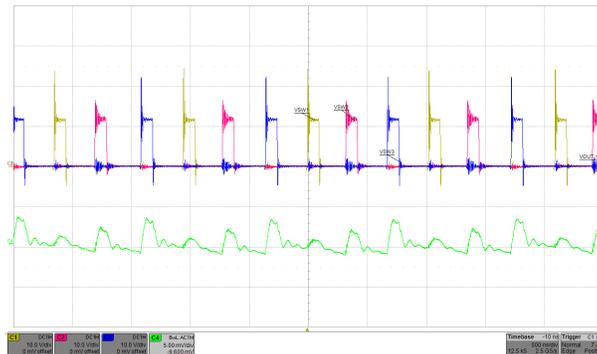
Figure 3-5. 12 V$_{IN}$, 1.1 V$_{OUT}$, 45-A Load, Three-Phase

3.3 Load Transients

Load transient response is shown in the following figures.
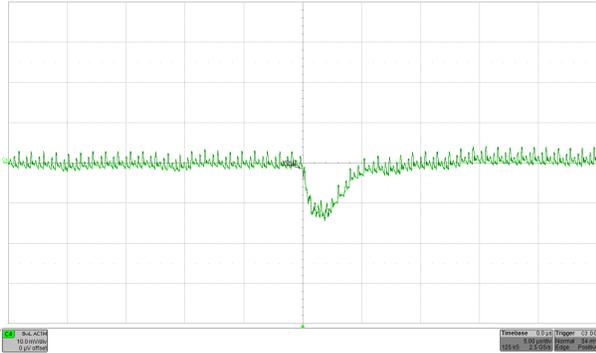
Figure 3-6. 12 V$_{IN}$, 1.1 V$_{OUT}$, 15-A to 45-A Load Step, –12 mV (–1.1%)
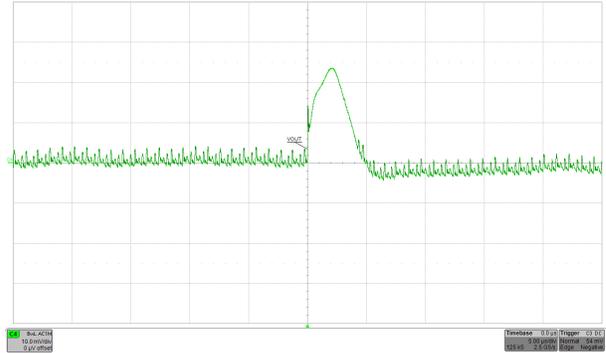
Figure 3-7. 12 V$_{IN}$, 1.1 V$_{OUT}$, 45-A to 15-A Load Step, +24 mV (–2.2%)

3.4 Overcurrent Protection, Short-Circuit Protection

Overload and short-circuit protection is shown in the following figures.
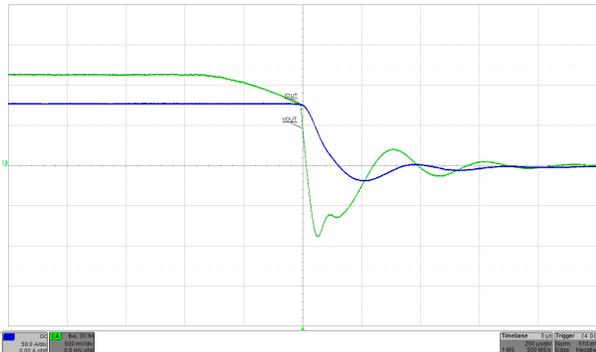
Figure 3-8. 12 V$_{IN}$, 1.1 V$_{OUT}$, Overload Applied, OCP = 75 A
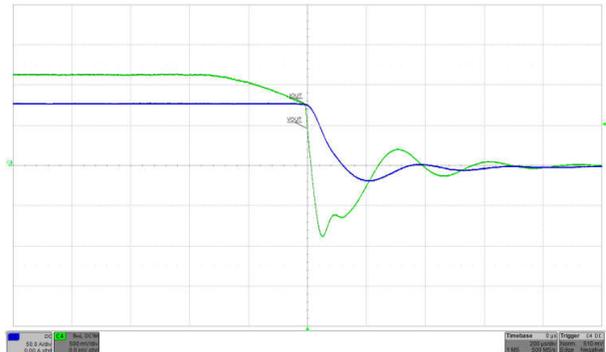
Figure 3-9. 12 V$_{IN}$, 1.1 V$_{OUT}$, Short-Circuit Applied, SCP = 75 A

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