*Test Report: PMP23637*

# *Compact Dual-Phase Multi-Cell Battery Charger Reference Design With Dual FETs*

## Description

This reference design features the BQ25770/ BQ25773, 2-to-5 cell NVDC quasi-dual-phase buck-boost battery charge controller in a high-density design for notebook PC and portable applications. The dual-phase topology utilizes two small inductors and two half bridge dual-FETs, thus minimizing hot spots and spreading heat across the board. The topology also supports a 2-to-5 cell battery and accepts a wide input range including USB adapter, high voltage USB-C® Power Delivery (PD) sources, and traditional adapters.

## Features

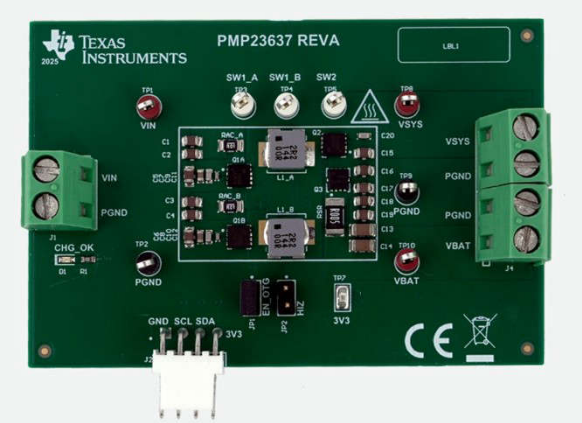
- High power 240W
- Peak efficiency 98.2%
- Dual Field Effect Transistor (FET) in 3.3mm × 3.3mm package
- Compact size: 0.75in × 1.15in (19.1mm × 29.2mm)
- Excellent thermal performance

## Applications

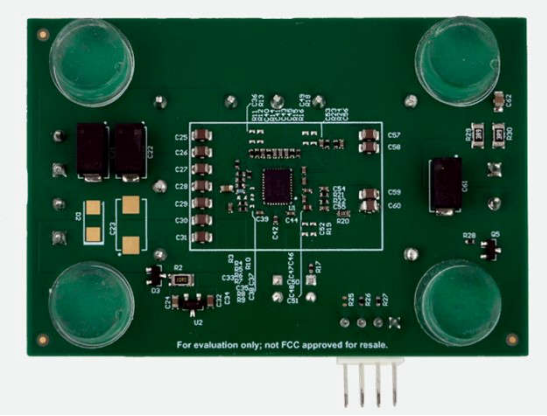
- Standard notebook PC
- Tablet (multimedia)
- Chromebook and WOA

## Resources

| | |
|---|---|
| BQ25773 | Product Folder |
| LM3480 | Product Folder |




**Top View**




**Bottom View**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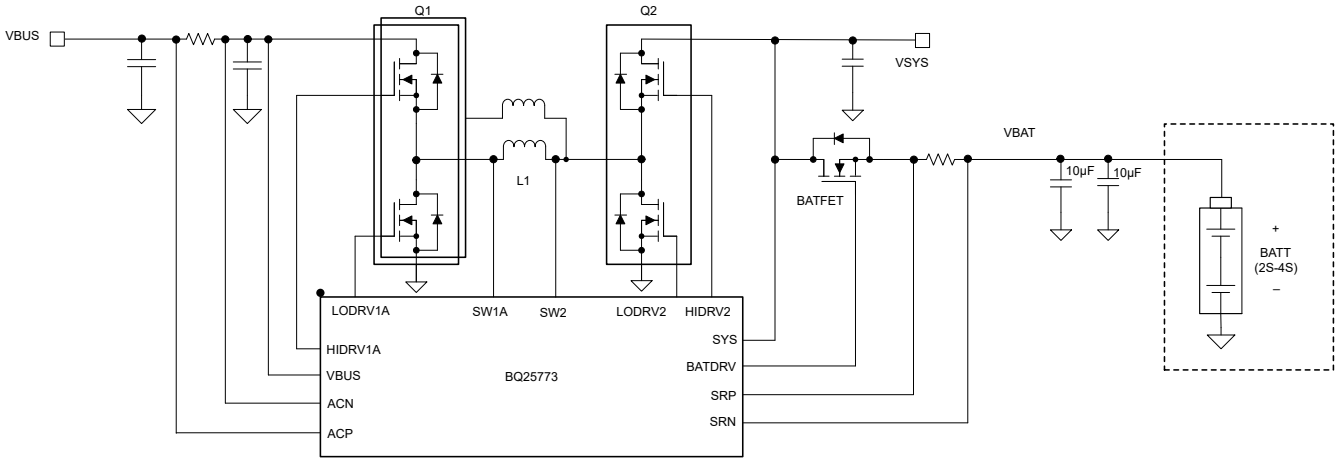


**Block Diagram**

# 1 Test Prerequisites

## 1.1 Voltage and Current Requirements

**Table 1-1. Voltage and Current Requirements**

| Parameter | Specifications |
|---|---|
| Input voltage, Vin | 3.5 – 20V / 240W |
| Output voltage, Vo | 9 – 17.8V / 240W |
| Input current | 8.2A (10mΩ) / 16.4A (5mΩ) maximum |
| Output current | 16.3A (5mΩ) maximum |

**Note**

Input voltage can extend to 28V or 36V using high-voltage FETs.

## 1.2 Required Equipment

- Main power supply: 0-20V, 0-12A
- Bipolar power supply: 20V, ±12A
- EV2400 or USB2ANY interface device (This design does not include the EV2400 or USB2ANY interface device; the EV2400 or USB2ANY must be ordered separately.)

## 1.3 Dimensions

0.75in × 1.15in (19.1mm × 29.2mm)



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# 2 Testing and Results

## 2.1 System Efficiency Graphs

The efficiency while providing power to the system output is shown in Figure 2-1. For this test, the charging current was 0A, and the input voltage was 20V.

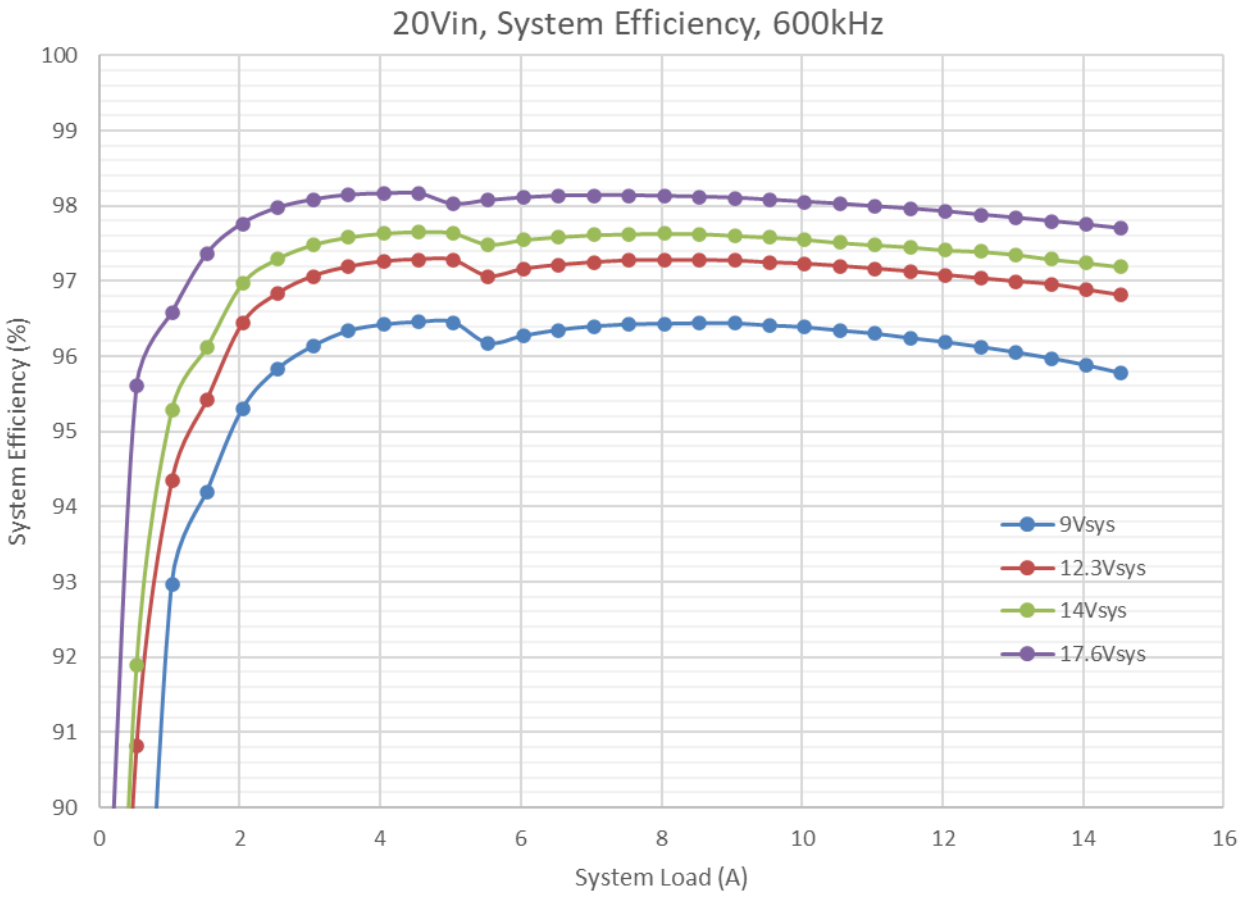


**Figure 2-1. System Efficiency Graph**


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## 2.2 System Efficiency Data

System efficiency data is shown in Table 2-1.

**Table 2-1. Efficiency Data**

| $V_{BUS}$ (V) | $I_{BUS}$ (A) | $V_{SYS}$ (V) | $I_{SYS}$ (A) | $P_{LOSS}$ (W) | System Efficiency (%) |
|---|---|---|---|---|---|
| 19.998 | 0.086 | 9.002 | 0.149 | 0.380 | 77.96 |
| 19.994 | 0.285 | 9.004 | 0.537 | 0.861 | 84.89 |
| 19.991 | 0.503 | 9.002 | 1.038 | 0.706 | 92.97 |
| 19.986 | 0.736 | 9.003 | 1.540 | 0.853 | 94.20 |
| 19.982 | 0.965 | 9.000 | 2.041 | 0.907 | 95.29 |
| 19.978 | 1.195 | 9.000 | 2.542 | 0.996 | 95.83 |
| 19.974 | 1.428 | 8.999 | 3.046 | 1.103 | 96.13 |
| 19.969 | 1.660 | 8.999 | 3.548 | 1.215 | 96.33 |
| 19.965 | 1.892 | 8.998 | 4.048 | 1.353 | 96.42 |
| 19.961 | 2.126 | 8.998 | 4.549 | 1.506 | 96.45 |
| 19.957 | 2.353 | 8.998 | 5.034 | 1.666 | 96.45 |
| 19.953 | 2.596 | 8.998 | 5.535 | 1.981 | 96.17 |
| 19.949 | 2.828 | 8.997 | 6.037 | 2.106 | 96.27 |
| 19.944 | 3.061 | 8.998 | 6.537 | 2.230 | 96.35 |
| 19.940 | 3.295 | 8.997 | 7.039 | 2.368 | 96.40 |
| 19.936 | 3.529 | 8.996 | 7.540 | 2.518 | 96.42 |
| 19.931 | 3.764 | 8.996 | 8.042 | 2.680 | 96.43 |
| 19.927 | 3.999 | 8.996 | 8.542 | 2.839 | 96.44 |
| 19.923 | 4.235 | 8.996 | 9.044 | 3.007 | 96.44 |
| 19.919 | 4.465 | 8.996 | 9.530 | 3.196 | 96.41 |
| 19.915 | 4.702 | 8.996 | 10.032 | 3.386 | 96.38 |
| 19.910 | 4.940 | 8.996 | 10.533 | 3.601 | 96.34 |
| 19.906 | 5.178 | 8.995 | 11.035 | 3.815 | 96.30 |
| 19.901 | 5.420 | 8.996 | 11.540 | 4.057 | 96.24 |
| 19.897 | 5.660 | 8.995 | 12.042 | 4.296 | 96.19 |
| 19.892 | 5.900 | 8.995 | 12.542 | 4.552 | 96.12 |
| 19.888 | 6.142 | 8.996 | 13.044 | 4.825 | 96.05 |
| 19.884 | 6.385 | 8.995 | 13.545 | 5.118 | 95.97 |
| 19.879 | 6.629 | 8.995 | 14.047 | 5.431 | 95.88 |
| 19.875 | 6.867 | 8.995 | 14.532 | 5.766 | 95.77 |
| 19.870 | 7.110 | 8.995 | 15.034 | 6.047 | 95.72 |
| 19.866 | 7.355 | 8.995 | 15.535 | 6.380 | 95.63 |
| 19.861 | 7.605 | 8.995 | 16.037 | 6.787 | 95.51 |
| 19.997 | 0.108 | 12.307 | 0.145 | 0.372 | 82.77 |
| 19.993 | 0.363 | 12.306 | 0.536 | 0.667 | 90.81 |
| 19.987 | 0.677 | 12.305 | 1.037 | 0.766 | 94.34 |
| 19.981 | 0.994 | 12.305 | 1.540 | 0.908 | 95.43 |
| 19.976 | 1.303 | 12.301 | 2.041 | 0.928 | 96.43 |
| 19.970 | 1.617 | 12.301 | 2.543 | 1.023 | 96.83 |
| 19.964 | 1.934 | 12.301 | 3.047 | 1.134 | 97.06 |
| 19.958 | 2.250 | 12.300 | 3.549 | 1.262 | 97.19 |
| 19.952 | 2.566 | 12.300 | 4.049 | 1.403 | 97.26 |
| 19.946 | 2.884 | 12.299 | 4.550 | 1.562 | 97.29 |



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**Table 2-1. Efficiency Data (continued)**

| $V_{BUS}$ (V) | $I_{BUS}$ (A) | $V_{SYS}$ (V) | $I_{SYS}$ (A) | $P_{LOSS}$ (W) | System Efficiency (%) |
|---|---|---|---|---|---|
| 19.941 | 3.193 | 12.299 | 5.035 | 1.733 | 97.28 |
| 19.935 | 3.519 | 12.298 | 5.536 | 2.059 | 97.06 |
| 19.930 | 3.835 | 12.298 | 6.038 | 2.171 | 97.16 |
| 19.924 | 4.151 | 12.298 | 6.538 | 2.305 | 97.21 |
| 19.918 | 4.470 | 12.298 | 7.040 | 2.450 | 97.25 |
| 19.913 | 4.788 | 12.298 | 7.541 | 2.600 | 97.27 |
| 19.907 | 5.108 | 12.297 | 8.043 | 2.770 | 97.28 |
| 19.901 | 5.427 | 12.297 | 8.543 | 2.945 | 97.27 |
| 19.895 | 5.748 | 12.297 | 9.045 | 3.122 | 97.27 |
| 19.890 | 6.060 | 12.297 | 9.531 | 3.322 | 97.24 |
| 19.884 | 6.382 | 12.297 | 10.033 | 3.515 | 97.23 |
| 19.878 | 6.704 | 12.297 | 10.533 | 3.733 | 97.20 |
| 19.872 | 7.029 | 12.297 | 11.036 | 3.962 | 97.16 |
| 19.866 | 7.355 | 12.297 | 11.541 | 4.198 | 97.13 |
| 19.860 | 7.681 | 12.297 | 12.043 | 4.457 | 97.08 |
| 19.854 | 8.006 | 12.297 | 12.543 | 4.712 | 97.04 |
| 19.848 | 8.332 | 12.297 | 13.044 | 4.972 | 96.99 |
| 19.841 | 8.659 | 12.297 | 13.546 | 5.227 | 96.96 |
| 19.836 | 8.989 | 12.297 | 14.048 | 5.559 | 96.88 |
| 19.829 | 9.309 | 12.297 | 14.532 | 5.882 | 96.81 |
| 19.996 | 0.122 | 14.011 | 0.146 | 0.403 | 83.54 |
| 19.991 | 0.409 | 14.010 | 0.536 | 0.662 | 91.90 |
| 19.985 | 0.763 | 14.009 | 1.038 | 0.720 | 95.28 |
| 19.978 | 1.123 | 14.010 | 1.540 | 0.870 | 96.12 |
| 19.972 | 1.476 | 14.006 | 2.041 | 0.895 | 96.97 |
| 19.965 | 1.833 | 14.005 | 2.543 | 0.990 | 97.29 |
| 19.959 | 2.194 | 14.005 | 3.047 | 1.103 | 97.48 |
| 19.952 | 2.553 | 14.004 | 3.549 | 1.232 | 97.58 |
| 19.946 | 2.912 | 14.003 | 4.049 | 1.375 | 97.63 |
| 19.939 | 3.273 | 14.003 | 4.551 | 1.530 | 97.66 |
| 19.933 | 3.624 | 14.003 | 5.036 | 1.707 | 97.64 |
| 19.927 | 3.991 | 14.003 | 5.537 | 1.998 | 97.49 |
| 19.920 | 4.351 | 14.003 | 6.039 | 2.126 | 97.55 |
| 19.914 | 4.711 | 14.002 | 6.538 | 2.264 | 97.59 |
| 19.907 | 5.073 | 14.002 | 7.040 | 2.412 | 97.61 |
| 19.900 | 5.436 | 14.002 | 7.542 | 2.570 | 97.62 |
| 19.894 | 5.799 | 14.002 | 8.044 | 2.733 | 97.63 |
| 19.887 | 6.162 | 14.002 | 8.544 | 2.910 | 97.63 |
| 19.880 | 6.527 | 14.002 | 9.046 | 3.110 | 97.60 |
| 19.874 | 6.882 | 14.002 | 9.532 | 3.309 | 97.58 |
| 19.867 | 7.249 | 14.002 | 10.033 | 3.524 | 97.55 |
| 19.861 | 7.616 | 14.002 | 10.534 | 3.769 | 97.51 |
| 19.854 | 7.984 | 14.002 | 11.036 | 3.999 | 97.48 |
| 19.847 | 8.355 | 14.002 | 11.541 | 4.227 | 97.45 |
| 19.840 | 8.725 | 14.001 | 12.043 | 4.484 | 97.41 |
| 19.834 | 9.092 | 14.002 | 12.543 | 4.705 | 97.39 |


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**Table 2-1. Efficiency Data (continued)**

| $V_{BUS}$ (V) | $I_{BUS}$ (A) | $V_{SYS}$ (V) | $I_{SYS}$ (A) | $P_{LOSS}$ (W) | System Efficiency (%) |
|---|---|---|---|---|---|
| 19.827 | 9.463 | 14.002 | 13.044 | 4.968 | 97.35 |
| 19.820 | 9.836 | 14.001 | 13.546 | 5.288 | 97.29 |
| 19.813 | 10.209 | 14.002 | 14.048 | 5.582 | 97.24 |
| 19.806 | 10.571 | 14.002 | 14.532 | 5.890 | 97.19 |
| 19.996 | 0.145 | 17.613 | 0.146 | 0.329 | 88.70 |
| 19.990 | 0.494 | 17.612 | 0.536 | 0.434 | 95.60 |
| 19.982 | 0.947 | 17.609 | 1.038 | 0.648 | 96.58 |
| 19.973 | 1.394 | 17.607 | 1.540 | 0.733 | 97.37 |
| 19.965 | 1.842 | 17.608 | 2.041 | 0.823 | 97.76 |
| 19.957 | 2.290 | 17.607 | 2.543 | 0.927 | 97.97 |
| 19.948 | 2.743 | 17.606 | 3.048 | 1.051 | 98.08 |
| 19.940 | 3.193 | 17.606 | 3.549 | 1.183 | 98.14 |
| 19.932 | 3.644 | 17.606 | 4.050 | 1.338 | 98.16 |
| 19.924 | 4.097 | 17.606 | 4.551 | 1.502 | 98.16 |
| 19.916 | 4.542 | 17.606 | 5.036 | 1.788 | 98.02 |
| 19.909 | 4.993 | 17.606 | 5.537 | 1.918 | 98.07 |
| 19.900 | 5.446 | 17.606 | 6.039 | 2.051 | 98.11 |
| 19.892 | 5.897 | 17.606 | 6.539 | 2.193 | 98.13 |
| 19.884 | 6.353 | 17.606 | 7.041 | 2.354 | 98.14 |
| 19.876 | 6.808 | 17.605 | 7.542 | 2.522 | 98.14 |
| 19.867 | 7.264 | 17.605 | 8.044 | 2.703 | 98.13 |
| 19.859 | 7.720 | 17.605 | 8.544 | 2.886 | 98.12 |
| 19.851 | 8.178 | 17.605 | 9.046 | 3.079 | 98.10 |
| 19.843 | 8.623 | 17.605 | 9.532 | 3.288 | 98.08 |
| 19.834 | 9.083 | 17.605 | 10.033 | 3.510 | 98.05 |
| 19.825 | 9.542 | 17.604 | 10.534 | 3.735 | 98.03 |
| 19.817 | 10.005 | 17.604 | 11.036 | 3.983 | 97.99 |
| 19.808 | 10.470 | 17.604 | 11.541 | 4.230 | 97.96 |
| 19.800 | 10.934 | 17.605 | 12.043 | 4.496 | 97.92 |
| 19.791 | 11.398 | 17.604 | 12.543 | 4.783 | 97.88 |
| 19.783 | 11.865 | 17.605 | 13.044 | 5.074 | 97.84 |
| 19.774 | 12.331 | 17.605 | 13.546 | 5.376 | 97.80 |
| 19.765 | 12.800 | 17.605 | 14.048 | 5.697 | 97.75 |
| 19.757 | 13.254 | 17.605 | 14.532 | 6.027 | 97.70 |



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## 2.3 Charge Efficiency Graphs

The efficiency while charging a battery is shown in Figure 2-2. For this test, the system current was 0A, and the input voltage was 20V.

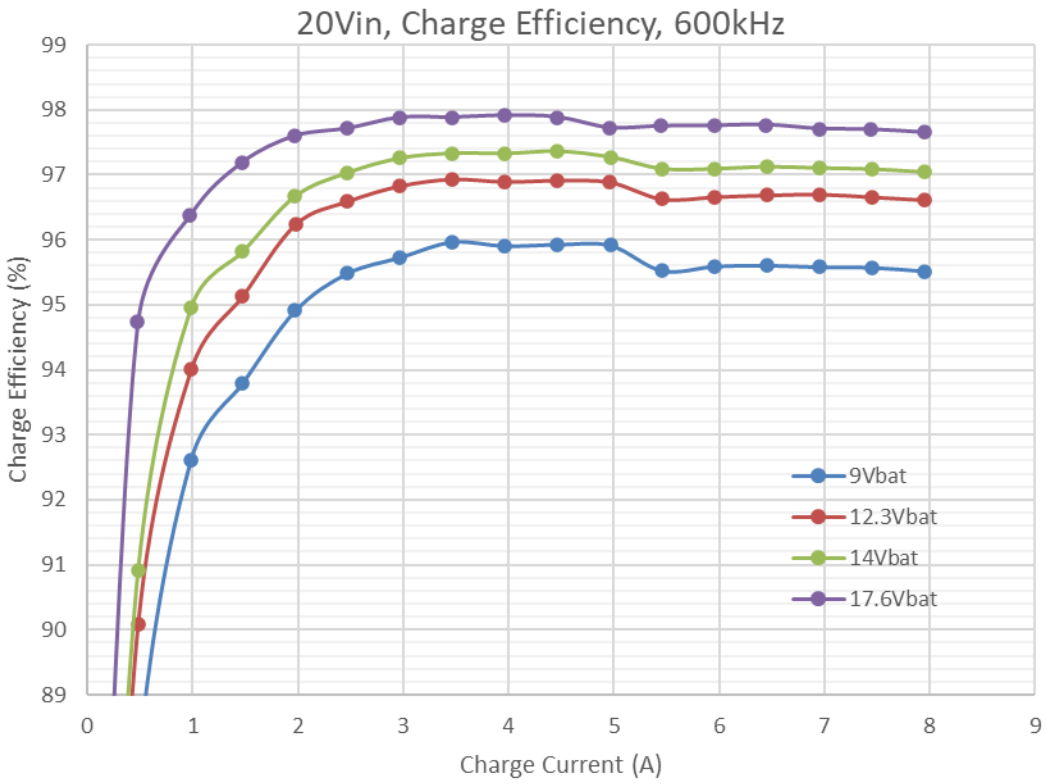


**Figure 2-2. Charge Efficiency Graph**

## 2.4 Charging Efficiency Data

Charging efficiency data is shown in Table 2-2.

**Table 2-2. Efficiency Data**

| $V_{BUS}$ (V) | $I_{BUS}$ (A) | $V_{SYS}$ (V) | $V_{BAT}$ (V) | $I_{BAT}$ (A) | $P_{LOSS}$ (W) | Charging Efficiency (%) |
|---|---|---|---|---|---|---|
| 19.998 | 0.065 | 9.013 | 9.012 | 0.114 | 0.279 | 78.63 |
| 19.995 | 0.246 | 9.018 | 9.012 | 0.479 | 0.593 | 87.93 |
| 19.990 | 0.478 | 9.025 | 9.013 | 0.982 | 0.707 | 92.60 |
| 19.987 | 0.710 | 9.031 | 9.014 | 1.476 | 0.880 | 93.80 |
| 19.983 | 0.938 | 9.038 | 9.015 | 1.972 | 0.954 | 94.91 |
| 19.978 | 1.168 | 9.045 | 9.016 | 2.471 | 1.053 | 95.49 |
| 19.974 | 1.401 | 9.052 | 9.017 | 2.971 | 1.195 | 95.73 |
| 19.969 | 1.631 | 9.059 | 9.018 | 3.465 | 1.313 | 95.97 |
| 19.965 | 1.867 | 9.066 | 9.019 | 3.964 | 1.525 | 95.91 |
| 19.960 | 2.103 | 9.072 | 9.020 | 4.464 | 1.709 | 95.93 |
| 19.956 | 2.341 | 9.079 | 9.021 | 4.966 | 1.908 | 95.91 |
| 19.952 | 2.583 | 9.086 | 9.022 | 5.457 | 2.306 | 95.53 |
| 19.948 | 2.820 | 9.093 | 9.023 | 5.960 | 2.479 | 95.59 |
| 19.943 | 3.055 | 9.101 | 9.024 | 6.454 | 2.675 | 95.61 |
| 19.939 | 3.294 | 9.108 | 9.025 | 6.956 | 2.902 | 95.58 |


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**Table 2-2. Efficiency Data (continued)**

| $V_{BUS}$ (V) | $I_{BUS}$ (A) | $V_{SYS}$ (V) | $V_{BAT}$ (V) | $I_{BAT}$ (A) | $P_{LOSS}$ (W) | Charging Efficiency (%) |
|---|---|---|---|---|---|---|
| 19.935 | 3.529 | 9.115 | 9.026 | 7.450 | 3.113 | 95.58 |
| 19.930 | 3.771 | 9.122 | 9.027 | 7.953 | 3.369 | 95.52 |
| 19.997 | 0.086 | 12.321 | 12.320 | 0.111 | 0.346 | 79.77 |
| 19.993 | 0.328 | 12.326 | 12.320 | 0.480 | 0.650 | 90.09 |
| 19.987 | 0.645 | 12.333 | 12.321 | 0.984 | 0.773 | 94.00 |
| 19.982 | 0.956 | 12.340 | 12.322 | 1.476 | 0.929 | 95.14 |
| 19.976 | 1.267 | 12.346 | 12.323 | 1.976 | 0.952 | 96.24 |
| 19.970 | 1.577 | 12.353 | 12.324 | 2.468 | 1.073 | 96.59 |
| 19.964 | 1.894 | 12.360 | 12.325 | 2.971 | 1.199 | 96.83 |
| 19.958 | 2.205 | 12.367 | 12.326 | 3.460 | 1.350 | 96.93 |
| 19.953 | 2.527 | 12.374 | 12.327 | 3.963 | 1.566 | 96.89 |
| 19.947 | 2.846 | 12.381 | 12.328 | 4.462 | 1.752 | 96.91 |
| 19.941 | 3.168 | 12.388 | 12.329 | 4.964 | 1.968 | 96.89 |
| 19.936 | 3.492 | 12.395 | 12.330 | 5.456 | 2.349 | 96.63 |
| 19.929 | 3.815 | 12.402 | 12.331 | 5.959 | 2.539 | 96.66 |
| 19.924 | 4.131 | 12.409 | 12.332 | 6.452 | 2.727 | 96.69 |
| 19.918 | 4.455 | 12.416 | 12.333 | 6.957 | 2.929 | 96.70 |
| 19.912 | 4.774 | 12.423 | 12.334 | 7.450 | 3.178 | 96.66 |
| 19.906 | 5.101 | 12.431 | 12.335 | 7.952 | 3.439 | 96.61 |
| 19.997 | 0.098 | 14.025 | 14.023 | 0.112 | 0.373 | 80.88 |
| 19.993 | 0.370 | 14.030 | 14.024 | 0.480 | 0.672 | 90.91 |
| 19.986 | 0.726 | 14.037 | 14.025 | 0.982 | 0.733 | 94.95 |
| 19.979 | 1.080 | 14.043 | 14.026 | 1.475 | 0.903 | 95.82 |
| 19.973 | 1.432 | 14.050 | 14.027 | 1.972 | 0.953 | 96.67 |
| 19.966 | 1.786 | 14.057 | 14.028 | 2.467 | 1.058 | 97.03 |
| 19.959 | 2.147 | 14.064 | 14.029 | 2.970 | 1.175 | 97.26 |
| 19.953 | 2.501 | 14.071 | 14.030 | 3.462 | 1.331 | 97.33 |
| 19.946 | 2.864 | 14.077 | 14.031 | 3.963 | 1.526 | 97.33 |
| 19.939 | 3.226 | 14.085 | 14.032 | 4.464 | 1.696 | 97.36 |
| 19.933 | 3.594 | 14.091 | 14.033 | 4.966 | 1.952 | 97.28 |
| 19.927 | 3.957 | 14.099 | 14.034 | 5.456 | 2.292 | 97.09 |
| 19.920 | 4.322 | 14.106 | 14.035 | 5.956 | 2.503 | 97.09 |
| 19.913 | 4.683 | 14.113 | 14.036 | 6.453 | 2.681 | 97.13 |
| 19.907 | 5.051 | 14.120 | 14.037 | 6.956 | 2.912 | 97.10 |
| 19.900 | 5.413 | 14.127 | 14.038 | 7.449 | 3.136 | 97.09 |
| 19.894 | 5.782 | 14.135 | 14.039 | 7.951 | 3.401 | 97.04 |
| 19.997 | 0.115 | 17.628 | 17.627 | 0.110 | 0.357 | 84.43 |
| 19.991 | 0.445 | 17.633 | 17.627 | 0.479 | 0.468 | 94.74 |
| 19.983 | 0.895 | 17.640 | 17.628 | 0.978 | 0.647 | 96.38 |
| 19.974 | 1.334 | 17.646 | 17.629 | 1.468 | 0.749 | 97.19 |
| 19.966 | 1.783 | 17.653 | 17.630 | 1.971 | 0.855 | 97.60 |
| 19.958 | 2.229 | 17.660 | 17.631 | 2.466 | 1.019 | 97.71 |
| 19.949 | 2.679 | 17.667 | 17.632 | 2.967 | 1.132 | 97.88 |
| 19.941 | 3.124 | 17.674 | 17.633 | 3.458 | 1.319 | 97.88 |
| 19.933 | 3.578 | 17.681 | 17.634 | 3.960 | 1.489 | 97.91 |
| 19.925 | 4.035 | 17.688 | 17.635 | 4.462 | 1.699 | 97.89 |



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**Table 2-2. Efficiency Data (continued)**

| $V_{BUS}$ (V) | $I_{BUS}$ (A) | $V_{SYS}$ (V) | $V_{BAT}$ (V) | $I_{BAT}$ (A) | $P_{LOSS}$ (W) | Charging Efficiency (%) |
|---|---|---|---|---|---|---|
| 19.917 | 4.492 | 17.695 | 17.637 | 4.957 | 2.036 | 97.72 |
| 19.909 | 4.939 | 17.701 | 17.637 | 5.450 | 2.213 | 97.75 |
| 19.900 | 5.396 | 17.709 | 17.638 | 5.951 | 2.410 | 97.76 |
| 19.892 | 5.849 | 17.716 | 17.639 | 6.448 | 2.597 | 97.77 |
| 19.883 | 6.309 | 17.723 | 17.640 | 6.948 | 2.875 | 97.71 |
| 19.875 | 6.763 | 17.731 | 17.642 | 7.444 | 3.097 | 97.70 |
| 19.867 | 7.226 | 17.738 | 17.642 | 7.946 | 3.372 | 97.65 |

## 2.5 Thermal Images

For all tests, input voltage was 20V, ambient temperature was room temperature, and there was no forced air flow.

### *2.5.1 140W Input, 16V System Voltage*

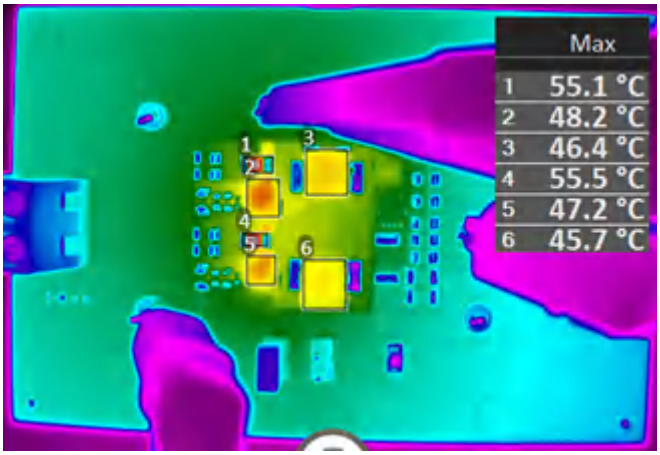


**Figure 2-3. 140W Input, 16V System Voltage Thermal Image**

**Table 2-3. 140W Input, 16V System Voltage Thermal Data**

| Point | Device | Temperature (°C) |
|---|---|---|
| 1 | Phase A RAC | 55.1 |
| 2 | Phase A FETs | 48.2 |
| 3 | Phase A Inductor | 46.4 |
| 4 | Phase B RAC | 55.5 |
| 5 | Phase B FETs | 47.2 |
| 6 | Phase B Inductor | 45.7 |


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### 2.5.2 180W Input, 9V System Voltage

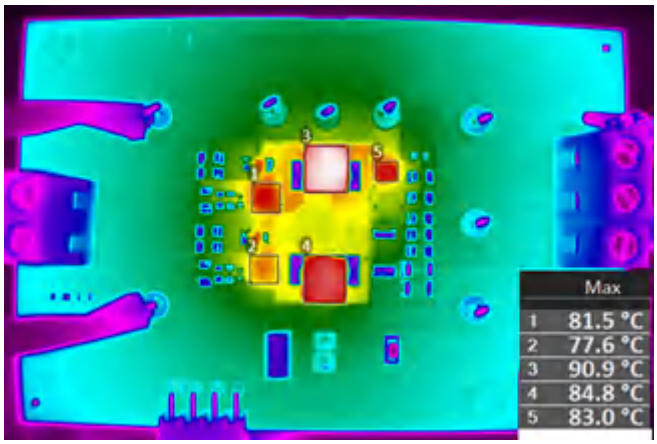


**Figure 2-4. 180W Input, 9V System Voltage Thermal Image**

**Table 2-4. 180W Input, 9V System Voltage Thermal Data**

| Point | Device | Temperature (°C) |
|---|---|---|
| 1 | Phase A FETs | 81.5 |
| 2 | Phase B FETs | 77.6 |
| 3 | Phase A Inductor | 90.9 |
| 4 | Phase B Inductor | 84.8 |
| 5 | Boost FET | 83.0 |

### 2.5.3 210W Input, 12.3V System Voltage

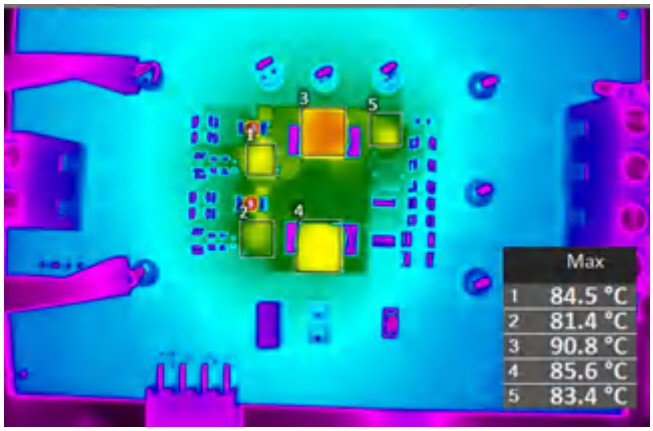


**Figure 2-5. 210W Input, 12.3V System Voltage Thermal Image**

**Table 2-5. 210W Input, 12.3V System Voltage Thermal Data**

| Point | Device | Temperature (°C) |
|---|---|---|
| 1 | Phase A FETs | 84.5 |
| 2 | Phase B FETs | 81.4 |
| 3 | Phase A Inductor | 90.8 |
| 4 | Phase B Inductor | 85.6 |
| 5 | Boost FET | 83.4 |



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### 2.5.4 220W Input, 14V System Voltage

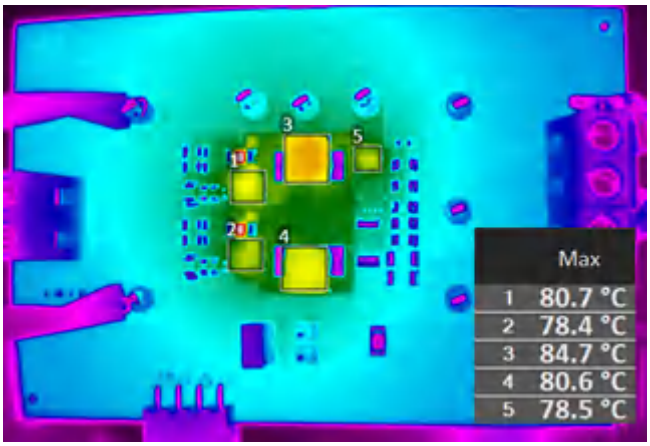


**Figure 2-6. 220W Input, 14V System Voltage Thermal Image**

**Table 2-6. 220W Input, 14V System Voltage Thermal Data**

| Point | Device | Temperature (°C) |
|---|---|---|
| 1 | Phase A FETs | 80.7 |
| 2 | Phase B FETs | 78.4 |
| 3 | Phase A Inductor | 84.7 |
| 4 | Phase B Inductor | 80.6 |
| 5 | Boost FET | 78.5 |

### 2.5.5 240W Input, 17.6V System Voltage

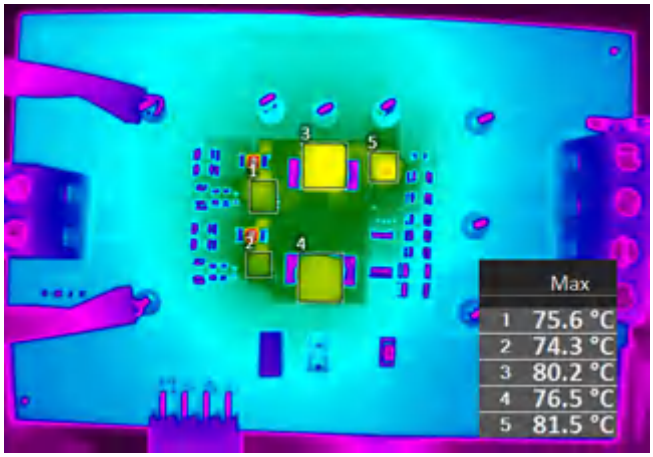


**Figure 2-7. 240W Input, 17.6V System Voltage Thermal Image**

**Table 2-7. 240W Input, 17.6V System Voltage Thermal Data**

| Point | Device | Temperature (°C) |
|---|---|---|
| 1 | Phase A FETs | 75.6 |
| 2 | Phase B FETs | 74.3 |
| 3 | Phase A Inductor | 80.2 |
| 4 | Phase B Inductor | 76.5 |
| 5 | Boost FET | 81.5 |


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# 3 Waveforms

## 3.1 Typical Charging Waveforms

Switching behavior during charging is shown in Figure 3-1 through Figure 3-2. The input voltage was 20V, and the battery voltage was 16V.

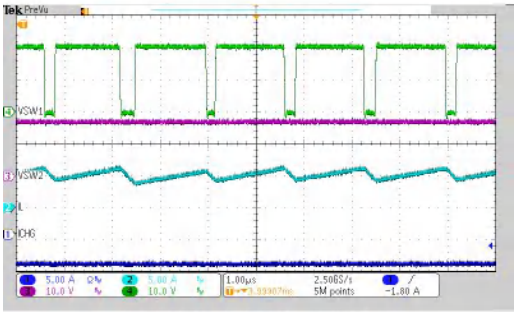


**Figure 3-1. Waveforms With 6A Charging Current**

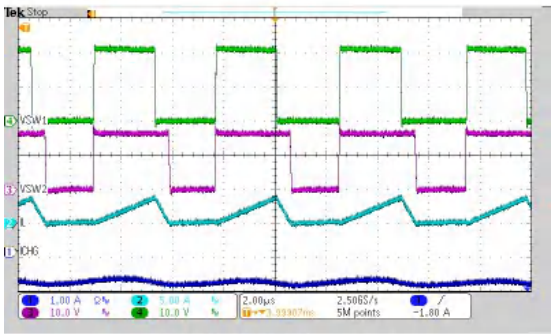


**Figure 3-2. Waveforms With 1A Charging Current**

## 3.2 Start-up and Shutdown

Start-up and shut-down behaviors are shown in Figure 3-3 and Figure 3-4. The input voltage was 20V, and the battery voltage was 16V.

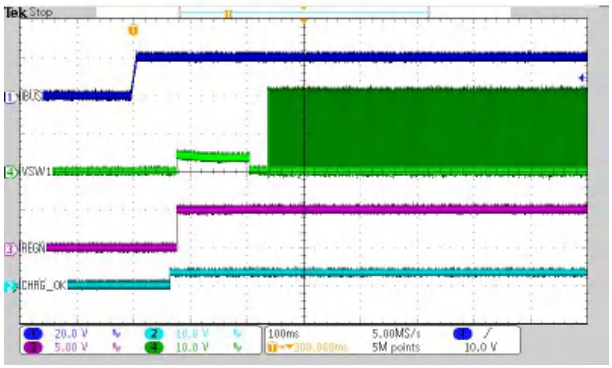


**Figure 3-3. Start-up Waveforms**

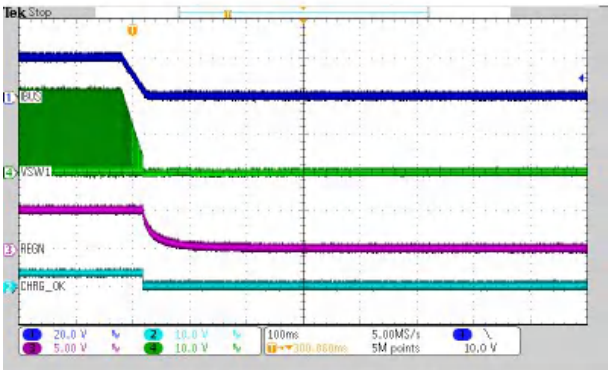


**Figure 3-4. Shutdown Waveforms**



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### 3.3 Charge Enable and Disable

Charge Enable and Charge Disable behaviors are shown in Figure 3-5 and Figure 3-6. The input voltage was 20V, the battery voltage was 16V, and the charging current was 4A.

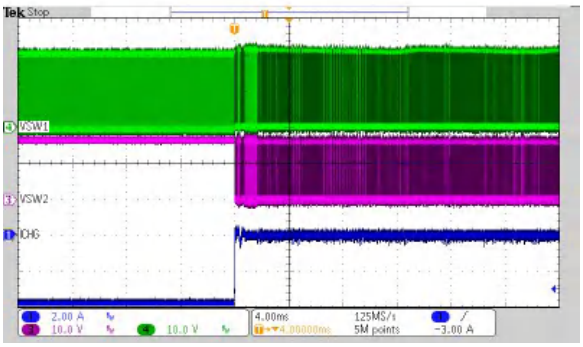


**Figure 3-5. Charge Enable Waveforms**

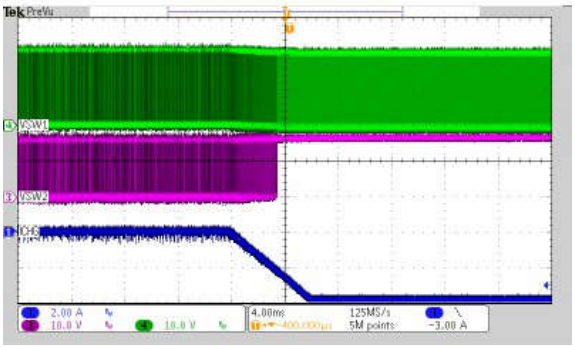


**Figure 3-6. Charge Disable Waveforms**

### 3.4 System Transients

Load transient response is shown in Figure 3-7. The input voltage was 20V, the system voltage was 12.3V, and the system current was stepped between 0A and 10A.

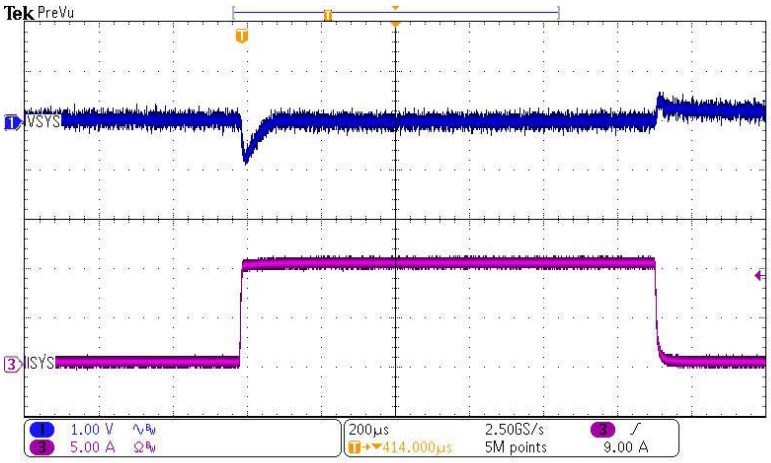


**Figure 3-7. System Transient Waveforms**


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## 3.5 Typical OTG Waveforms

Switching behavior during OTG is shown in Figure 3-8 and Figure 3-9. The battery voltage was 16V and the OTG voltage was 5V.

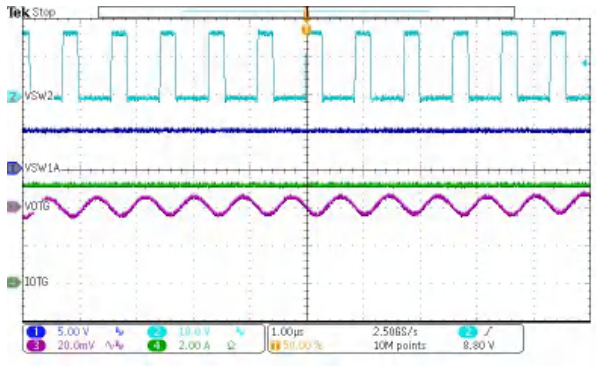


**Figure 3-8. Waveforms With 5A OTG Current**

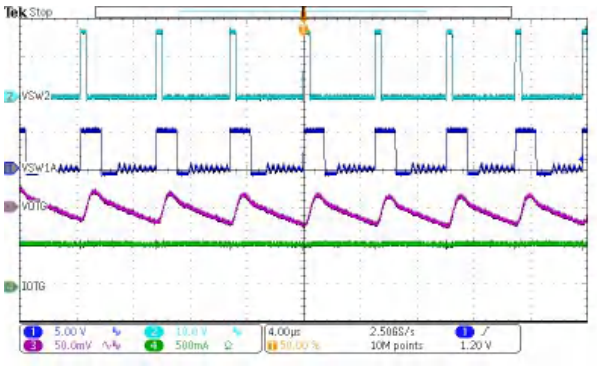


**Figure 3-9. Waveforms With 500mA OTG Current**

## 3.6 OTG Transients

Load transient response during OTG is shown in Figure 3-10 and Figure 3-11. The battery voltage was 17.8V, the OTG voltage was 5V, and an additional 100µF capacitor was attached with EN_BIG_CAP_OTG=1.

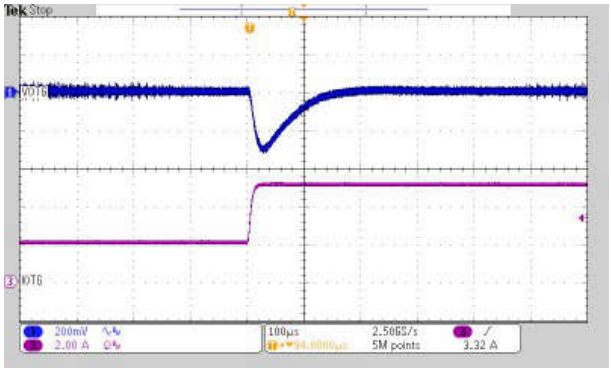


**Figure 3-10. OTG 2A to 5A Transient Waveforms**

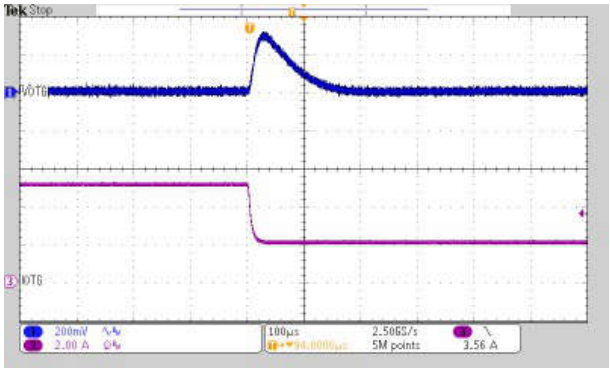


**Figure 3-11. OTG 5A to 2A Transient Waveforms**

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