4 Performance with LED loads

The unit was designed to source 350 mA into a string of 18 1 W LEDs. The project goal was to obtain the highest possible efficiency.

Table 1. Numeric data for 18-LED load

Line voltage	90 V	96 V	102 V	108 V	114 V	120 V	126 V	132 V	138 V
Input power, watts	20.5	20.77	20.82	20.61	20.51	20.46	20.31	19.95	19.48
Power factor	0.973	0.978	0.982	0.985	0.987	0.988	0.990	0.991	0.991
Output voltage	54.8	54.8	54.7	54.7	54.6	54.6	54.5	54.4	54.3
Output current, amps	0.348	0.353	0.355	0.352	0.351	0.35	0.348	0.342	0.334
Output power, watts	19.070	19.344	19.418	19.254	19.164	19.110	18.966	18.604	18.136
Efficiency%	93.03	93.14	93.27	93.42	93.44	93.40	93.38	93.26	93.10
Power loss, watts	1.429	1.425	1.401	1.355	1.345	1.350	1.344	1.345	1.343

5 Graphical data

Figure 8. LED current vs. line voltage for 18

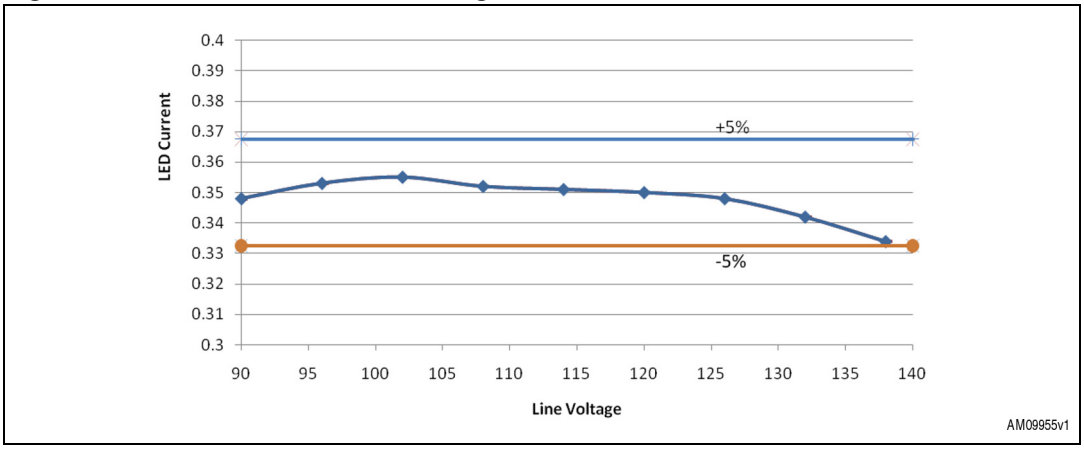


Figure 9. Power factor vs. line voltage

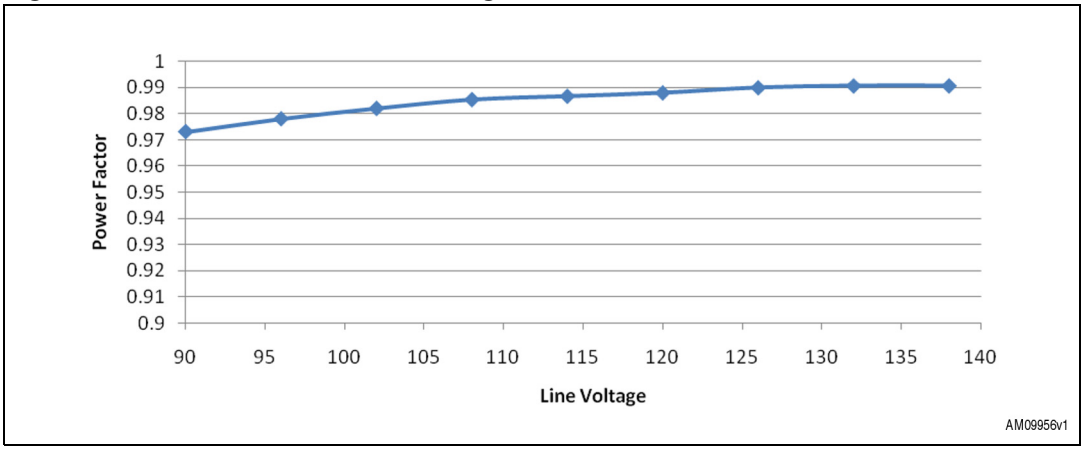


Figure 10. Efficiency vs. line voltage

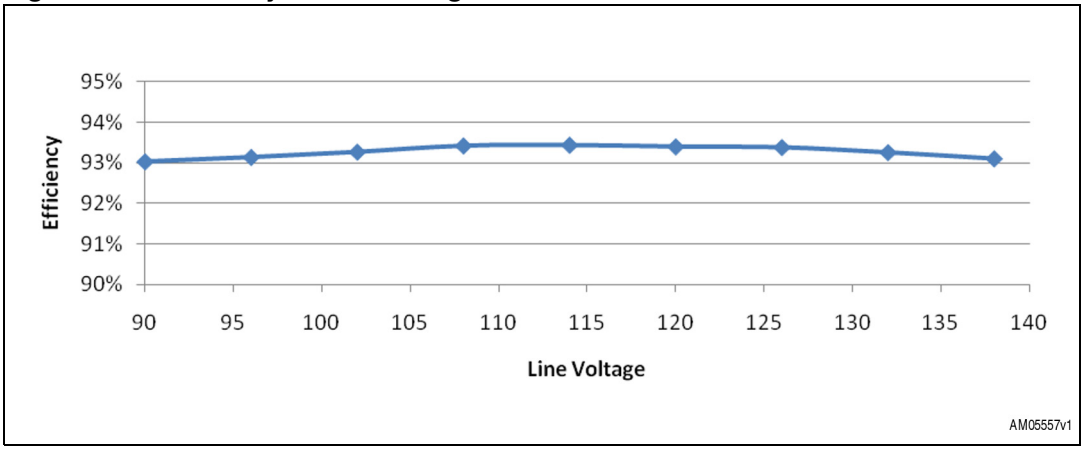
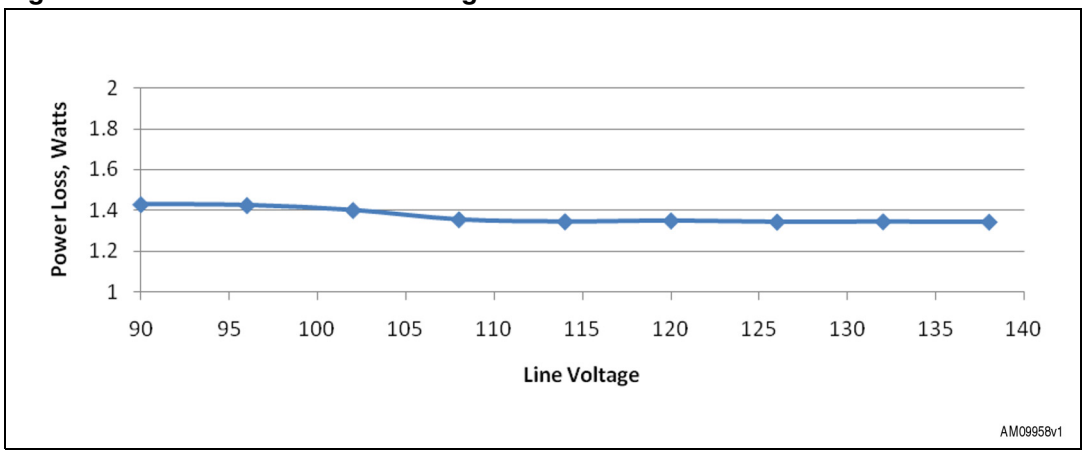


Figure 11. Power loss vs. line voltage



6 Waveforms

Trace colors:

- Yellow = line voltage, 50 V/div ref 0
- Magenta = line current, 100 mA/div ref 0
- Blue = LED voltage, 10 V/div ref -3 div
- Green = LED current, 100 mA/div ref -3 div

Figure 12. Waveforms at 96 V line

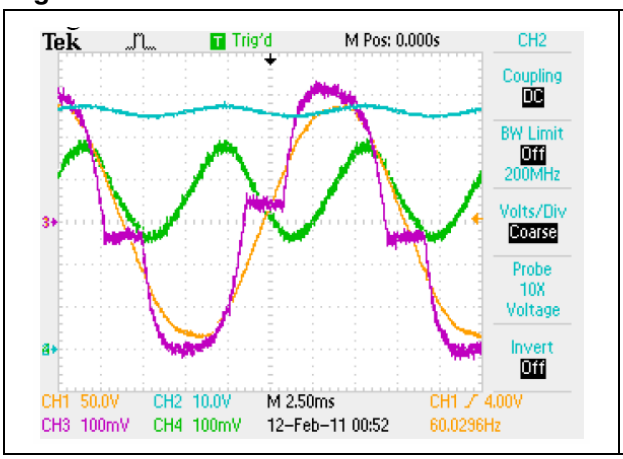


Figure 13. Waveforms at 108 V line

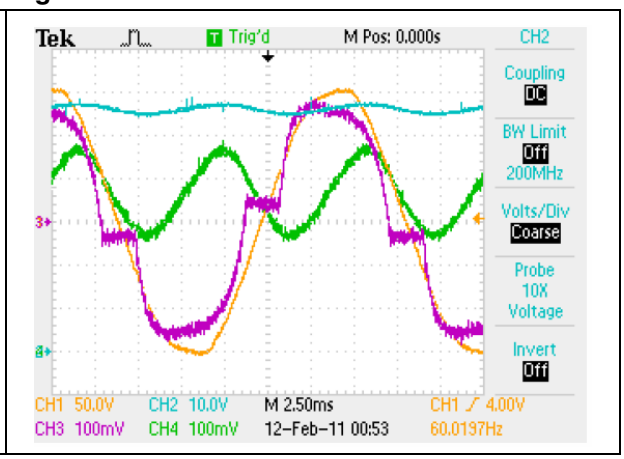


Figure 14. Waveforms at 120 V line

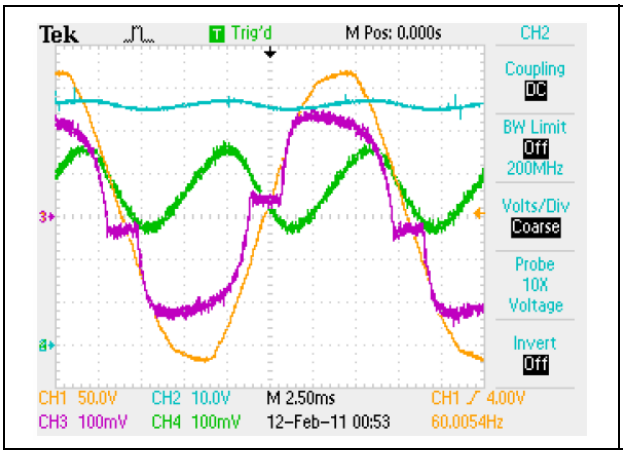
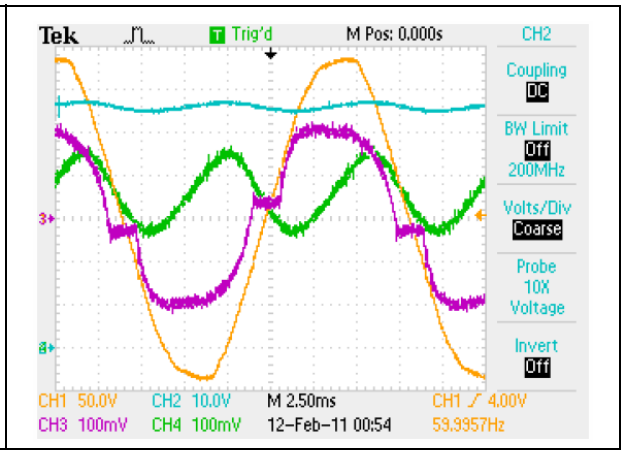


Figure 15. Waveforms at 132 V line



Note that the flat spot near the zero crossing becomes longer as the load voltage becomes a larger percentage of the line voltage (low line is worst). This will place an upper limit on the LED output voltage as waveform distortion reduces power factor. The design can be pushed to higher numbers of LEDs, up to the point where power factor or THD become limiting factors.

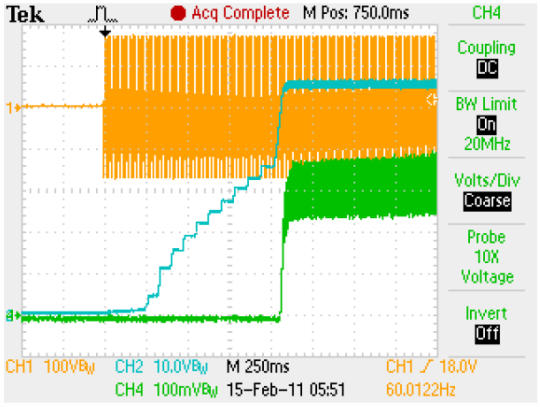
7 Startup

Startup scope photo - cold start, everything discharged, 7 LEDs, 120 V input.

Trace colors:

- Yellow AC line, 100 V/div, ref +2 div
- Blue LED voltage, 10 V/div, ref -3 div
- Green LED current, 100 mA/div, ref -3 div

Figure 16. Startup waveforms



This startup time is too long for some applications. Some circuitry should be added to increase the current limit during startup. An R-C series network could be added from U1 pin 1 to ground (pin 8). The network would have no effect once the feedback loop takes over – the voltage on pin 1 is stable at 2.5 V.

The time can also be reduced by reducing the value of R7, but this will reduce efficiency.

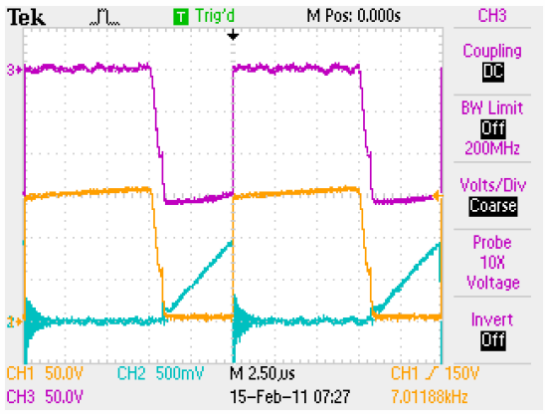
8 Component stress

This plot was taken near the peak of line voltage, where stresses are greatest.

Trace colors:

- Yellow Q2 drain voltage, 100 V/div, ref -3 div
- Blue Q2 drain current, 0.735 A/div, ref -3 div
- Magenta D1 diode voltage, 100 mA/div, ref -3 div

Figure 17. Component electrical stress



9 Thermal stress

It is not likely that the layout will be used as is by the customer. The temperatures below are for guidance only – measurements were taken after 30 minutes operation, in open air, on the workbench, in a 25.3 °C ambient, 120 V input, 18 LED load. The board axis was horizontal, board position vertical. L3 was above L2.

Table 2. Thermal stress

Component	Temperature
L2	40.3
BR1	62.4
Q2	52.5
L1	51.4
L3	46.1
U1	42.3
D1	59.3
C2	32.2

10 Conducted EMI

The following plots each show the maximum of 3 successive sweeps (peak hold).

Figure 18. Conducted EMI, line 1

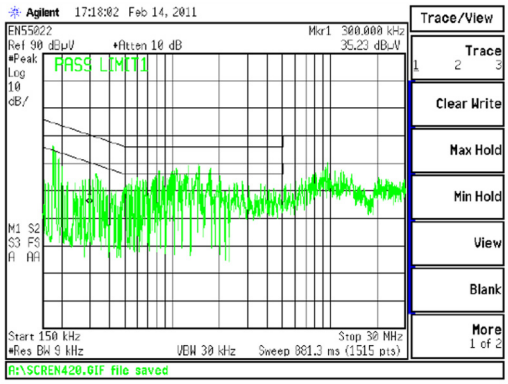
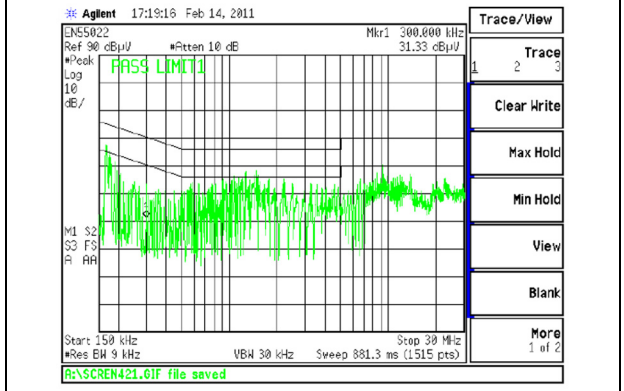


Figure 19. Conducted EMI, line 2



This unit should pass average and quasi-peak testing as is. If difficulties are encountered, the values of C7 and C1 can be increased at the expense of reduced power factor.