Microsemi Power Management Solution for AFS-EVAL-KIT

Author: Dennis Mattocks

Rev. 1.0, 2013-03-29

Scope

This document presents data covering proposed AMSG power management ICs targeted to replace competitor's parts used in Microsemi SOC's AFS Fusion Evaluation Kit. Power requirements are addressed via a comparison list between targeted power management ICs for retrofitting, as compared to Microsemi power management ICs determined to fit the requirements. .

Test images and data of the competitor's solution vs. the AMSG solution follow the comparison for each selected part. Lastly, schematic diagrams and suggested PCB layouts of the proposed AMSG devices are at the end of this document.

Power Requirements

Parts targeted for retrofit are referenced to their respective schematic page. Please reference the AFS-EVAL-Kit Schematic, document number: AFS-EVAL-BRD600-SA, Rev 1.1, for details.

Schematic Page 2

1) U11 – National LM2678S-3.3
    a. Power on board non-synchronous buck 9V to 3.3V @ 5A; 22uH Inductor is rated at 2.3A sat and 2.7A rms.
    b. 8V minimum input voltage – 40V maximum input voltage
    c. -40°C to 125°C Tj rated
    d. Internal Boost Diode
    e. No external feedback components required
    f. 3% regulation over temperature; 2% regulation at 25°C
    g. External enable – 1.4V to 2.0V threshold
    h. 150uA max standby Q current over temperature
    i. 6mA Q current non-switching
    j. 5.75A to 8.75A current limit over temperature
    k. Rdson = 0.12Ω (typical), 0.225Ω (max)
    l. 225kHz to 280kHz switching frequency.
    m. 91% max duty cycle
    n. TO-263 7 pin package

Suggested replacement = NX7102; capable of 9V to 3.3V at 3A max.

    a. Power on board synchronous buck; adjustable output.
    b. 4.75V minimum input voltage – 18V maximum input voltage

c. -40°C to 85°C operating ambient temperature (Ta)

d. Internal Boost Diode

e. External feedback components required

f. Reference specified +/- 2.7% at 25°C

g. External enable – 0.4V to 1.5V threshold

h. 10uA max standby current at 25°C

i. 1.2mA max Q current non-switching

j. High side current limit specified at 4.3A minimum at 25°C.

k. RDSon 0.130Ω high side max, 0.12Ω low side max, at 25°C.

l. 300kHz to 380kHz switching frequency.

m. 97% max. duty cycle

n. SOIC 8 pin with exposed pad package

Differences/risks:

a. Regulation is not as tight.

b. Maximum input voltage is lower (18V vs. 40V); but will be sufficient for the demo board input voltage of 9V.

c. Maximum current is less (3A vs. 5A), but should be sufficient for the demo board given the present design's inductor has a saturation current of 2.3A.

d. National part is non-synchronous and requires external diode rectifier. NX7102 is synchronous and does not require external diode. Low output current efficiency will be less for the NX7102.

2) U20 – National LM2674M-5.0

a. Power on board non-synchronous buck 9V to 5V 500mA max

b. 8V minimum input voltage

c. -40°C to 125°C Tj rated

d. Internal Boost Diode

e. No external feedback components required

f. 3% regulation over temperature; 1.5% regulation at 25°C

g. External enable – 1.4V to 2.0V threshold

h. 150uA max standby Q current over temperature

i. 3.6mA Q current non-switching

j. 5.75A to 8.75A current limit over temperature

k. Rdson = 0.25Ω (typical), 0.4Ω (max)

l. 225kHz to 275kHz switching frequency.

m. 95% max duty cycle

n. SO8 package

Suggested replacement = NX7101; capable of 9V to 5V at 2A.

a. Power on board synchronous buck; adjustable output.

b. 4.75V minimum input voltage

c. -40°C to 85°C operating ambient temperature (Ta)

d. Internal Boost Diode

e. External feedback components required

f. Reference specified +1.8%, - 2.2% at 25°C

g. External enable – 0.4V to 1.5V threshold

h. 10uA max standby current at 25°C

i. 1.45mA max Q current non-switching

j. High side current limit specified at 4.3A minimum at 25°C.

k. RDSon 0.145Ω high side max, 0.135Ω low side max, at 25°C.

l. 300kHz to 380kHz switching frequency.

m. 97% max. duty cycle

n. SOIC 8 pin package

Differences/risks:

a. Regulation is not as tight.

b. NX7101 is a 2A rated part; National part is 500mA part; however, both are in SO8 package.

c. National part is non-synchronous and requires external diode rectifier. NX7101 is synchronous and does not require external diode. Low output current efficiency will be less for the NX7101.

Test Data

U11 – 9V to 3.3V Buck

Old Device Steady State:

Output: 3.301V (measured at TP55); EVB is steady state with Demo software

Average Steady State Inductor Current: 86mA (with SW1 enabled and D1 – D7 lit).

Frequency: 253kHz

Microsemi Device Steady State:

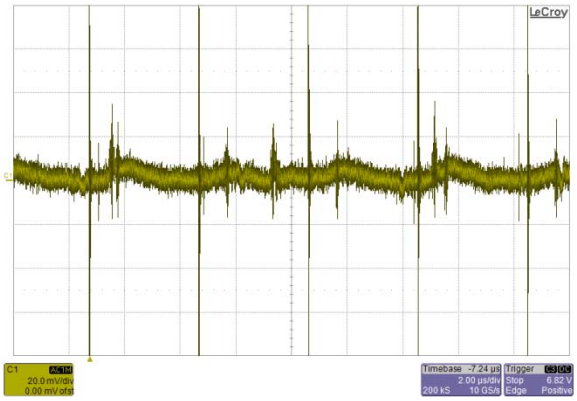
Output: 3.315V (measured at TP55); EVB is steady state with Demo software

Output: 3.305V (measured at C2); EVB in steady state with additional 2A load connected to TP55.

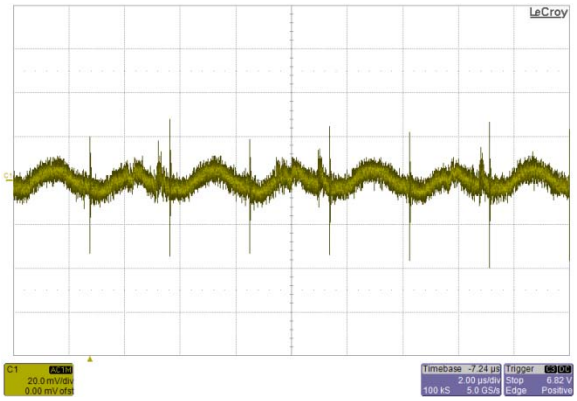
Average Steady-State Inductor Current: 86mA (with SW1 enabled and D1 – D7 lit).

Frequency: 349kHz

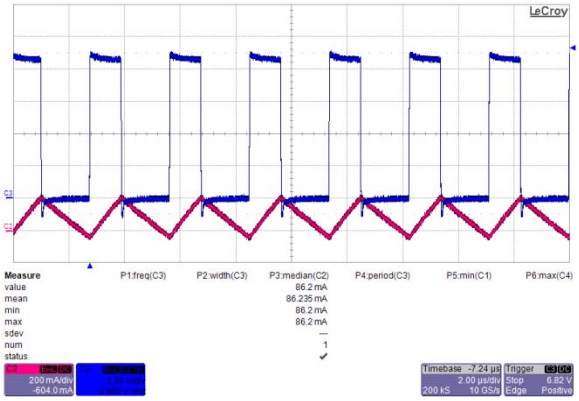
Images:



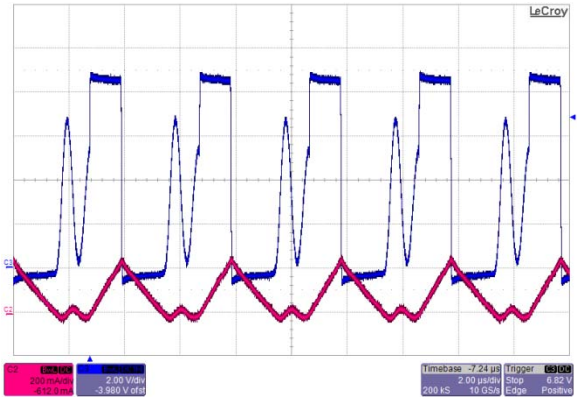
National Part – Steady State Output Ripple



Microsemi Part – Steady State Output Ripple



Microsemi Part Steady State Switch Node and Inductor Current



National Part Steady State Switch Node and Inductor Current

Summary of Observations: U11 regulates the main 3.3V power rail on the demo board. The present demo board is using a 5A National LM2678. As of this writing the maximum current requirements for the 3.3V rail is unknown, but the inductor used with the LM2678 has a saturation current of 2.3A, so based on inductor saturation the NX7102 is chosen. The NX7102 was verified functional on the demo board up to a 2A load (provided by external load connected to the demo board). With the NX7102 installed, all functions provided by the demo program were exercised with no indication of problem. In addition, the FPGA was erased and reprogrammed with both the National and the Microsemi parts. The Flash Pro program's "inspect Device" function was used to status the FPGA before and after programming. No indication of programming issues was observed with the Microsemi part. The following are the device status printouts after programming with both the National and the Microsemi part:

National LM2678 after Reprogramming FPGA (FSK_Tutorial.pdb):

Device Status:

IDCode (read from the device) (HEX): 633261cf

User Information:

UROW data (HEX): 377f0058e5d3f4bd72fed3cb688041c1

Programming Method: PDB

Programmer: FlashPro4

Programmer Software: FlashPro vX.X

Design Name: FSK_tutori

Design Check Sum: 377F

Algorithm Version: 20

Array Prog. Cycle Count: 1

Device State:

IRCapture Register (HEX): 55

FPGA Array Status: Programmed and enabled

Factory Data:

Factory Serial Number (HEX): 8126a32c4c98

Security:

Device has no security enforced.

Analog Block:

OABTR Register (HEX): 0dbe33b

3.3V (vdd33): PASS

1.5V (vdd15): PASS

Bandgap: PASS

-3.3V (vddn33): PASS

ADC Reference: PASS

FPGA_Good: PASS

Status: Analog Block is operational

Microsemi NX7102 after Reprogramming FPGA (FSK_Tutorial.pdb):

Device Status:

IDCode (read from the device) (HEX): 633261cf

User Information:

UROW data (HEX): 377f00d8e5d3f4bd72fed3cb688041c1

Programming Method: PDB

Programmer: FlashPro4

Programmer Software: FlashPro vX.X

Design Name: FSK_tutori

Design Check Sum: 377F

Algorithm Version: 20

Array Prog. Cycle Count: 3

Device State:

IRCapture Register (HEX): 55

FPGA Array Status: Programmed and enabled

Factory Data:

Factory Serial Number (HEX): 8126a32c4c98

Security:

Device has no security enforced.

Analog Block:

OABTR Register (HEX): 0dbe33b

3.3V (vdd33): PASS

1.5V (vdd15): PASS

Bandgap: PASS

-3.3V (vddn33): PASS

ADC Reference: PASS

FPGA_Good: PASS

Status: Analog Block is operational

U20 – 9V to 5V Buck

Old Device Steady State:

Output: 4.971V (Measured at TP47); EVB with “Fusion” displayed on LCD screen

Average Inductor Current: Less than 40mA (inductor current is discontinuous)

Frequency: 264kHz

Microsemi Device Steady State:

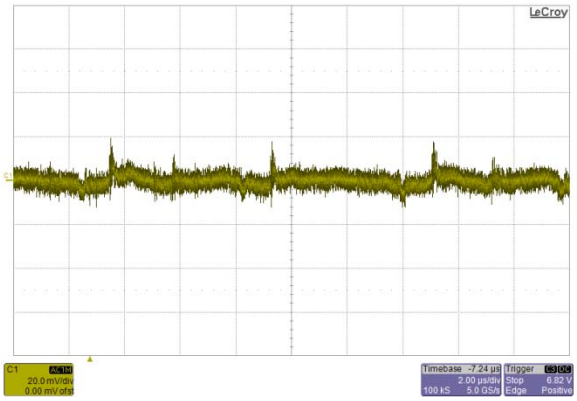
Output: 5.016 (Measured at TP47); EVB with “Fusion” displayed on LCD screen

Output: 5.011V (Measured at C91); EVB with 0.50A external load, LCD disconnected

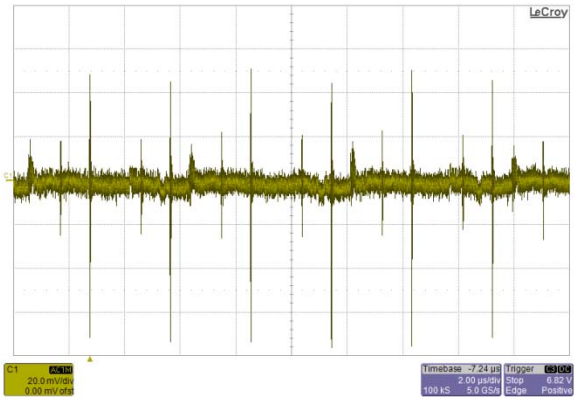
Average Inductor Current: Less than 40mA (inductor current is discontinuous)

Frequency: 344kHz

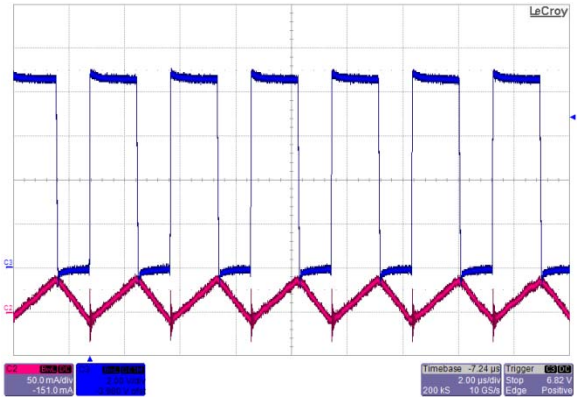
Images:



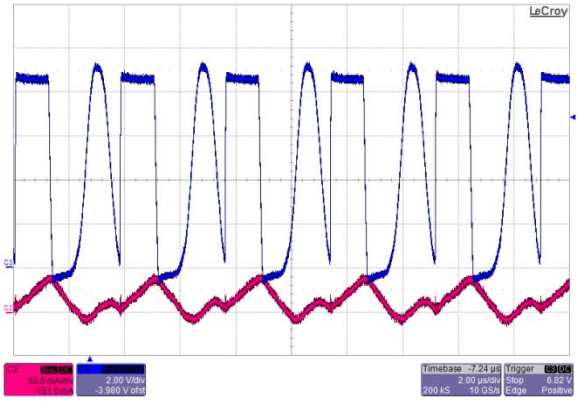
National Part – Steady State Output Ripple



Microsemi Part – Steady State Output Ripple



Microsemi Part Steady State Switch Node and Inductor Current



National Part Steady State Switch Node and Inductor Current

Summary of Observations: U20 regulates the 5V rail, used to provide VCC to the LCD display, as well as the tri-color LED used in the demo. The demo board used in this evaluation did not have the tri-color LED (U1) installed. As of this writing the maximum current required for the 5V rail is unknown; however the NX7101 was verified functional up to 500mA using an external load connected to the demo board. No degrading in LCD functionality was observed with the NX7101 regulating the 5V rail.

Schematics and BOM

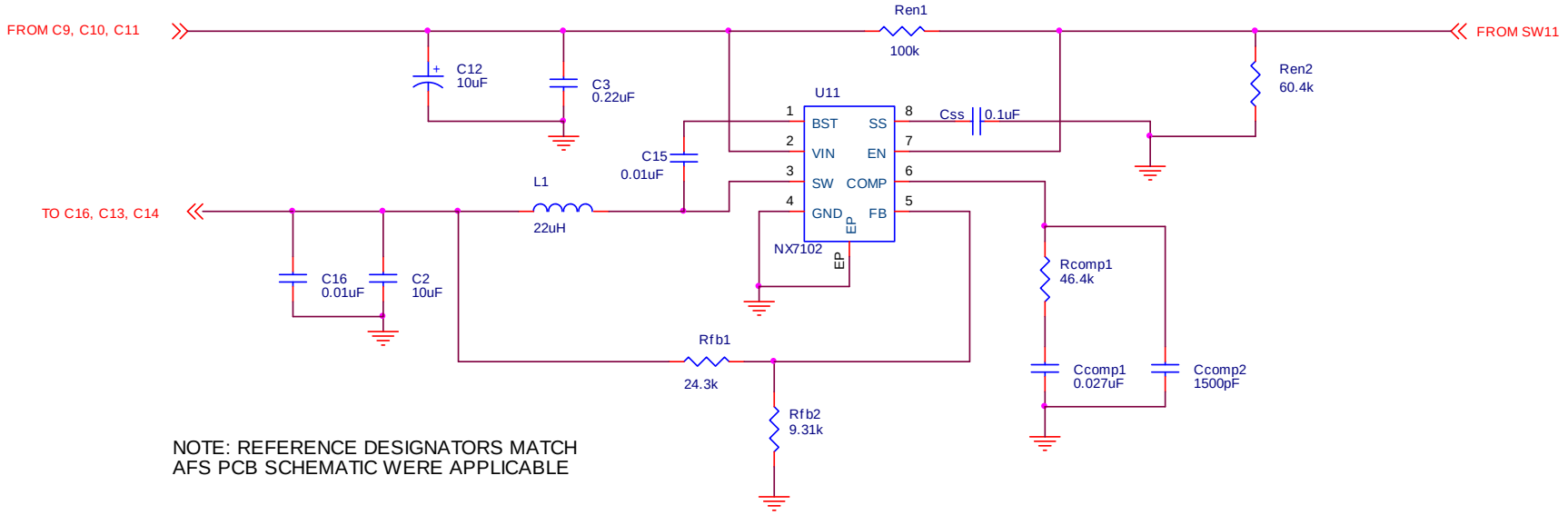


Figure 1. U11 9V to 3.3V Circuit

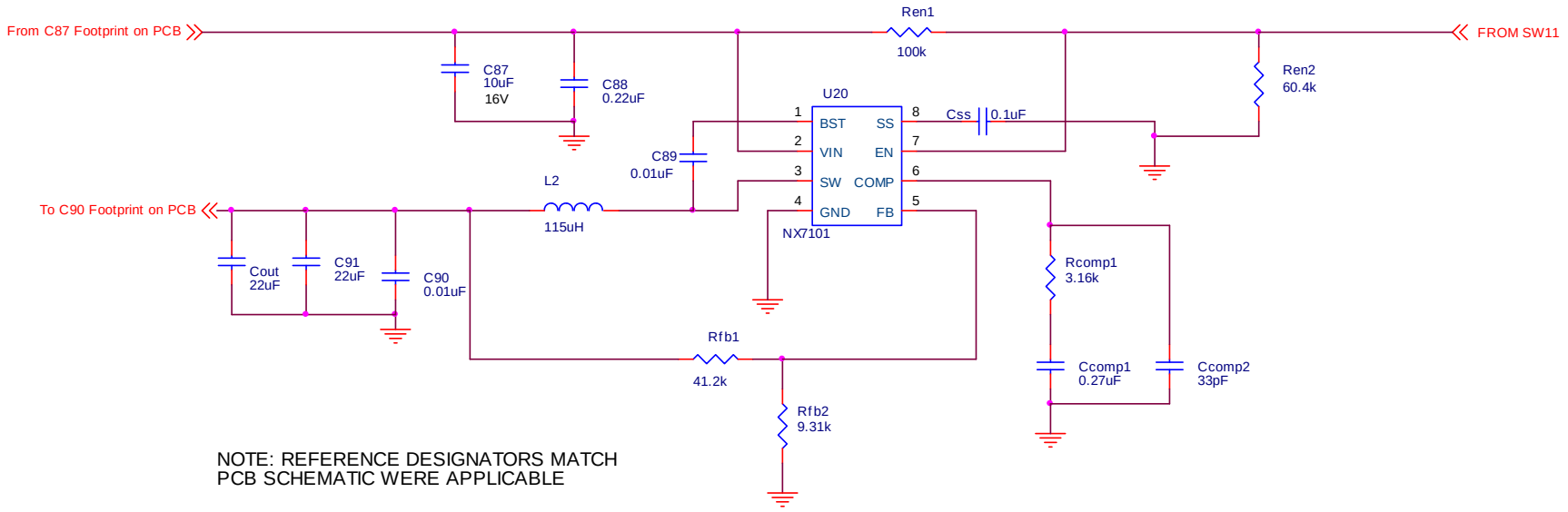


Figure 2. U20 – 9V to 5V Circuit

U11 9V to 3.3V Circuit:

Item Number	Quantity	Part Reference	Description	Manufacturer	Manufacturer Part Number
1	1	Ccomp1	Capacitor, Ceramic, 0.027uF, X5R, 6.3V or greater, 0603 SMD	Any	Any
2	1	Ccomp2	Capacitor, Ceramic, 1500pF, X5R, 6.3V or greater, 0603 SMD	Any	Any
3	1	Css	Capacitor, Ceramic, 0.1uF, X5R, 6.3V or greater, 0603 SMD	Any	Any
4	1	C2	10UF/16V	KEMET	C1210C106K4PACTU
5	1	C12	10UF/35V	KEMET	T491D106K035AS
6	1	C3	0.22UF/50V	KEMET	C1206C224K5RACTU
7	2	C15,C16	0.01UF/50V	KEMET	C0603C103K5RACTU
8	1	L1	22UH	COILCRAFT	DO3316P-223
9	1	Rcomp1	Resistor, 1%, 46.4k, 0603 SMD*	Any	Any
10	1	Ren1	Resistor, 1%, 100k, 0603 SMD*	Any	Any
11	1	Ren2	Resistor, 1%, 60.4k, 0603 SMD*	Any	Any
12	1	Rfb1	Resistor, 1%,24.3k, 0603 SMD	Any	Any
13	1	Rfb2	Resistor, 1%, 9.31k, 0603 SMD	Any	Any
14	1	U11	IC, 3A Synchronous Buck Regulator	Microsemi	NX7102IDE

*These parts may be replaced with the closest 5% equivalent

Highlighted items are items already in the existing AFS design.

U20 9V to 5V Circuit:

Item	Quantity	Part	Description	Manufacturer	Manufacturer Part

Number		Reference			Number
1	1	Ccomp1	Capacitor, Ceramic, 0.27uF, X5R, 6.3V or greater, 0603 SMD	Any	Any
2	1	Ccomp2	Capacitor, Ceramic, 33pF, NPO, 6.3V or greater, 0603	Any	Any
3	1	Css	Capacitor, Ceramic, 0.1uF, X5R, 6.3V or greater, 0603 SMD	Any	Any
4	1	C87	Capacitor, Ceramic, 10uF, X7R,16V, 1206 SMD	Any	Any
5	1	C88	0.22UF/50V	KEMET	C1206C224K5RACTU
6	2	C89,C90	0.01UF/50V	KEMET	C0603C103K5RACTU
7	2	Cout, C91	Capacitor, Ceramic, 22uF, X5R, 10V, 1206 SMD	Any	Any
8	1	L2	115uH	PULSE ENGINEERING	PE-53820S
9	1	Rcomp1	Resistor, 1%, 3.16k 0603 SMD*	Any	Any
10	1	Ren1	Resistor, 1%, 100k, 0603 SMD*	Any	Any
11	1	Ren2	Resistor, 1%, 60.4k, 0603 SMD*	Any	Any
12	1	Rfb1	Resistor, 1%, 41.2k, 0603 SMD	Any	Any
13	1	Rfb2	Resistor, 1%, 9.31k, 0603 SMD	Any	Any
14	1	U20	IC, 2A Synchronous Buck Controller	Microsemi	NX7101IDM

*These parts may be replaced with the closest 5% equivalent

Highlighted items are items already in the existing AFS design.

Note: Highlighted items are items already in the existing A2F design.

PCB Layouts

The two circuit schematics (reference Figures 1 and 2) were respectively assembled on a small two-sided PCB for testing. The following PCB Layouts can be used as a reference to retrofit the Microsemi parts onto the existing PCB:

U11 9V to 3.3V Circuit

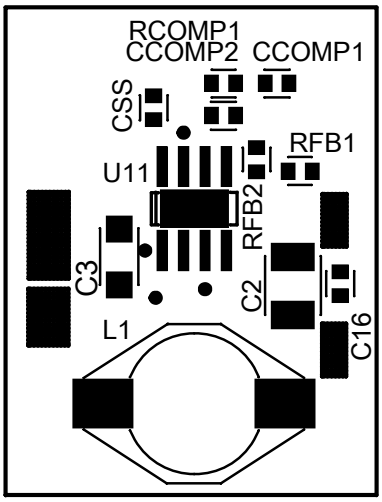


Figure 3. U11 Circuit Top Assembly

Finished Board Size = 0.865 (W) X 1.137 (H)

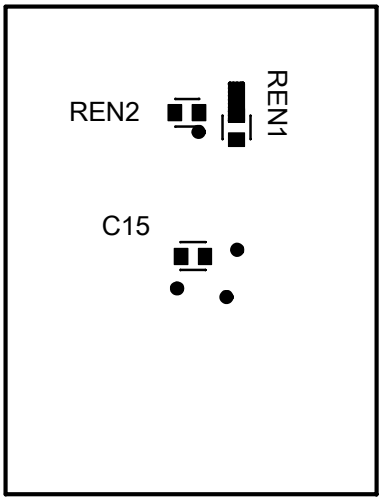


Figure 4. U11 Circuit Bottom Assembly

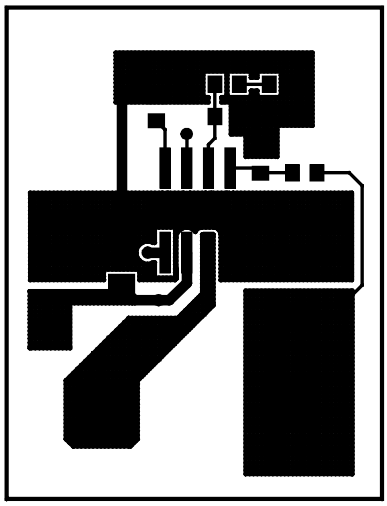


Figure 5. U11 Circuit Top Layer

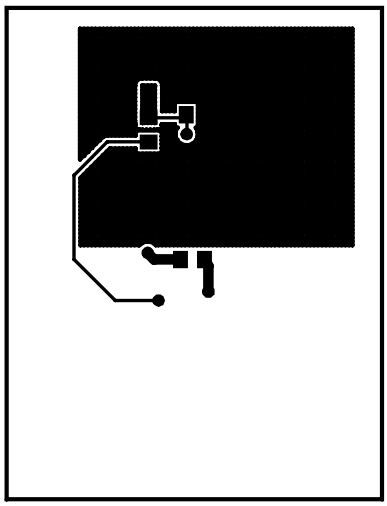


Figure 6. U11 Circuit Bottom Layer

U20 9V to 5V Circuit

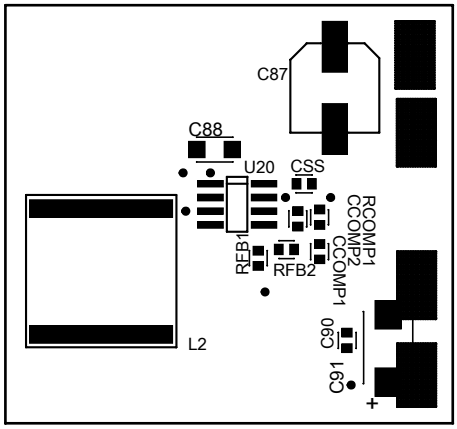


Figure 7. U20 Circuit Top Assembly

Finished Board Size = 1.637 (W) X 1.527 (H)

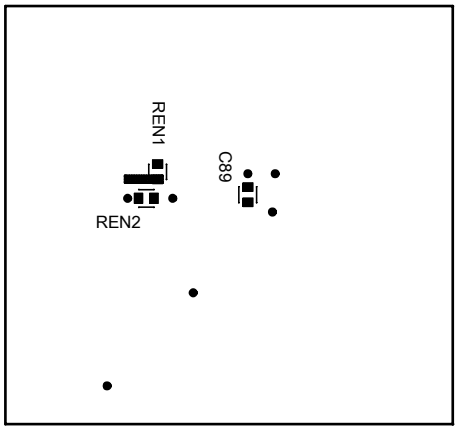


Figure 8. U20 Circuit Bottom Assembly

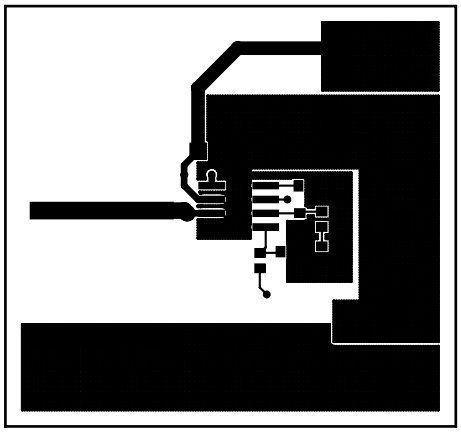


Figure 9. U20 Circuit Top Layer

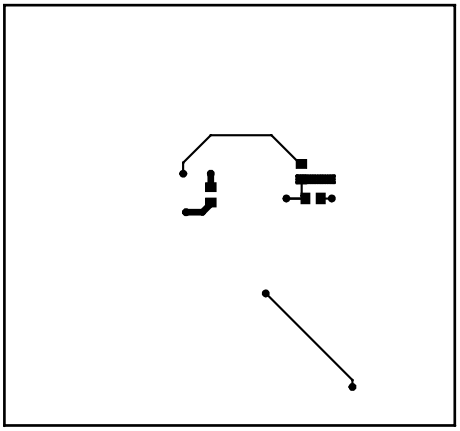


Figure 10. U20 Circuit Bottom Layer