Fluid Level Controller

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Introduction

The fluid level controller application note is a design using GreenPak2 to control the water level inside a tank using the property of water electrical conductivity.

The electrical conductivity (EC) of water estimates the total amount of solids dissolved in water -TDS, which stands for Total Dissolved Solids. TDS is measured in ppm (parts per million) or in mg/l.

Distilled water does not contain dissolved salts and, as a result, it does not conduct electricity and has an electrical conductivity of zero.

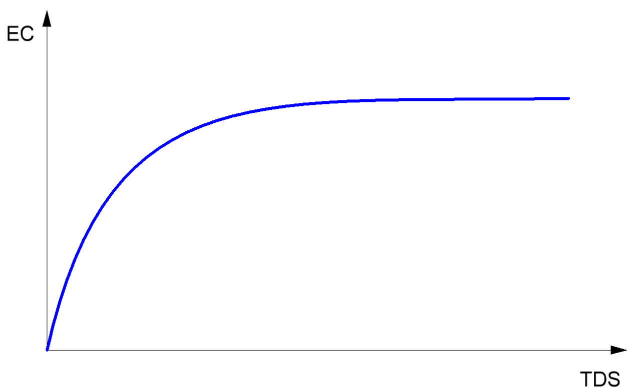

Figure 1. Electrical characteristic of waters conductivity

In this example we use three anti corrosion wires as sensors, set at different depths as pictured in figure 2. This arrangement results in three ranges as depicted.

To perform its task, the GreenPAK2 chip sends a 50mS wide pulse every 1s to the middle wire. This signal is received at the top and the bottom wires where the top is connected to PIN 3 and the bottom is connected to PIN 4. Pulsed sampling is used for additional power savings.

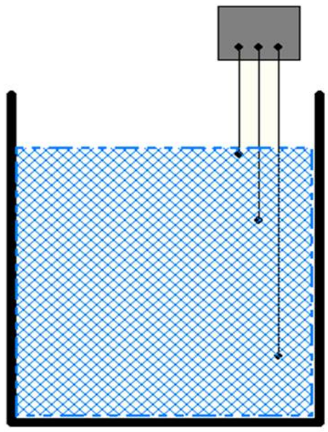

Figure 2. Wires inside the tank

Working functionality

The first state is when the connection is lost between the middle and bottom wires. This means that the water level is low and the pump should turn ON and start filling the tank.

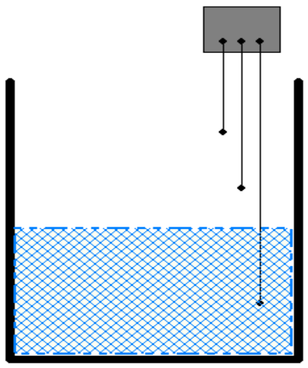

Figure 3. The 1st state

The second state is when the middle and bottom wires become re-connected. This means that the water level is increasing but the tank is not full yet, so that the pump should be ON.

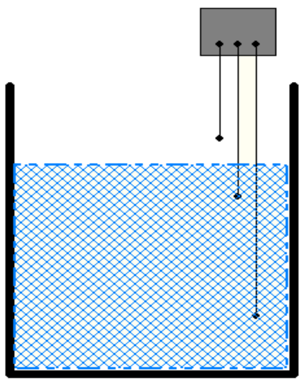

Figure 4. The 2nd state

The third state is when the middle and the top connect. This means that the tank is full, so the pump should be OFF.

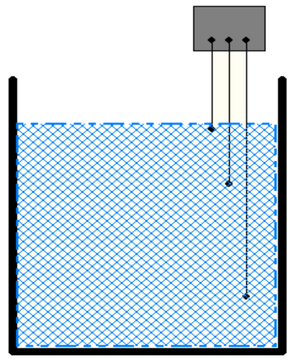

Figure 5. The 3rd state

The fourth state is when the connection between the middle and bottom is lost. This means that the water level is falling but the water level is not low enough to fill yet, so the pump should be OFF.

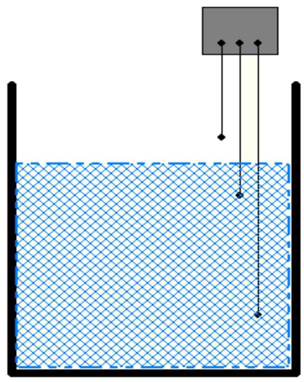

Figure 6. The 4th state

Then the first state repeats again. This circuit operation depends on taking samples for the water levels and to save the value between samples on DFFs.

Design description

GreenPAK2 generates the sampling pulses using two counters. CNT1/DLY1 sets the high pulse width, while CNT2/DLY2/FSM0 sets the output low time. A 50ms high pulse width is set by CNT1 “counter data”: 1418 by the formula:

$$Time\ period = (counter\ data + 1)/CLK$$

CNT2/DLY2/FSM0 controls the output low time with its “counter data” set to 21. Note that its' clock input is the CNT1/DLY1 output. This sets the low time in multiples of the high pulse width (50ms high and 1s low).

This high pulse will turn the circuit ON for 50ms and controls sampling of pins 3, 4. ACMP0 and ACMP1 are configured to improve the noise tolerance of the long wires. The sample result is saved in DFF1 and DFF2, then the pulse turns the circuit OFF for a second.

The CNT0/DLY0 and the 2-bit LUT2 combination is a glitch filter, where CNT0/DLY0 delay period equals 100us to reject the glitches generated by ACMP0 switching. Also, the CNT3/DLY3/FSM1 and the 2-bit LUT3 combination is a glitch filter, where CNT3/DLY3/FSM1 delay period equals 100us to reject the glitches generated by ACMP1 switching.

Pins 3, 4 are configured as “Analog in” with an internal 300k pull down resistor. When the middle wire presents a signal pulse high, conduction through the fluid can cause the corresponding wire (low / high) to pull up and be detected as “high” by the ACMP's.

The logic in this design is previous state dependent (latched). A 3-bit LUT0 keeps track of the direction of whether the water level is rising or falling. The truth table of this 3-bit LUT0 is shown in figure 8.

The 3-bit LUT0s output is buffered at pin11 to drive a relay that in turn, operates the pump.

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{THD}	ACMP0 Voltage Threshold	1475	-	1525	mV
V_{AIR}	ACMP Analog Input Voltage Range	0	-	1000	mV
T_{DLY0}	DLY0 Time Delay	-	0.1059	-	ms
T_{CNT1}	CNT1 Period Time	-	50.0706	-	ms
T_{CNT2}	CNT2 Period Time	-	2207	-	ms
T_{DLY3}	DLY3 Time Delay	-	0.1059	-	ms

Table 1. Design Main Electrical Characteristics

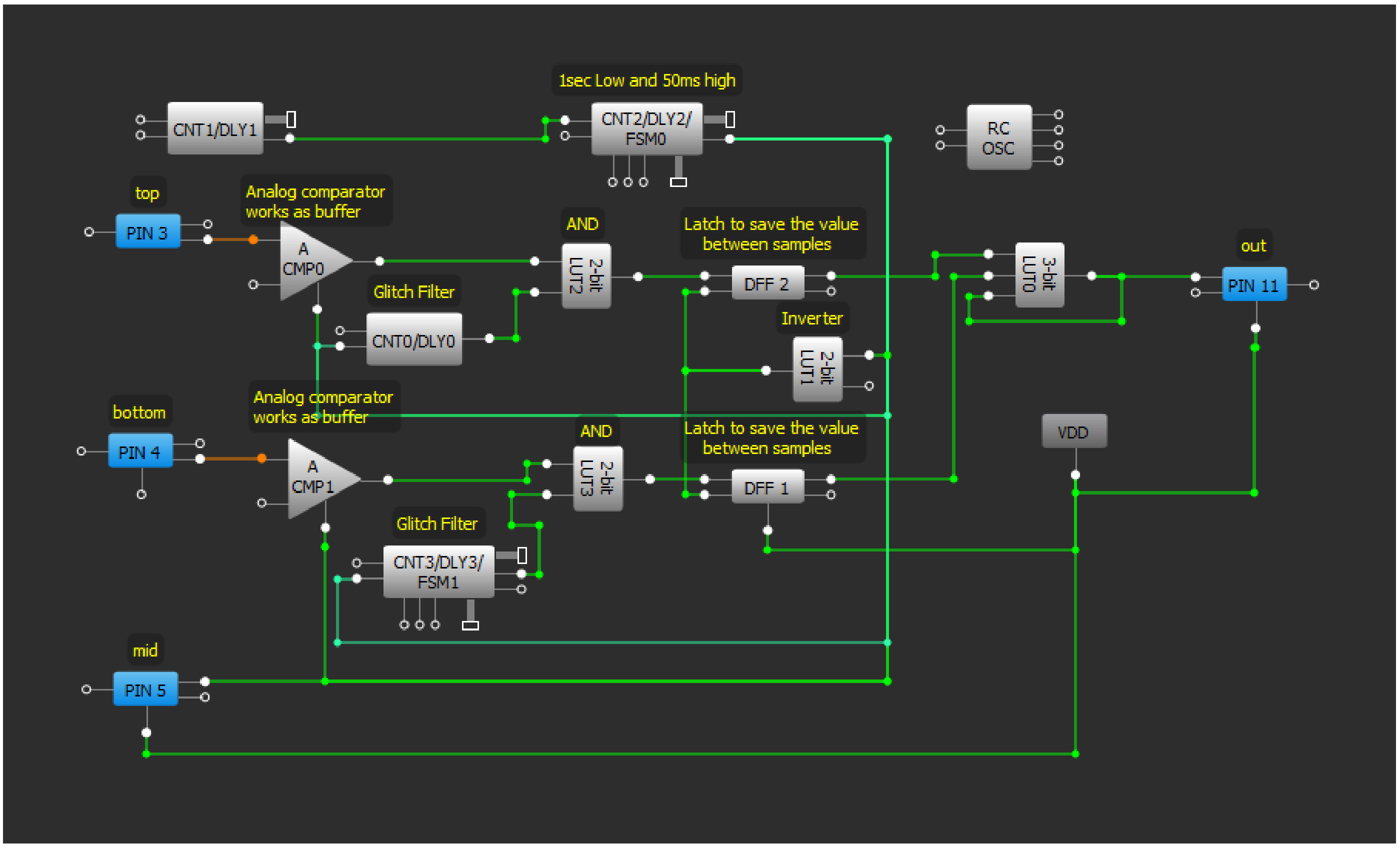

Figure 7. Design connections in GreenPAK2

3-bit LUT0			
IN2	IN1	IN0	OUT
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

Figure 8. 3-bit LUT0 properties

PIN 3	
Mode:	Analog in
Resistor:	Pull Down
Resistor value:	300K
Initial state:	Output floating
OE:	Disable

Figure 9. PIN 3 properties

PIN 4	
Mode:	Analog in
Resistor:	Pull Down
Resistor value:	300K
Initial state:	Output floating
OE:	From matrix

Figure 10. PIN 4 properties

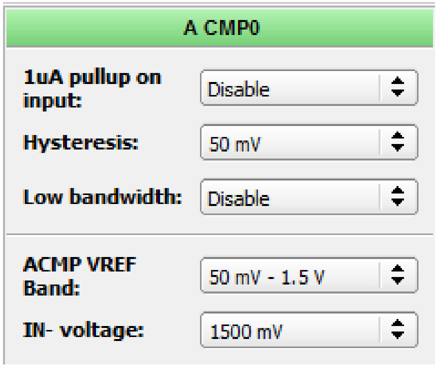

Figure 11. CMP0 properties

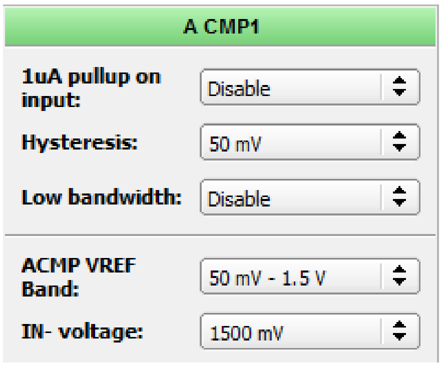

Figure 12. CMP1 properties

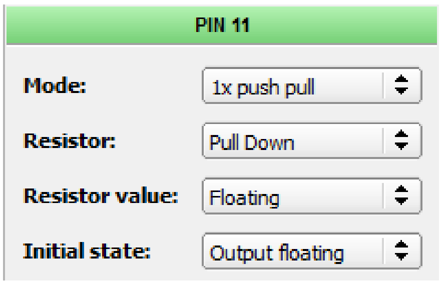

Figure 13. PIN 11 properties

Note: For proper operation of the circuit, don't forget to correctly configure input and output pins.

In case of schematic you see on Figure 14 inputs are configured as digital input with Schmitt trigger, and output as push-pull.

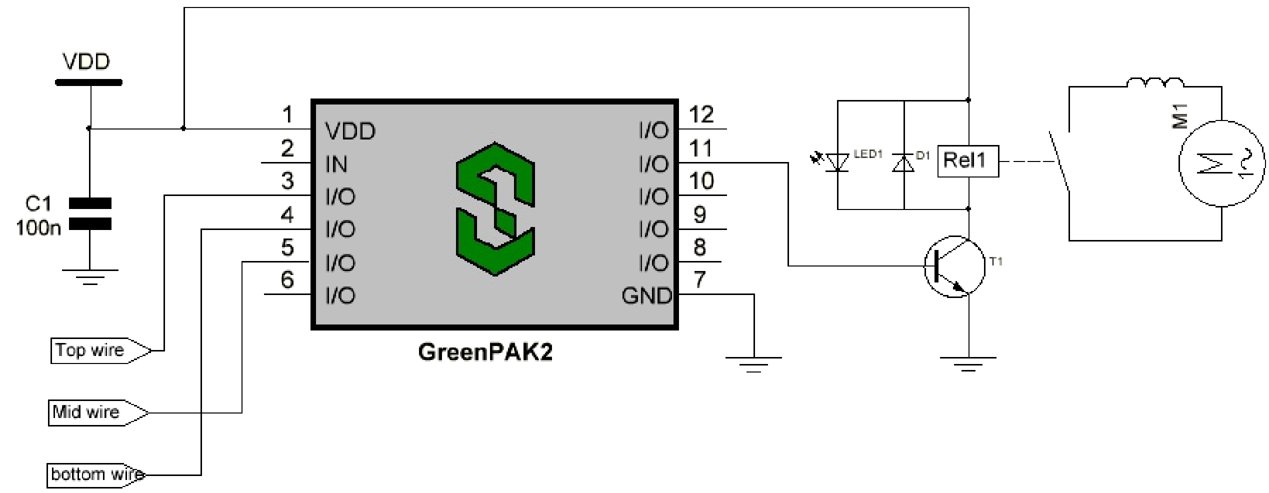

Figure 14. Applications circuit

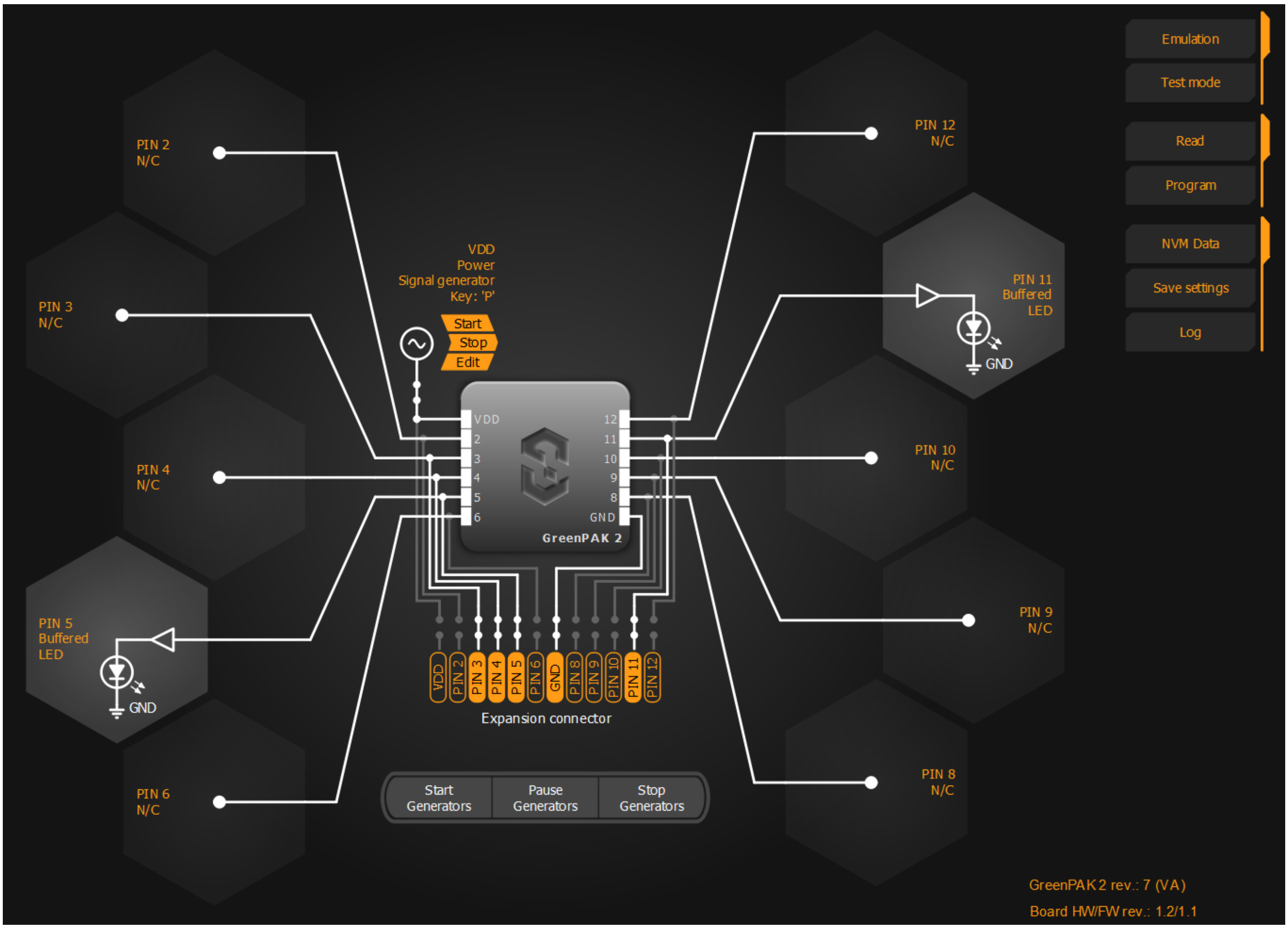

Figure 15. GreenPAK2 Emulation Tool

Design Connections

The inputs are PIN3 and PIN4 where they configured as Analog inputs with 300k Pull down resistor.

The outputs are PIN5 and PIN11, both configured as 1X Push Pull outputs with floating resistor.

As can be seen from Figure 17 the real waveform coincides with the theoretical one shown on Figure 16.

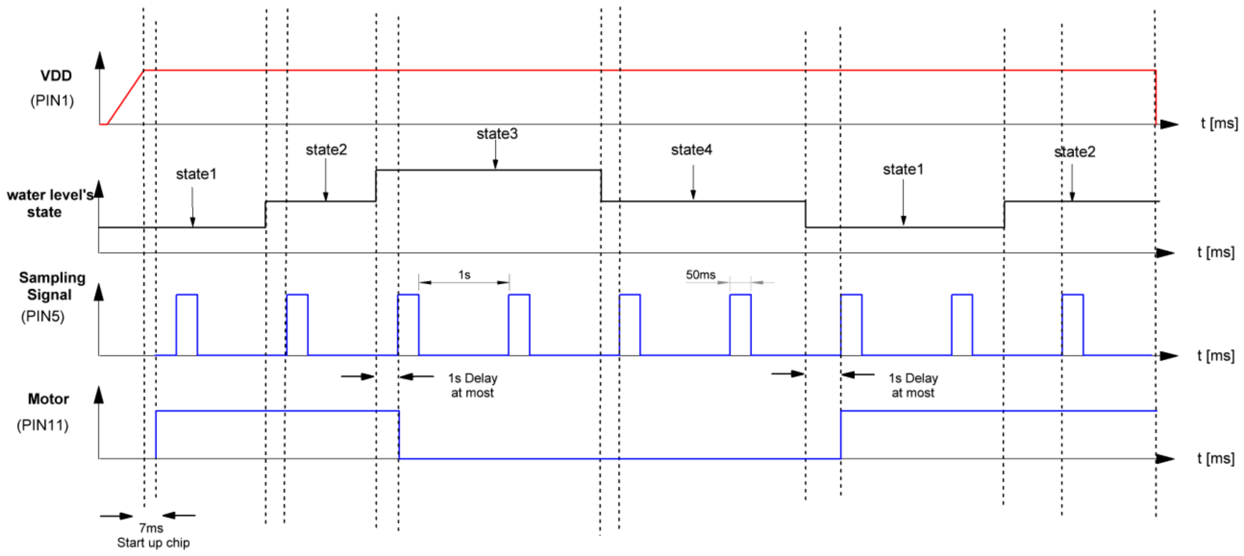

Figure 16. Timing diagram

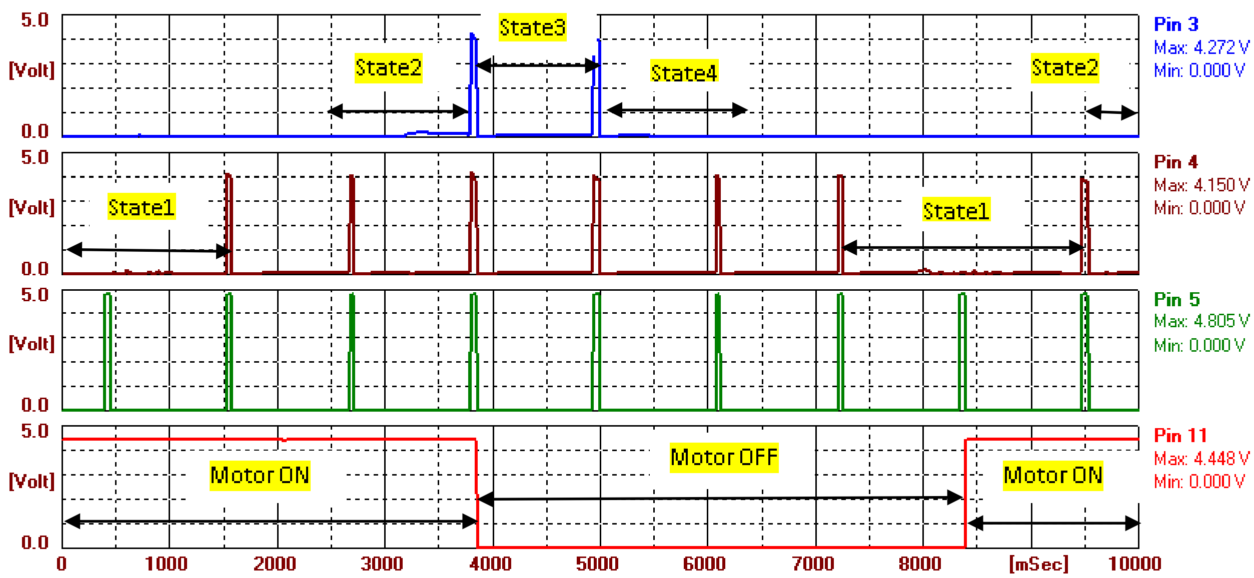

Figure 17. Functionality waveform

Conclusion

The GreenPAK product family is very useful for applications that require analog input from sensing elements, filtering, and timing control for power savings.

About the Author

Name: Saif Abu Baker

Background: Saif Abu Baker graduated from Yarmouk University in 2013, studying at the Department of Electrical Power Engineering. Presently, he is working with Configurable Mixed Signal ICs (CMICs) and their application notes and power supplies designing.

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Document History

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Revision	Orig. of Change	Submission Date	Description of Change
A	Saif Abu Baker	3/13/2014	New application note

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