ZigBit™ OEM Module 1.1

Application Note

ZigBit™ Temperature Stress Testing

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Summary

This Application note describes the procedure used to test ZigBit™ (ZDM-A1281-B0 and ZDM-A1281-A2) modules for critical failures in the industrial temperature range (-40 ºC to +85 ºC). It outlines test methodology and offers a summary of test results from which conclusions are drawn. It then provides a set of recommendations to developers wishing to use ZigBit™ modules in applications where temperature fluctuations or extreme temperature range are an issue.

Related documents:

[1] Range Measurement Tool Users Guide. MeshNetics Doc. P-ZBN-451

[2] ZigBit™ Development Kit 2.0 User's Guide. MeshNetics Doc. S-ZDK-451

Test Setup

Temperature measurements were conducted using Espec SH-661 benchtop test chamber. Two different module configurations were tested: (1) ZigBit ZDM-A1281-B0 mounted on a MeshBean board with PCB antenna, and (2) ZigBit ZDM-A1281-A2 (chip antenna version) mounted on a modified MeshBean board without a PCB antenna. A Freescale 13192EVM control receiver was also placed outside the chamber to provide a reference point for correct operation of the transmitting device under test (See Figure 1).

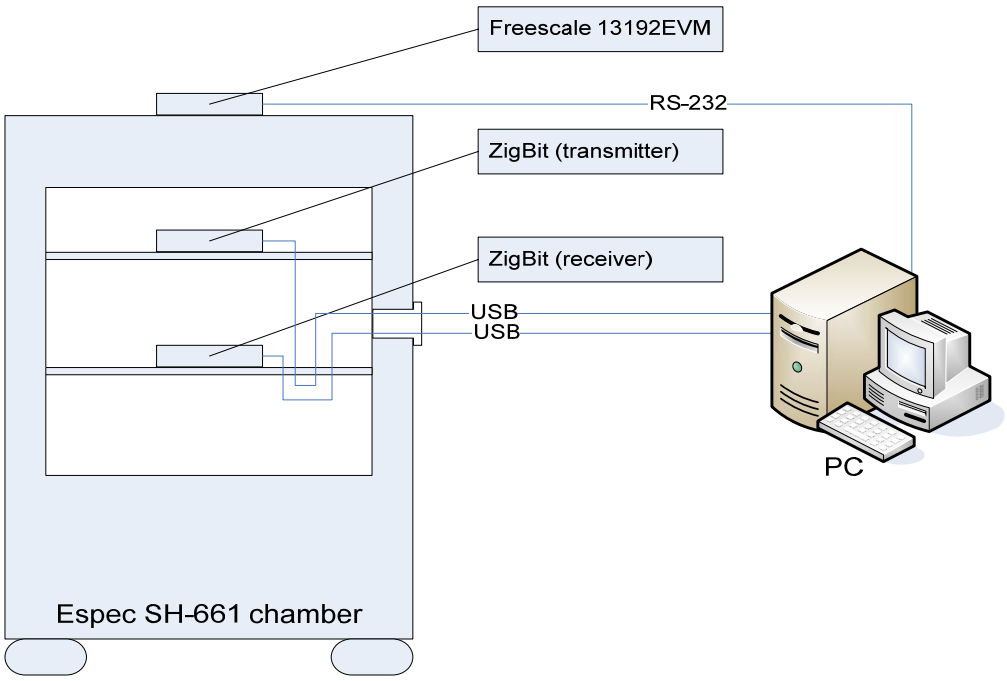

Figure 1. Test setup overview

USB cables between the two devices within the chamber and the PC ran through the chamber cable port, as shown. The same test sequence was repeated for a ZigBit ZDM-A1281-B0 and a ZigBit ZDM-A1281-A2 as receivers.

The thermo chamber remained in *continuous* mode throughout the tests. This was done to ensure the fastest possible transition between the adjacent temperature and humidity test points.

The Table 1 below specifies the software installed on all devices prior to testing. Receiver and transmitter ZigBits are programmed with the corresponding images from the Range Measurement Tool [1] available within MeshNetics ZigBit Development Kit [2].

Table 1. Test preconditions

Device	Software
Freescale 13192EVM	`rx_13192evm.s19`, receiver image for Freescale platform
ZigBit™ (transmitter)	`transmitter.hex`, transmitter image
ZigBit™ (receiver)	`receiver.hex`, receiver image
PC	Broy Terminal emulator

The next **Table 2** lists antenna placement and radio parameters for the devices under test.

Table 2. RF conditions

Parameter	Value
Antenna polarity	Horizontal, parallel to the front wall of the chamber
Module output power	+3 dBm
Channel	0x0B (2405 MHz)

Setup Notes

Prior to the first run of the tests, temperature in the chamber was raised to 85 ºC and relative humidity to 70%. Freescale 13192EVM device was originally placed within the chamber alongside with the MeshBean boards; however, its USB port failed before the test sequence began. Because its COM port connector did not fit through the test chamber's cable port, the Freescale device had to be removed from the chamber and connected to the PC via a COM port.

Relative humidity could not be set for all temperature points in the tested range, so this data is sparse. Occasionally available relative humidity values are reflected in the test results.

Test Procedures

Devices under test were exposed to two distinct temperature sequences:

- In the first sequence, the device was tested under gradual temperature change between the two extremes (10 ºC steps with at least 4 minutes at each one of the temperature levels).
- In the second sequence, the device was exposed to rapid temperature fluctuation (-40 ºC to +85 ºC and back in ~under 40 minutes).

Two different transmitter/receiver pairs of modules were tested: (1) ZDM-A1281-B0 transmitter and ZDM-A1281-B0 receiver, and (2) ZDM-A1281-B0 transmitter and ZDM-A1281-A2 receiver. The first sequence was applied to the first pair, while the second sequence was applied to both pairs of modules.

The following data was captured to log:

- Temperature and humidity in the chamber
- Data available from the range measurement software installed on transmitter and receiver devices (total packets received, packets lost, packets containing bit errors, LQI, RSSI)
- Time when measurement was taken (as recorded by the terminal program on the PC).

Summary of Test Results

Two tables, one for each transmitter/receiver pair tested, summarize the test results. The tables provide a summary of data logged during the test runs under the setup and procedure described above. The tables highlight each temperature point and any exceptional conditions detected and setup changes undertaken.

Table 3. ZDM-A1281-B0 transmitter and ZDM-A1281-B0 receiver

Pass	Time	Temperature	Humidity	Notes	Test type
1	15:35	60	40	Tests started	Gradual temperature change sequence
	15:40	70	19		
	15:52	70	45		
	15:55	70	50		
	16:05	70	42	Chamber door opened briefly	
	16:11	66	54	Chamber set to 80ºC, 70% hum.	
	16:16	80	15		
	16:26	85	11		
	16:28	85	N/A	Test pass finished	
2	16:28	85	N/A	Humidity control off	
	16:31	85	N/A	Transition to 70 ºC started	
	16:39	70	N/A	Pause at 70 ºC	
	16:43	70	N/A	Transition to 60 ºC started	
	16:46	60	N/A	Pause at 60 ºC	
	16:50	60	N/A	Transition to 50 ºC started	
	16:55	50	N/A	Pause at 50 ºC	
	16:59	50	N/A	Transition to 40 ºC started	
	17:03	40	17	Pause at 40 ºC	
	17:07	40	19	Transition to 30 ºC started	
	17:21	30	N/A	Pause at 30 ºC	
	17:25	30	N/A	Transition to 20 ºC started	
	17:36	20	N/A	Pause at 20 ºC	
	17:40	20	N/A	Transition to 10 ºC started	
	17:52	10	N/A	Pause at 10 ºC	
	17:56	10	N/A	Transition to 0 ºC	
	18:22	0	N/A	Test pass finished	
3	18:22	0	N/A	Transition to -40 ºC started	Rapid temperature change sequence
	18:29	-1	N/A	1st temperature below 0 ºC	
	18:40	-25	N/A	3 packet errors	
	18:48	-40	N/A	14 packets errors over 1 min. interval	
	3:32	-40	N/A	1 packet error	
	10:11	-40	N/A	Test pass finished	
4	10:11	-40	N/A	Transition to 85 ºC started	
	10:13	-20	N/A		
	10:14	-15	N/A	3 packet errors	
	10:16	-10	N/A		
	10:18	0	N/A		
	10:20	10	N/A		
	10:34	58	N/A	Receiver failure (first all packets contain errors, then all packets are dropped)	
	10:36	65	N/A	Receiver reset	
	10:44	85	N/A	Test pass finished	
5	10:44	85	N/A	Transition to -40 ºC started	

Pass	Time	Temperature	Humidity	Notes	Test type
	11:19	0	N/A		
	11:42	-30	N/A		
	11:50	-40	N/A		
	12:12	-40	N/A	Test pass finished	
6	12:12	-40	N/A	Transition to 85 ºC started	
	12:38	72	N/A	Receiver failure (first all packets contain errors, then all packets are dropped) and reset	
	12:43	85	N/A	Test pass finished	
7	12:43	85	N/A	Transition to -40 ºC started	
	13:27	-15	N/A		
	13:30	-18	N/A	2 error packets	
	13:58	-40	N/A		
	14:17	-40	N/A	Test pass finished	
8	14:17	-40	N/A	Transition to 85 ºC started	
	14:40	60	N/A	Receiver failure (first all packets contain errors, then all packets are dropped) and reset	
	15:10	85	N/A	Test pass finished	
9	15:10	85	N/A	Transition to -40 ºC started	
	15:39		N/A	2 error packets	
	16:00		N/A	1 error packet	
	16:30	-40	N/A	3 error packets	
	17:35	-40	N/A	Test pass finished	
10	17:35	-40	N/A	Transition to 85 ºC started	
	17:55	52	N/A	1 error packet	
	17:56	55	N/A	1 error packet	
	17:56	56.5	N/A	1 error packet	
	17:57	56.8	N/A	1 error packet	
	17:57	59.8	N/A	Receiver failure (first all packets contain errors, then all packets are dropped) and reset	
	18:07	85	N/A	Chamber door opened, thermocouple inserted and set for 50 ºC	
	18:08	85	N/A	7 error packets	
	18:08	85	N/A	Test pass finished	
11	18:18	50	N/A	Transition to 65 ºC started	
	18:23	65	N/A	Test pass finished	
	18:23	65	N/A	Tests finished	

Table 4. ZDM-A1281-B0 transmitter and ZDM-A1281-A2 receiver

Pass	Time	Temperature	Humidity	Notes	Test type
12	10:00	25	65	Tests started	Rapid tempe
	10:00	25	65	Transition to -40 ºC started	
	10:17	0	N/A		

Pass	Time	Temperature	Humidity	Notes	Test type
	10:45	-38	N/A	2 error packets	
	10:47	-40	N/A		
	11:02	-40	N/A	Test pass finished	
13	11:02	-40	N/A	Transition to 85 ºC started	
	11:21	52	N/A		
	11:31	70	N/A	Receiver failure (first all packets contain errors, then all packets are dropped)	
	11:36	85	N/A	Receiver reset	
	11:36	85	N/A	Test pass finished	
14	11:36	85	N/A	Transition to -40 ºC started	
	12:08	10	N/A	3 error packets	
	12:15	-3	N/A		
	12:45	-40	N/A	1 error packet	
	12:45	-40	N/A	Test pass finished	
15	12:45	-40	N/A	Transition to 85 ºC started	
	12:53	-20	N/A	2 error packets	
	13:17	80	N/A	Receiver failure (first all packets contain errors, then all packets are dropped)	
	13:57	85	N/A	Receiver failure	
	13:57	85	N/A	Test pass finished	
16	13:57	85	N/A	Transition to 1 ºC started	
	14:30	14	N/A	1 error packet	
	14:31	13	N/A	Sequence stopped and temperature set to 15 ºC	
	14:31	13	N/A	Test pass finished	
17	14:50	15	N/A	Transition to 85 ºC started	
	15:04	60	N/A		
	15:08	70	N/A		
	15:16	85	N/A	Test pass finished	
	15:16	85	N/A	Tests finished	

Conclusions

Overall, ZigBit™ modules performed well in the industrial temperature range. No significant deviations from normal operation of device were observed.

Under gradual temperature change sequence, the modules remained stable and no transmission errors were detected at any of the temperature points. Under rapid temperature change, the modules exhibited a relatively low packet error rate both during rapid temperature increases (1.5 – 2 ºC/min) and during rapid temperature drops (3 - 4 ºC/min).

Under rapid temperature change sequence, temporary failure of receiver (defined as a state from which full functionality can be restored with a reset) at 55 – 60 ºC for the PCB antenna version and 70 – 80 ºC for the chip antenna version can be explained by condensation accumulating inside the module or directly on the MeshBean board. In order to verify this theory, additional test passes (Pass 11 and 17) were conducted over exactly the failing range, but no errors were detected. As rapid temperature change, especially at the rate of 3 – 4 ºC, is not representative of any real-world temperature profiles, temporary receiver failures encountered in the course of testing are not to be viewed as critical.

Occasional unexplained packet errors can be attributed to shifting of the devices within the chamber, and the changes to the interferential condition inside the chamber that such shifting can cause.

In the course of testing, several improvements to the current test procedures were identified. These will be taken into account in all future tests.

- Enable activation of RESET button on the device from outside the chamber (via separate cable connection)
- Avoid moving the chamber during tests to avoid devices shifting inside
- Place 3-rd party control module inside the chamber
- Enable logging through the chamber's own RS-232 port.

Recommended Practices for Applications in Extreme Temperature Environments

Developers wishing to incorporate ZigBit™ modules in applications operating in extreme temperature environments are encouraged to place modules in a hermetic enclosure if any of the following conditions are true:

- Condensation may accumulate directly on the module.
- High temperatures *and* high humidity conditions may occur at the same time.
- Temperature gradients above 3 – 4 ºC are possible.