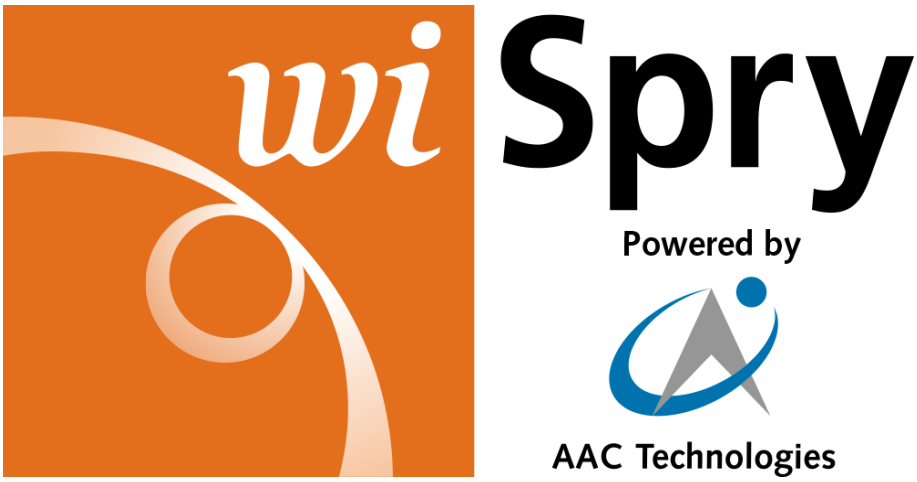


PE-xxxx
Revision A

MEMS CYCLING AND HOLD DOWN PROCEDURE

Table of Contents

1. Purpose and Scope

1.1 Purpose

This document defines the procedures and requirements for cycling and holding down stresses for MEMS capacitors.

1.2 Scope

This procedure applies to the qualification and ongoing production monitoring of all WiSpry products.

2. Responsibilities

The Product Engineering function is responsible for assuring compliance to the requirements of this document.

3. REFERENCE DOCUMENTS

Document No.	Document Name
PE-0002	Equipment Calibration Procedure

4. FORMS

Form No.	Form Name

5. DEFINITIONS (Not Applicable)

6. EQUIPMENT AND MATERIALS

Equipment consists of:

Item	Model	Manufacturer	Comments
Computer (equipment controller)	PC with Window XP, 7	Any	
Software (equipment controller)	LabView 2012 or Higher		
GPIB-USB-HS	778927-01	National Instruments	
Triple Output Power Supply	E3631A	Agilent/Keysight	w/ GBIP interface
Source Meter	2400	Keithley	w/ GBIP interface
DMM	2000	Keithley	w/GPIB interface
FPGA	PIX-7813R	National Instruments	
PXI Card Chassis	PIX-1033	National Instruments	
DUT boards	Various[1]	---	WiSpry Design
SHC68-68-RDIO Shielded Cable	191667-01	National Instruments	NI Cables

Notes:
[1] WS1050 board is 36 positions (model WS-EVB-165)

7. REQUIREMENTS AND PROCEDURES

7.1 Basic Hardware, Software, and Environmental Requirements

- Cycling and hold down hardware (boards, cables, connectors, bench equipment) must be able to:
  - Meet the electrical conditions specified in sections 7.2 and 7.3.
  - Meet WiSpry calibration requirements specified in PE-0002.
  - Be sufficiently robust to ensure minimum leakage currents.

- Cycling and hold down software should:
  - Allow for insitu monitoring for stiction events.
  - Meet the electrical conditions specified in sections 7.2 and 7.3.

- Cycling and hold down environmental controls shall:
  - Provide control of temperature and humidity.
  - Meet calibration requirements defined in PE-0002.

7.2 MEMS Cycling

The cycling conditions for product qualification and ongoing monitoring are:

Stress Condition	Requirement
MEMS Operating Voltage (V_{OP})	44 V
V_{DD}	3.7 V @ 12 KHz
Temperature	65 °C
Frequency	12 KHz
Duty Cycle	25%
Dual Voltage Actuation (DVA)	OFF
Beam Actuation	All beams cycles simultaneously

7.3 MEMS Hold Down

The hold down conditions for product qualification and ongoing monitoring are:

Stress Condition	Requirement
MEMS Operating Voltage (V_{OP})	44 V
V_{DD}	3.3 V
Temperature	65 °C
Frequency	----
Duty Cycle	100%
Dual Voltage Actuation (DVA)	OFF
Beam Actuation	All beams cycles simultaneously and held for the stress duration

7.4 Reject Criteria

For both cycling and hold down, the following conditions define a reject reading:

C_{OFF} ±46 fF per bank
C_{ON} ±657 fF per bank

7.5 Set-up and Handling Guidelines

- Handling recommendations for ESD
- Stabilize oven temperature prior to loading parts, 15 minutes minimum
- Preconditioning of new stress boards (to remove excess moisture absorption), 24 hour bake at 85C
- Optimal method to load boards
- Special software instructions
- Best way to unload parts
- Socket inspection after each run and cleaning/repair as required
- Sample control and storage post stress

7.6 Procedure to Set-up Test

- Fig. 1 below is the test set-up block diagram for WS1050 Reliability Test, Multi DUT
    - Using banana plug cables to connect all test equipments as the Fig. 1 below. For power supply E3631A, use channel 1 for VDD, channel 2 for +3.3V.

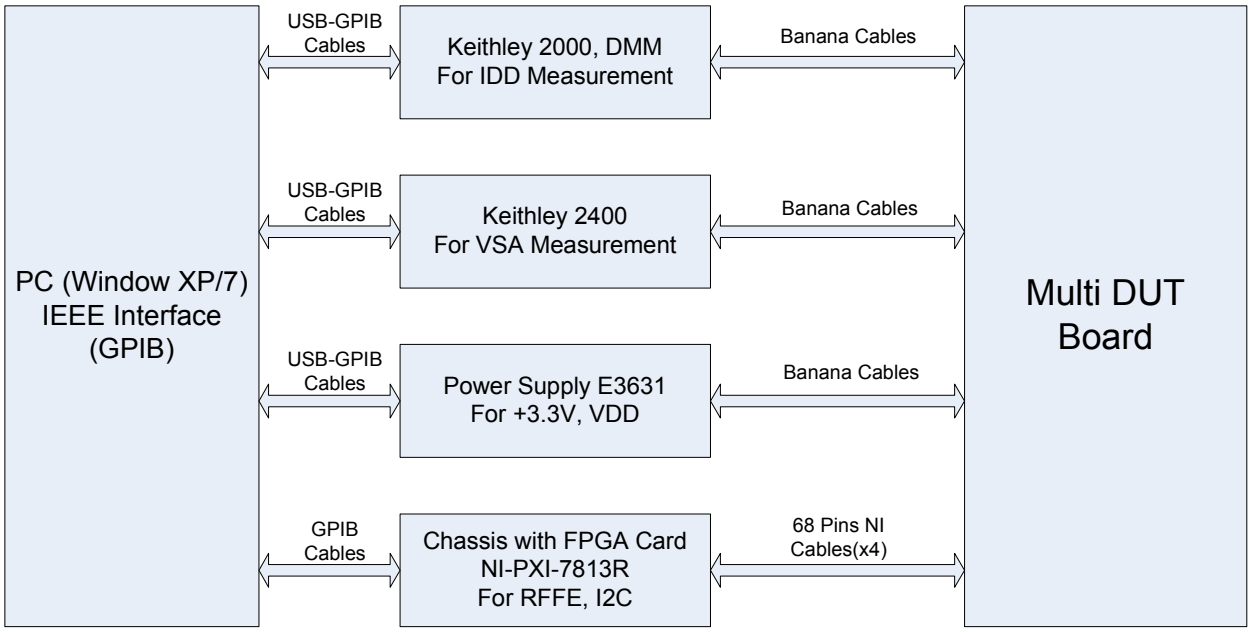


Fig 1. Test Setup Block Diagram

- Test Program: Using executable of WS1050 36 DUT Reliability HD_Cycling Ver1.4 as the latest test program version for stressing parts
    - Fig. 2 below is the front panel of the test program

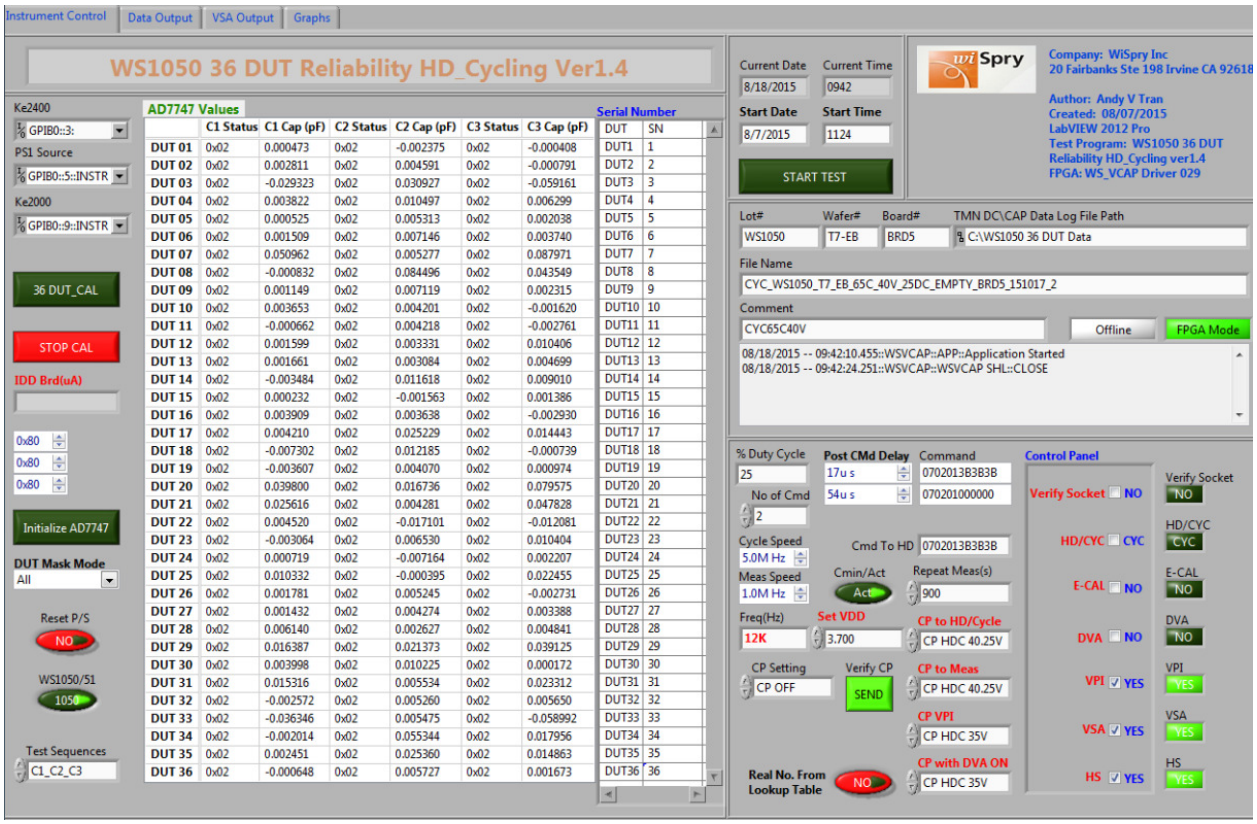


Fig. 2

This test program will be found at the link below:

S:\Software_Control\Released\36 DUT Board\WS1050 36 DUT Reliability HD_Cycling Ver1.4

7.7 Procedure to Run Test

- Set temperature from oven/chamber
    - Adjust temperatures from oven/chamber to meet the requirement (25C, 45C, 55C, 65C or 85C)
- Set-up test program
    - From labVIEW test program click  this button at the top left corner to run the test program, it will pop-up a dialog box (Fig. 3) below to ask the look up table for read point

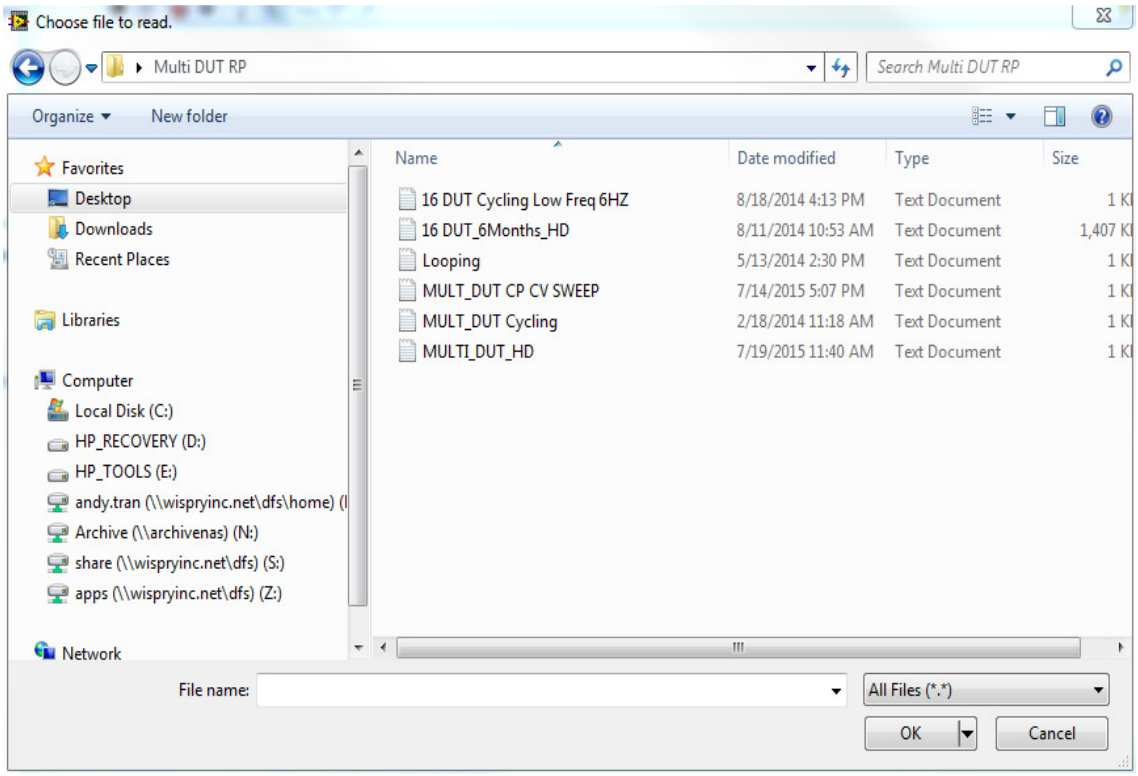
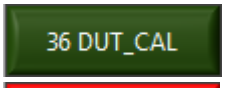


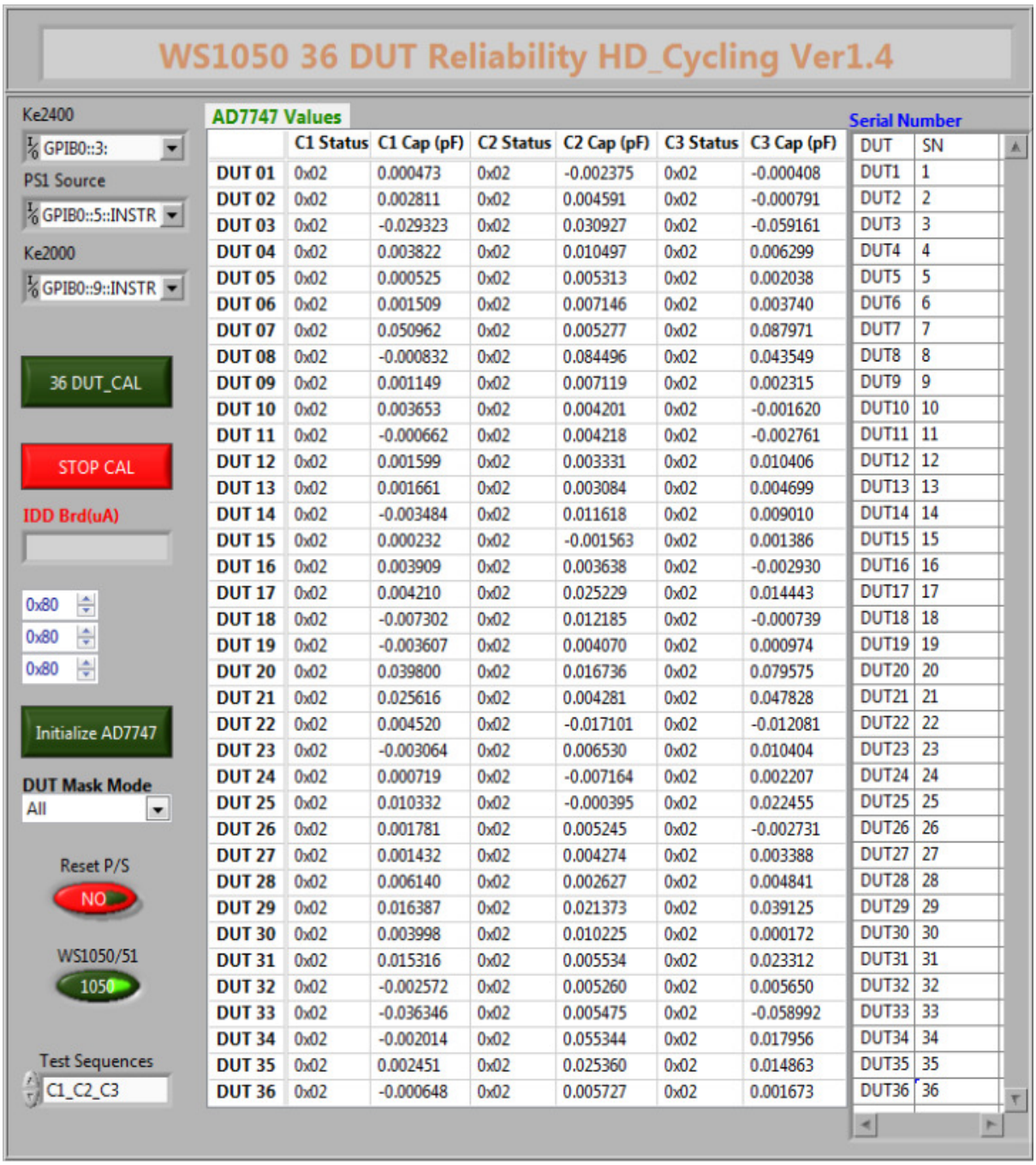
Fig. 3

Note: It depends on what stress you are running to select the correct file.
For instance:
If you are running cycling, the file will be selected is MULT_DUT Cycling
If you are running Hold Down, the file will be selected is MULT_DUT HD

- For calibration (Fig. 4): Make sure all sockets are empty and the CAP values of 36 DUT are around zeros "~0"for all three banks. If not, click on 36 DUT_CAL button 

to zero out the sockets, then click STOP CAL button 

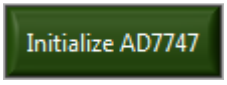
to stop the calibration



	C1 Status	C1 Cap (pF)	C2 Status	C2 Cap (pF)	C3 Status	C3 Cap (pF)
DUT 01	0x02	0.000473	0x02	-0.002375	0x02	-0.000408
DUT 02	0x02	0.002811	0x02	0.004591	0x02	-0.000791
DUT 03	0x02	-0.029323	0x02	0.030927	0x02	-0.059161
DUT 04	0x02	0.003822	0x02	0.010497	0x02	0.006299
DUT 05	0x02	0.000525	0x02	0.005313	0x02	0.002038
DUT 06	0x02	0.001509	0x02	0.007146	0x02	0.003740
DUT 07	0x02	0.050962	0x02	0.005277	0x02	0.087971
DUT 08	0x02	-0.000832	0x02	0.084496	0x02	0.043549
DUT 09	0x02	0.001149	0x02	0.007119	0x02	0.002315
DUT 10	0x02	0.003653	0x02	0.004201	0x02	-0.001620
DUT 11	0x02	-0.000662	0x02	0.004218	0x02	-0.002761
DUT 12	0x02	0.001599	0x02	0.003331	0x02	0.010406
DUT 13	0x02	0.001661	0x02	0.003084	0x02	0.004699
DUT 14	0x02	-0.003484	0x02	0.011618	0x02	0.009010
DUT 15	0x02	0.000232	0x02	-0.001563	0x02	0.001386
DUT 16	0x02	0.003909	0x02	0.003638	0x02	-0.002930
DUT 17	0x02	0.004210	0x02	0.025229	0x02	0.014443
DUT 18	0x02	-0.007302	0x02	0.012185	0x02	-0.000739
DUT 19	0x02	-0.003607	0x02	0.004070	0x02	0.000974
DUT 20	0x02	0.039800	0x02	0.016736	0x02	0.079575
DUT 21	0x02	0.025616	0x02	0.004281	0x02	0.047828
DUT 22	0x02	0.004520	0x02	-0.017101	0x02	-0.012081
DUT 23	0x02	-0.003064	0x02	0.006530	0x02	0.010404
DUT 24	0x02	0.000719	0x02	-0.007164	0x02	0.002207
DUT 25	0x02	0.010332	0x02	-0.000395	0x02	0.022455
DUT 26	0x02	0.001781	0x02	0.005245	0x02	-0.002731
DUT 27	0x02	0.001432	0x02	0.004274	0x02	0.003388
DUT 28	0x02	0.006140	0x02	0.002627	0x02	0.004841
DUT 29	0x02	0.016387	0x02	0.021373	0x02	0.039125
DUT 30	0x02	0.003998	0x02	0.010225	0x02	0.000172
DUT 31	0x02	0.015316	0x02	0.005534	0x02	0.023312
DUT 32	0x02	-0.002572	0x02	0.005260	0x02	0.005650
DUT 33	0x02	-0.036346	0x02	0.005475	0x02	-0.058992
DUT 34	0x02	-0.002014	0x02	0.055344	0x02	0.017956
DUT 35	0x02	0.002451	0x02	0.025360	0x02	0.014863
DUT 36	0x02	-0.000648	0x02	0.005727	0x02	0.001673

DUT	SN
DUT1	1
DUT2	2
DUT3	3
DUT4	4
DUT5	5
DUT6	6
DUT7	7
DUT8	8
DUT9	9
DUT10	10
DUT11	11
DUT12	12
DUT13	13
DUT14	14
DUT15	15
DUT16	16
DUT17	17
DUT18	18
DUT19	19
DUT20	20
DUT21	21
DUT22	22
DUT23	23
DUT24	24
DUT25	25
DUT26	26
DUT27	27
DUT28	28
DUT29	29
DUT30	30
DUT31	31
DUT32	32
DUT33	33
DUT34	34
DUT35	35
DUT36	36

Fig. 4

Note: If sockets are not zeros "~0", click on initialize AD7747 button 

to initialize the ADI chip, make sure the CAP values will be less than 1pF (<1pF) for all three banks of 36 DUT, click on 36 DUT_CAL button to zero out the sockets then click on STOP CAL button to stop the calibration.

- Set-up test condition (Fig. 5): The front panel below was set by default with cycling, DVA OFF, E-CAL OFF, VPI ON, VSA ON, HS (hand shake check) = ON, VDD = 3.7V, cycle speed = 12 KHz, CP stress = 40.25V, CP VPI = 35V.

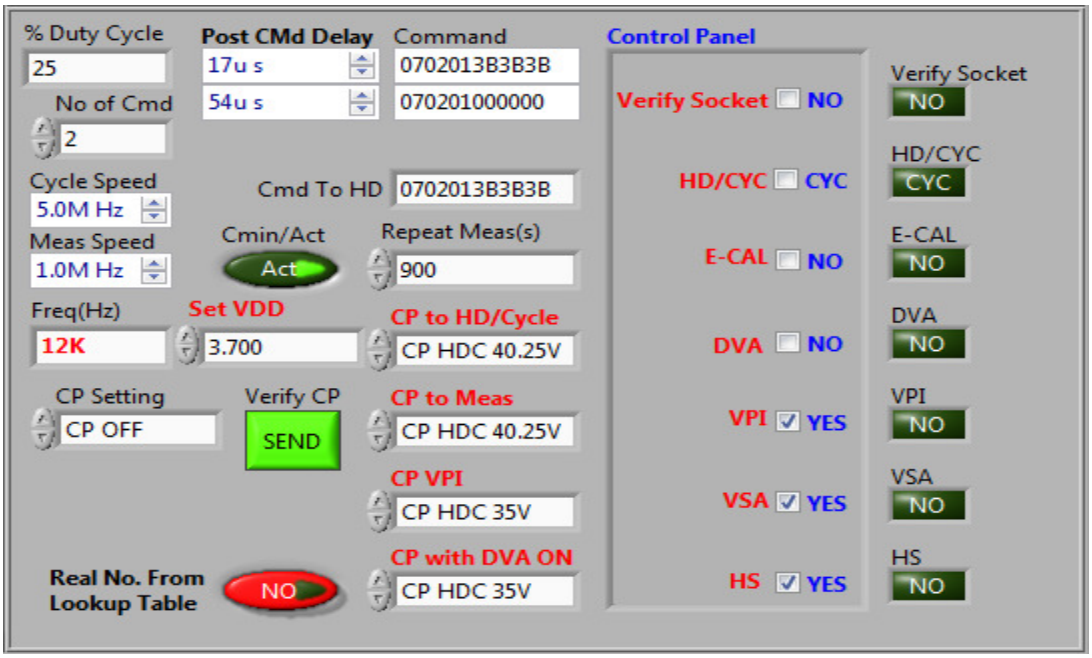
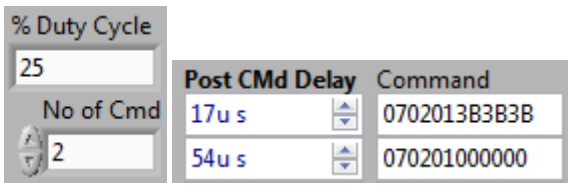
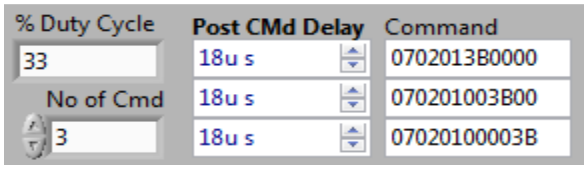


Fig. 5

- Set-up with standard stress (cycle): All Drivers ON, All Drivers OFF, 25% Duty. Make sure the numbers will be set as same as the boxes are shown below



- Set-up with special stress (cycle): C1 ON, C2 OFF, C3 OFF; C1 OFF, C2 ON, C3 OFF; C1 OFF, C2 OFF, C3 ON, 33% Duty. Make sure all the numbers will be set as same as the boxes are shown below



- Set-up for stress (hold down): All Drivers should be closed during hold down, 100% duty. This was set by default 

- Set-up for the data output (Fig. 6): The front panel below is to set-up to collect the test data.

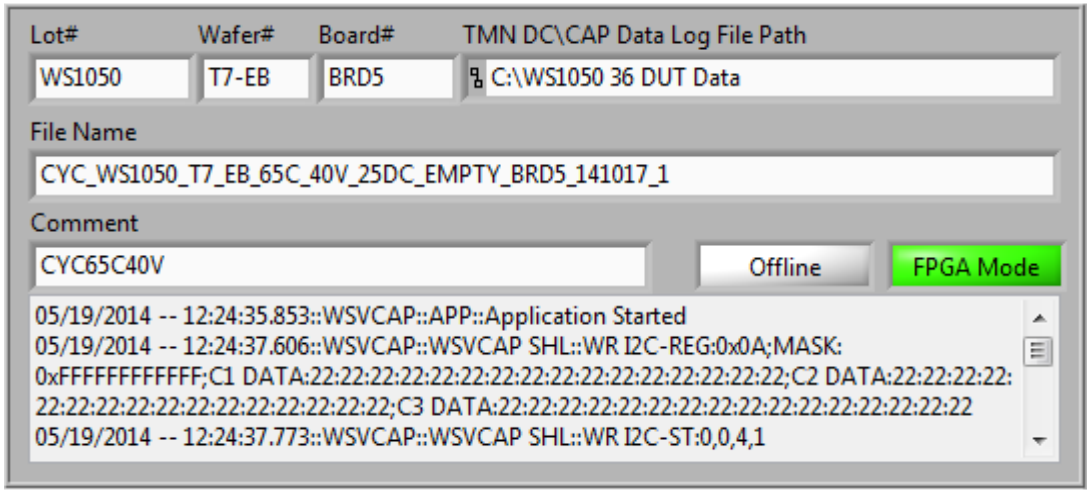


Fig. 6

Note: The file name will be
stress_lot#_wafer#_design_temperature_CPV Stress_duty_brd#_yymmdd_run

- Set-up date/time to run stress (Fig. 7): We can start to run the test immediately by click on the START TEST button, or we can set-up date/time to run the test by enter the Start Date and Start Time

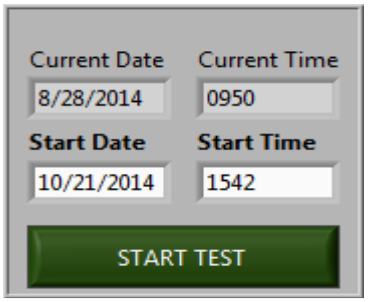


Fig. 7

- The front panel below (Fig. 8) indicates the CAP values for every read point.

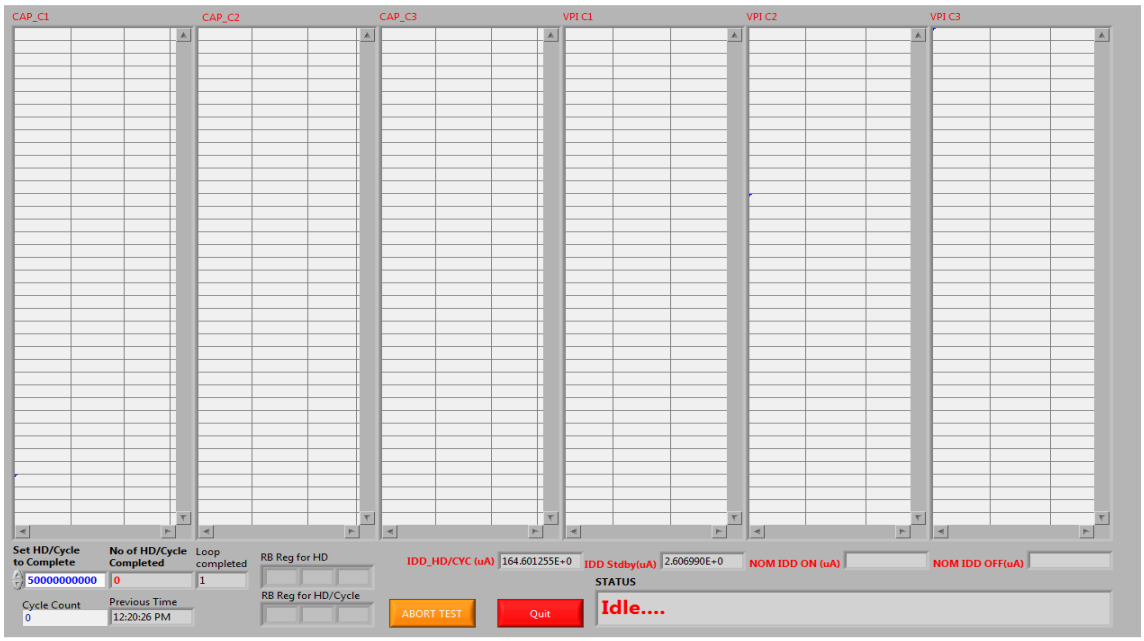


Fig. 8

- The front panel below (Fig. 9) indicates VSA, HS check, EFUSE, % Delta CAP for every read point

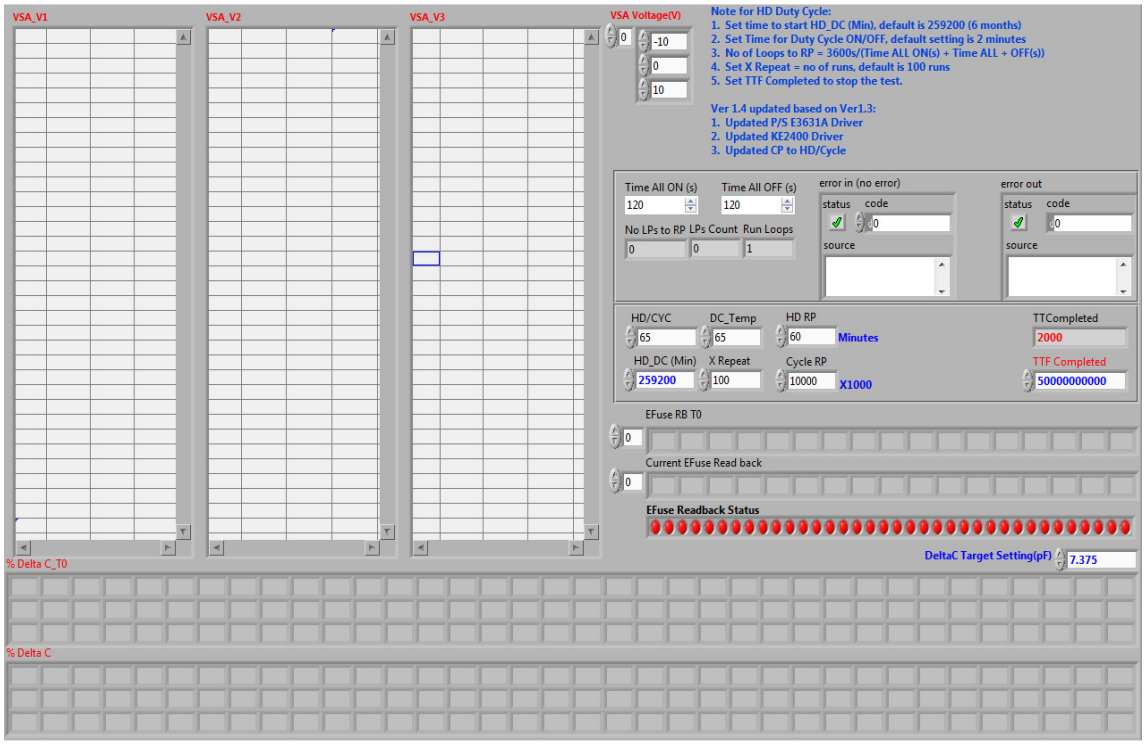


Fig. 9

- The plots below (Fig. 10) monitor the change of CMIN during stress.

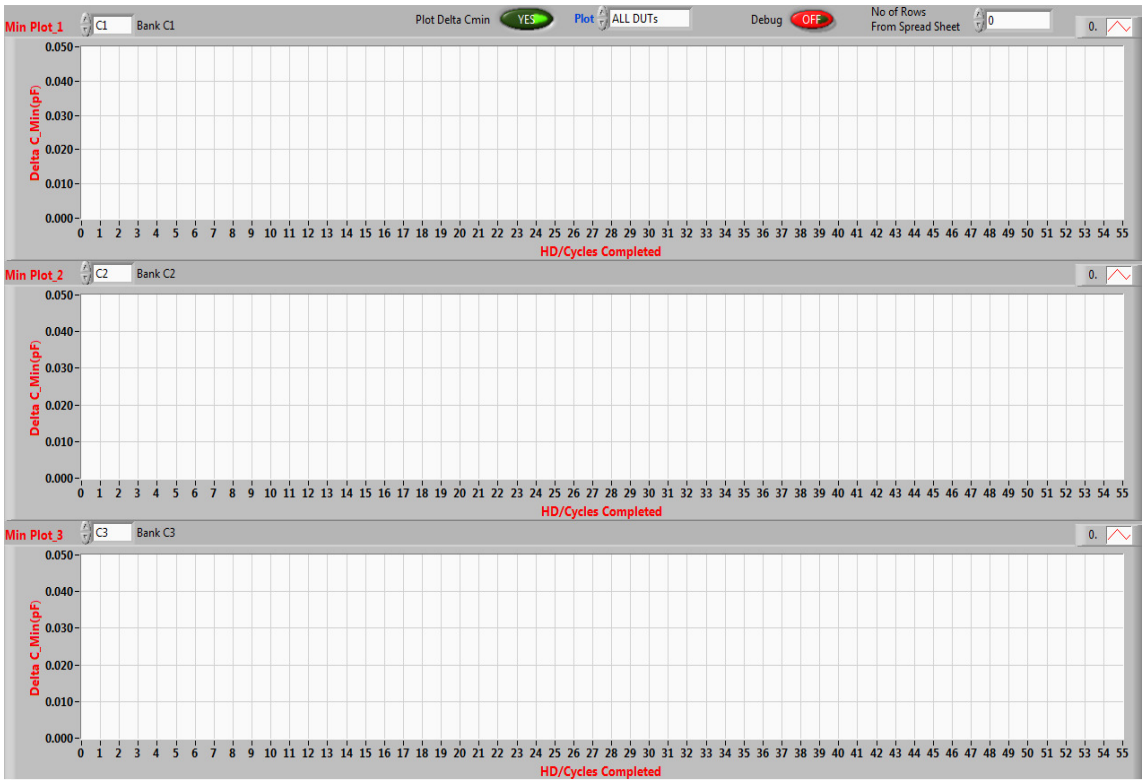
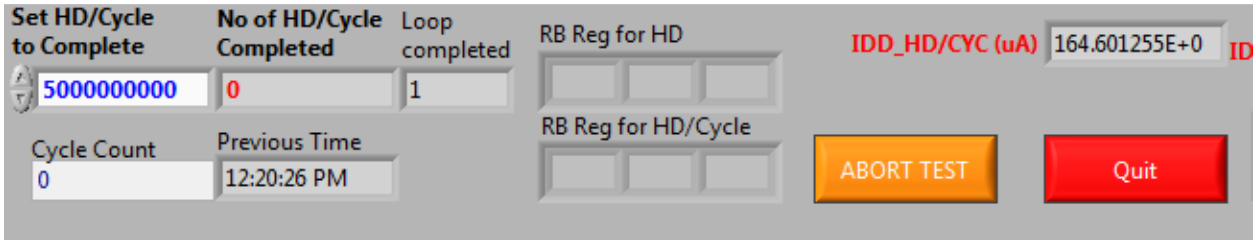


Fig. 10

- Stop stress or abort the test: We can abort the test immediately by click on the ABORT TEST button or enter the number that will be set to complete the test (5 billion cycles is set by default).



8. REVISION HISTORY

Rev	Description	Editor	Date
A	Initial Release	M. Johnson	12-Aug 2015