Qualcomm TECHNOLOGIES, INC

Thermal Tuning Procedure

80-N9649-1 B

Qualcomm Technologies, Inc.
5775 Morehouse Drive
San Diego, CA 92121
U.S.A.

Revision History

Revision	Date	Description
A	Feb 2012	Initial release
B	Feb 2013	Numerous changes were made to this document; it should be read in its entirety.

Contents

- Thermal Tuning
- Thermal Test Setup
- Thermal Tuning Procedure
- Thermal Lab Setup
- References
- Questions?

Thermal Tuning

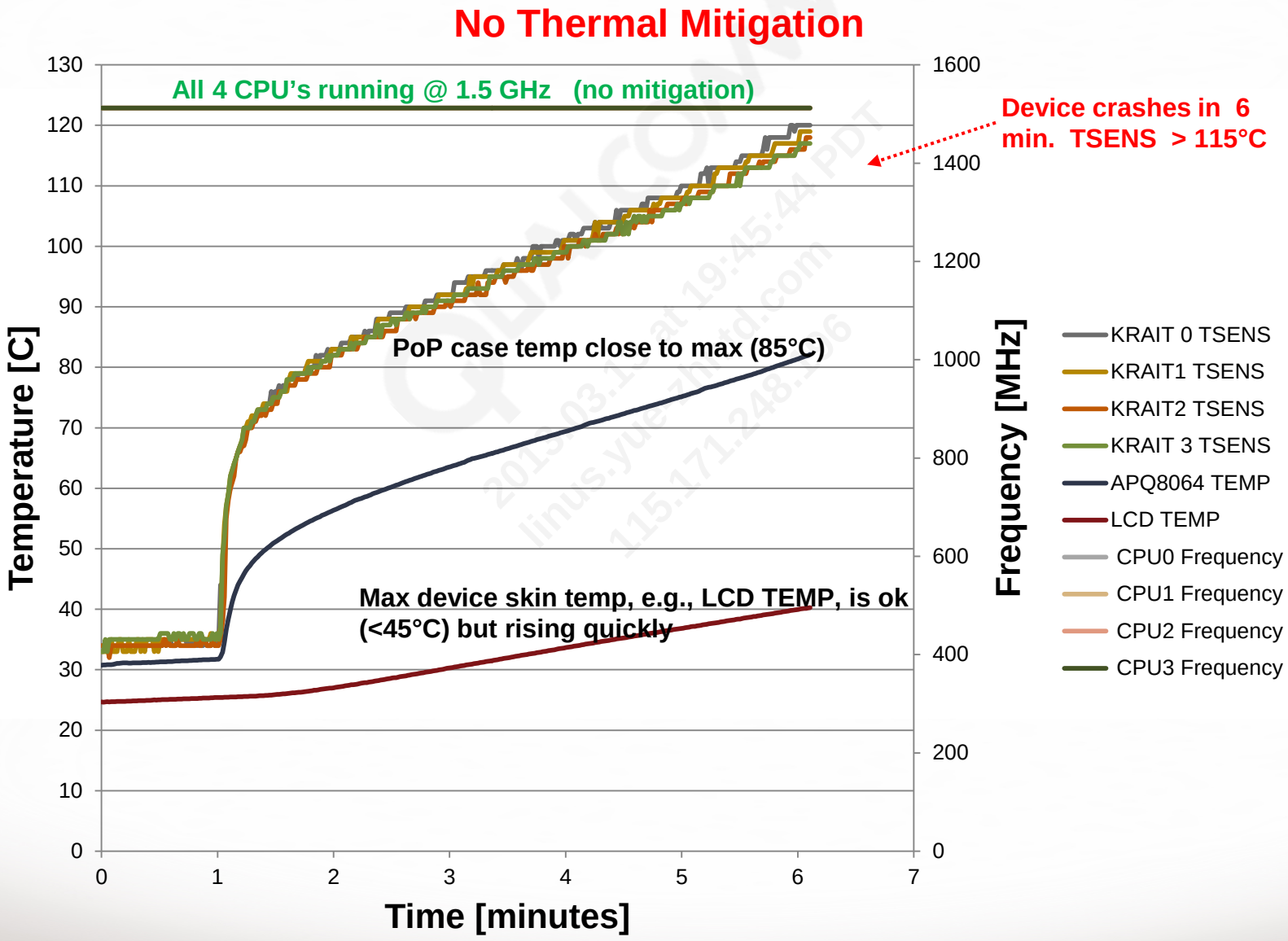
Thermal Tuning − Software

- What it is
  - Optimizing the default thermal configuration file based on device testing; the goal is to enable maximum CPU, GPU, Modem, Camera, etc. performance without compromising thermal limits of the chipset components or the device.
- Why it is needed
  - To ensure the Thermal Mitigation Algorithm performs optimally for a given mechanical/industrial design (MD/ID)

    Note: Once the MD/ID is defined, software thermal mitigation is the last remaining method to manage heat generation.

  - This will allow the device to operate at highest frequency, fps, and data rates for as long as possible before thermal mitigation begins to reduce performance.
- When it is needed
  - Thermal tuning needs to be performed as soon as Feature Complete (FC) software is available on chipsets that have PVS settings. Waiting too long to verify thermal key performance indicators (KPIs) may result in the delay of the customer launch. Starting too early (without PVS enabled or without FC software) may result in damaged devices or unnecessary time wasted in thermal and power debug.
- The following slides show the result of thermal mitigation thermal tuning.

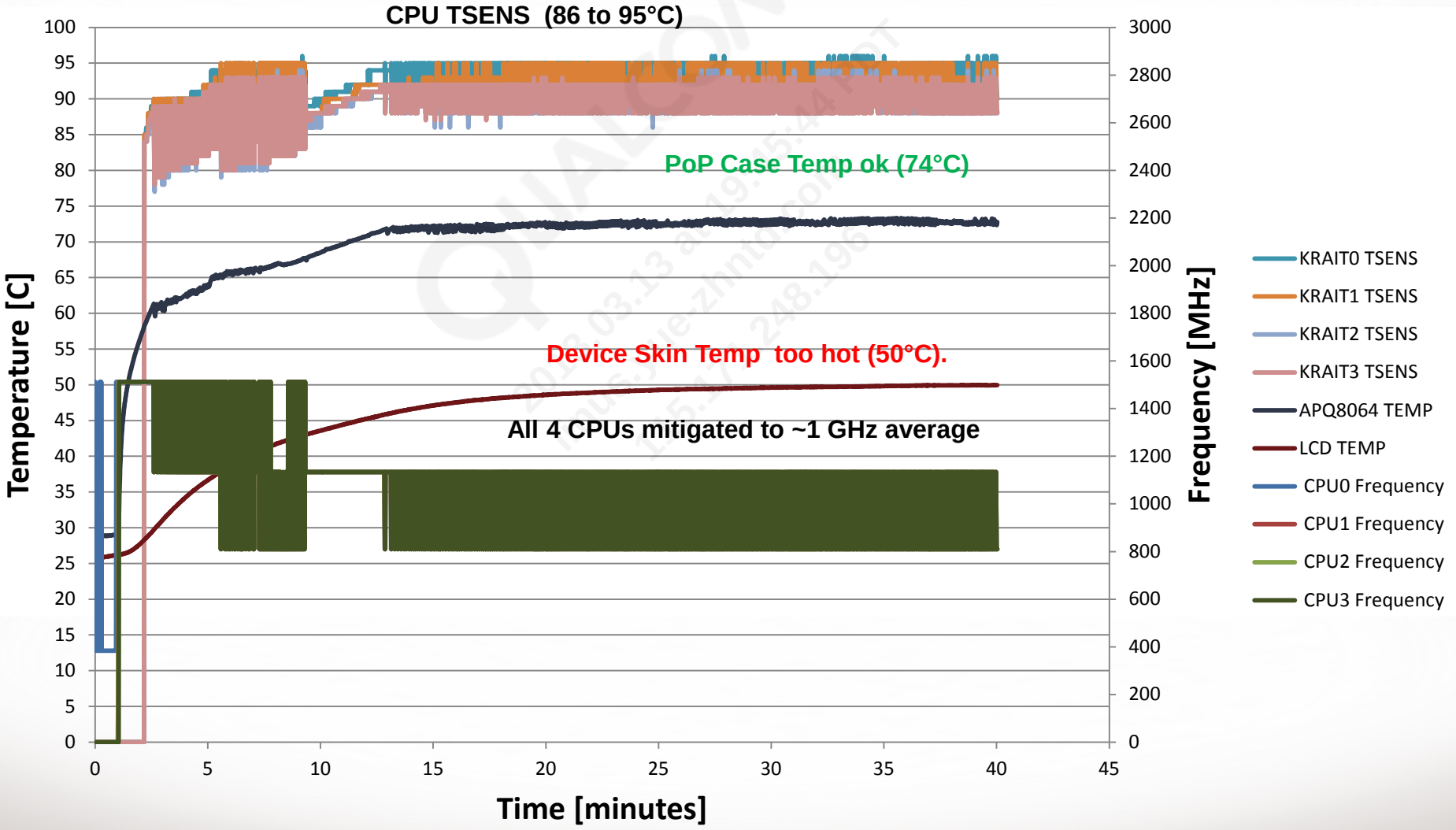
APQ8064+MDM9615 MTP Running QUAD



APQ8064+MDM9615 MTP Running QUAD (cont.)

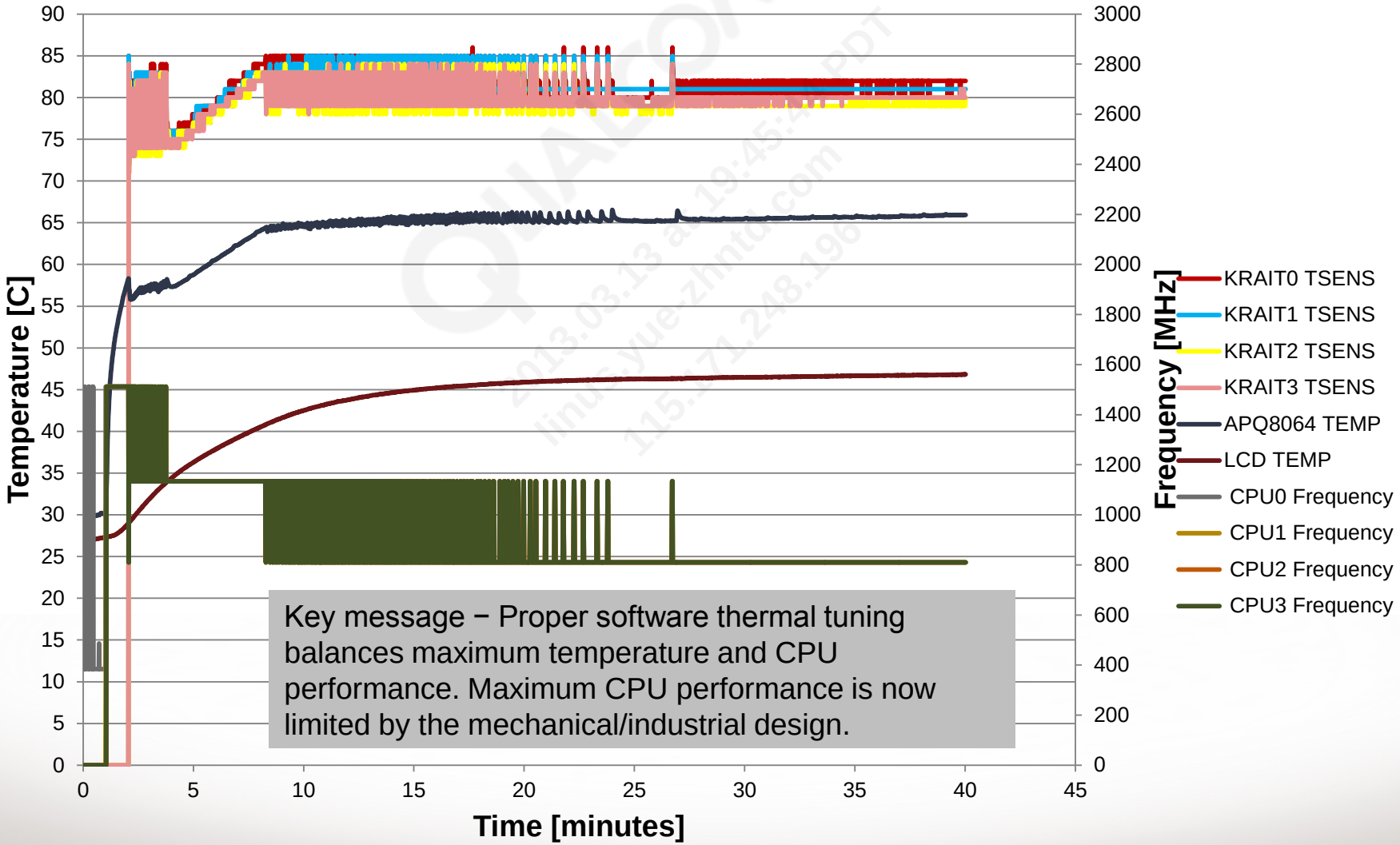
Thermal Mitigation Enabled

No Thermal Tuning – (Using default Thermald.Conf file)



Apq8064+mdm9615 MTP Running QUAD DHRYSTONE

Thermal Mitigation Enabled
Thermal Tuning Enabled – (Modified Thermald.Conf file)



Key Factors

- Key factors required for performing thermal tuning are:
  - PCB installed with all component shields into the final device skin; battery installed
  - QTI devices with Process Voltage Scaling (PVS) enabled
    - Attempts to do thermal tuning with initial ES devices (PVS not enabled) may result in exceeding device spec max case temperatures, system crashes, and damage to the device. See the Device Revision Guide to determine which devices are appropriate to use for thermal tuning.
  - QTI FC software
    - Thermal stress testing is used to identify “hotspots” on the Device Under Test (DUT) skin
    - Attempts to do thermal tuning with non-FC software may result in exceeding device spec max case temperatures, system crashes, and damage to the device. See the AMSS Release Notes to determine which builds are appropriate to use for thermal tuning.
  - Proper test setup
  - Proper test procedure

Note: The MD/ID design characteristic of each form factor has the most effect on the device’s overall performance.

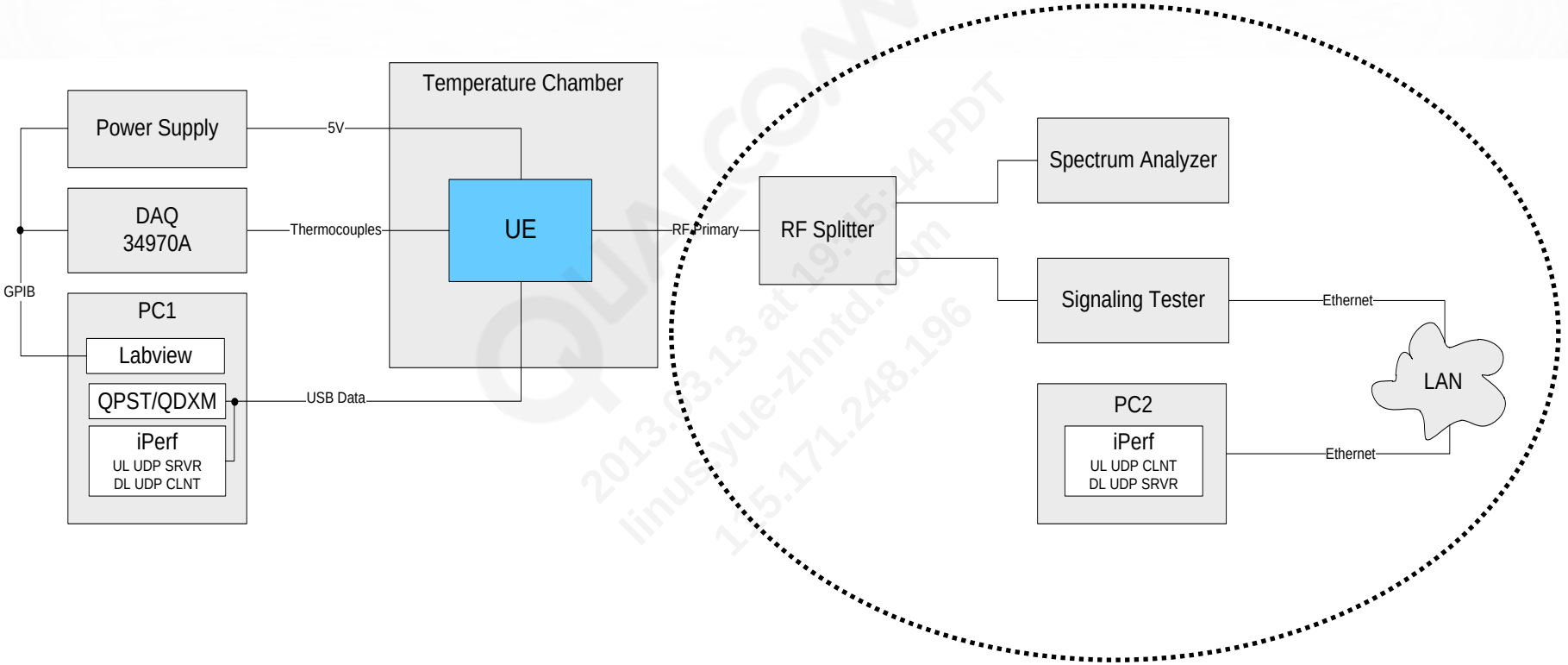
Thermal Test Setup

Thermal Lab Setup

- Purchase thermal lab-related materials.
  - Purchase data acquisition equipment as described below.
  - Purchase other required thermal equipment needed.
- Set up the environment.
  - Place your device in a mechanical vice.
  - Insert a Micro SD card.
    - This is required to run the glBenchmark 2.5 Egypt HD in a fixed frame loop.
  - Disable the USB charging (leave the USB plugged in).
  - Set the screen timeout to NEVER.
  - Set the display to maximum brightness.

Test Setup

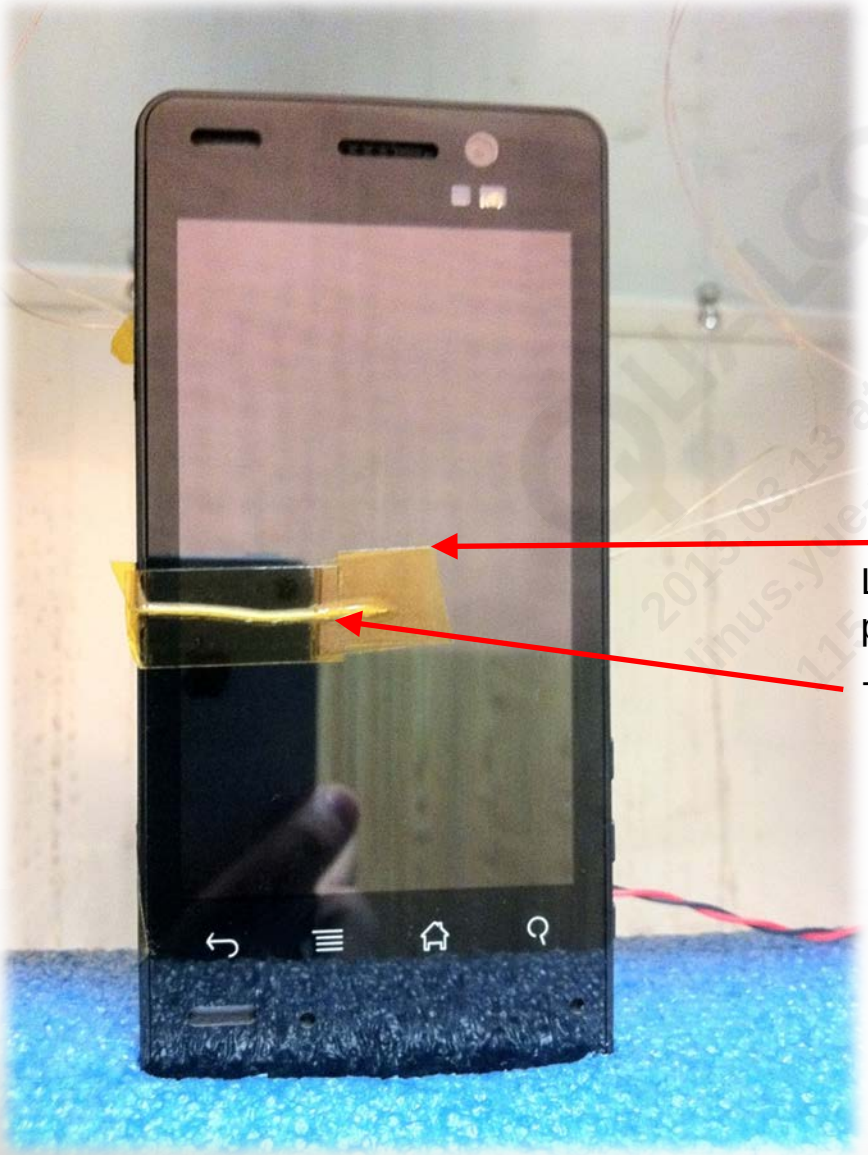
Required for modem-centric thermal use cases



Placement of Hotspot and Skin Thermocouples

- Verify whether a thermocouple has a break/open *before* you begin.
  - Use a digital multimeter with a temperature setting. Connect each probe to each of the two dissimilar metals to verify functionality. The multimeter should read a temperature close to ambient (~25°C).
- Untangle thermocouples and lay them out completely before you begin.
  - Create a label and attach it with kapton tape along each thermocouple.
  - Place your device in a styrofoam pad or any holding structure with insulation between the chamber and DUT to secure in an upright position (see slide 18).
- Run a very CPU-intensive application, i.e., Dual Dhrystone, at maximum CPU frequency for a few minutes without mitigation.
  - Use only QTI devices with PVS settings and FC software.
- With the application running, monitor the Device Skin with an IR camera and find the hotspot (hottest point), e.g., on APQ8064+MDM9615 MPT, this is on the LCD itself.
  - Place the thermocouple tip on the exact hotspot and place a few pieces of kapton tape over it. The tape should cover the length of the thermocouple.
  - Monitor the back cover with the IR camera to find the hotspot.
  - Place the thermocouple tip on the exact hotspot and place a few pieces of kapton tape over it. The tape should cover the length of the thermocouple.
- Power down and allow the device to cool back to ambient temperature.

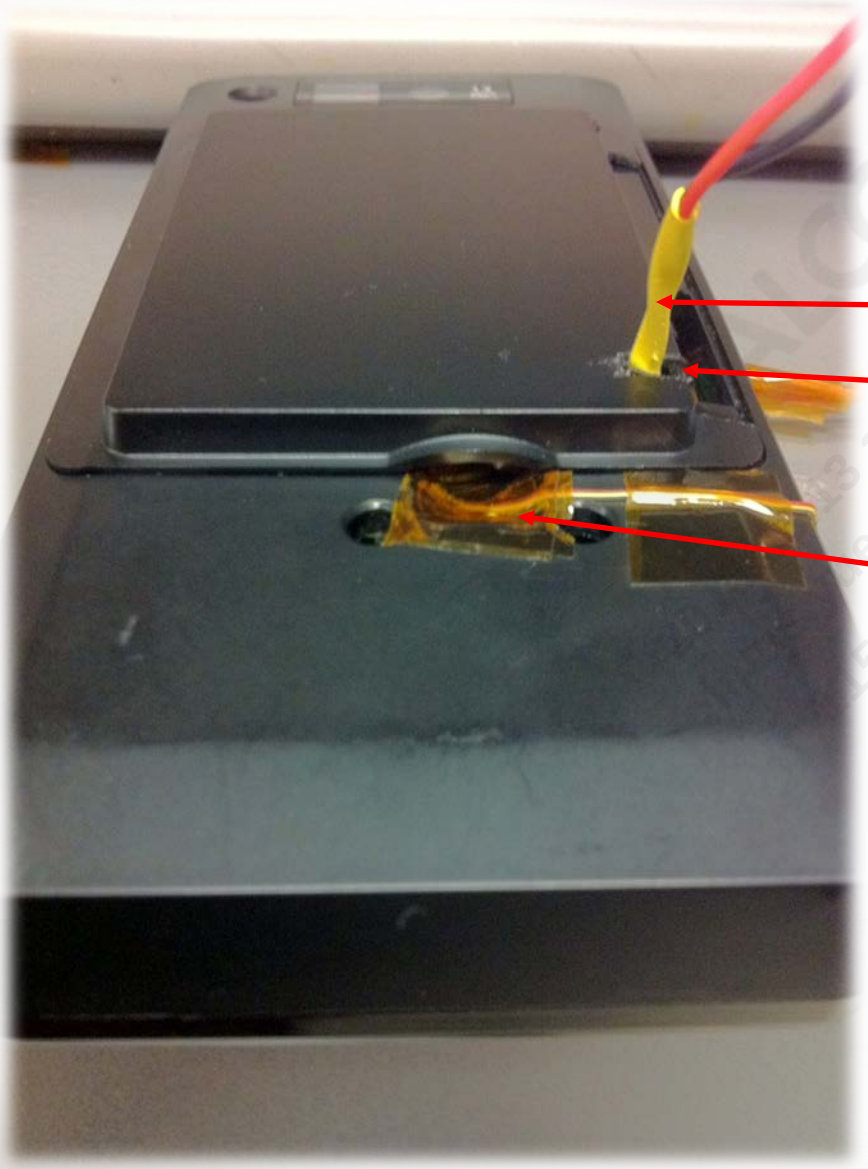
Proper LCD Thermocouple Placement



Layers of kapton tape to hold thermocouples in place

Thermocouple

Proper Backside Thermocouple Placement



Fake Battery leads

Hole cut into housing for fake battery leads

Back Cover thermocouple with kapton tape

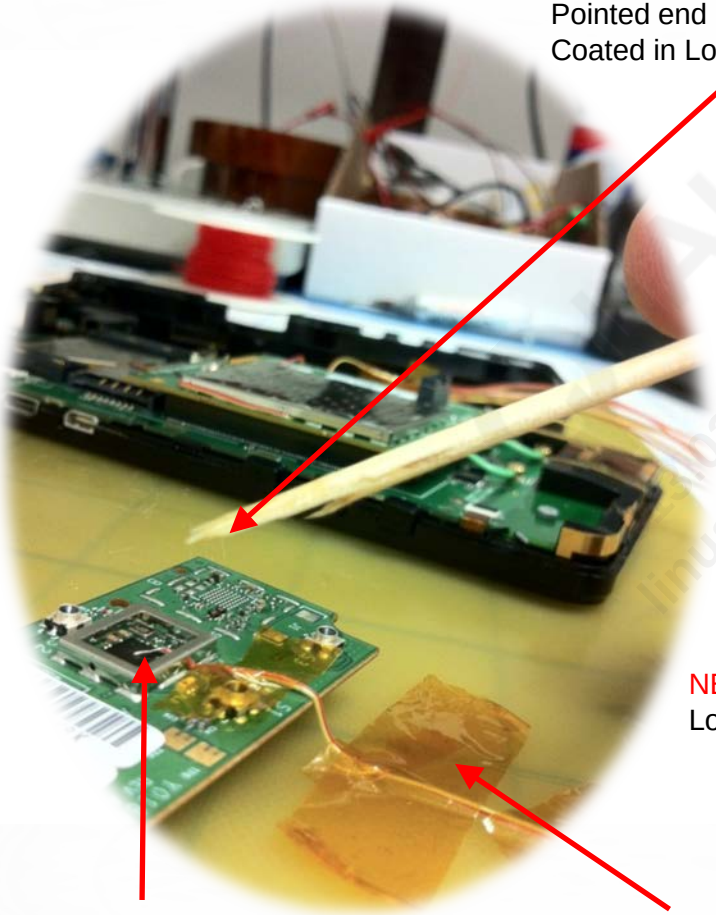
Placement of Internal Thermocouples

1. Completely disassemble your DUT. Remove the PCB from the housing assembly.
2. Plan your thermocouple routing before you begin.
3. Using the IC package mechanical specs, find the exact middle of the device.
4. Place the thermocouple at that spot. It is very important that it is exactly in the middle and that it maintains complete contact with the component. Place each thermocouple flat against the board when you route, using the kapton tape to securely hold it in place.
   - 36 AWG is thicker and more durable than 40 AWG but it needs more space and may not be routed underneath some shielding.
   - Decide before placement; 40 AWG is fragile and if broken will completely ruin your work once bonded with Loctite 444.
5. With tweezers grab the thermocouple shielding at the junction.
6. Make a crimp on the junction so it is no longer straight across but curved slightly downward.
   - It must be pointing downward so that when you place the kapton tape around it, the thermocouple must be able to touch the PoP memory on its own. Make sure the tip is in the exact middle and touching the component (see the next slide).
7. Use a microscope to verify.
8. Route cables so they make as little contact with other components as possible. Permanent mechanical rework may be necessary (cutting shielding bars or back cover of housing).

Note: You may flatten the body of the thermocouple after it is secured to the component (glue must be cured using the accelerant). The tip should *not* move.

Placement of Internal Thermocouples (cont.)

GOOD

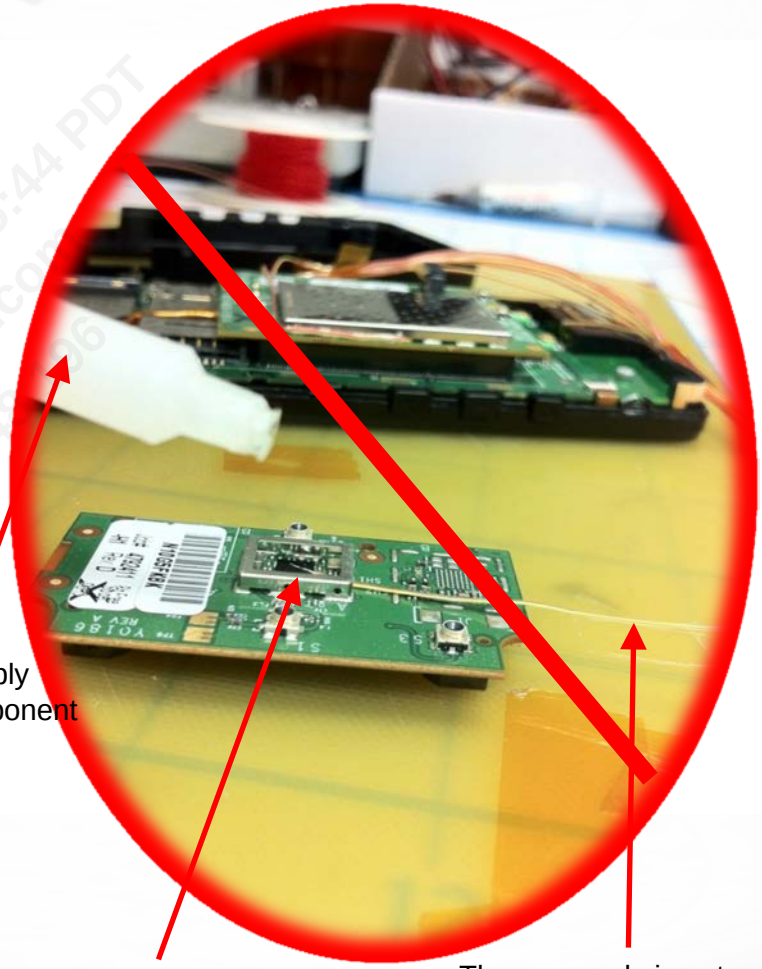


Pointed end of swab
Coated in Loctite 444

Junction bent downward to make complete contact with component

Kapton tape secures thermocouple

BAD



NEVER directly apply Loctite 444 to component

Junction is up in the air, and it is straight across; not bent downward

Thermocouple is not secured; very loose

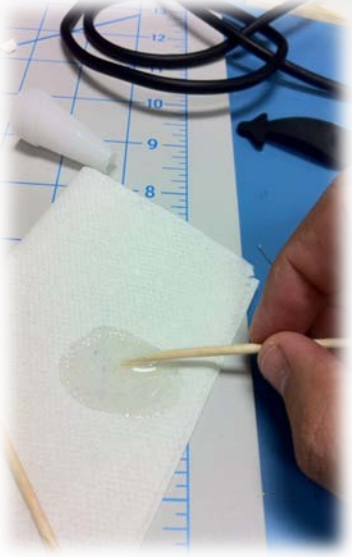
Placement of Internal Thermocouples (cont.)

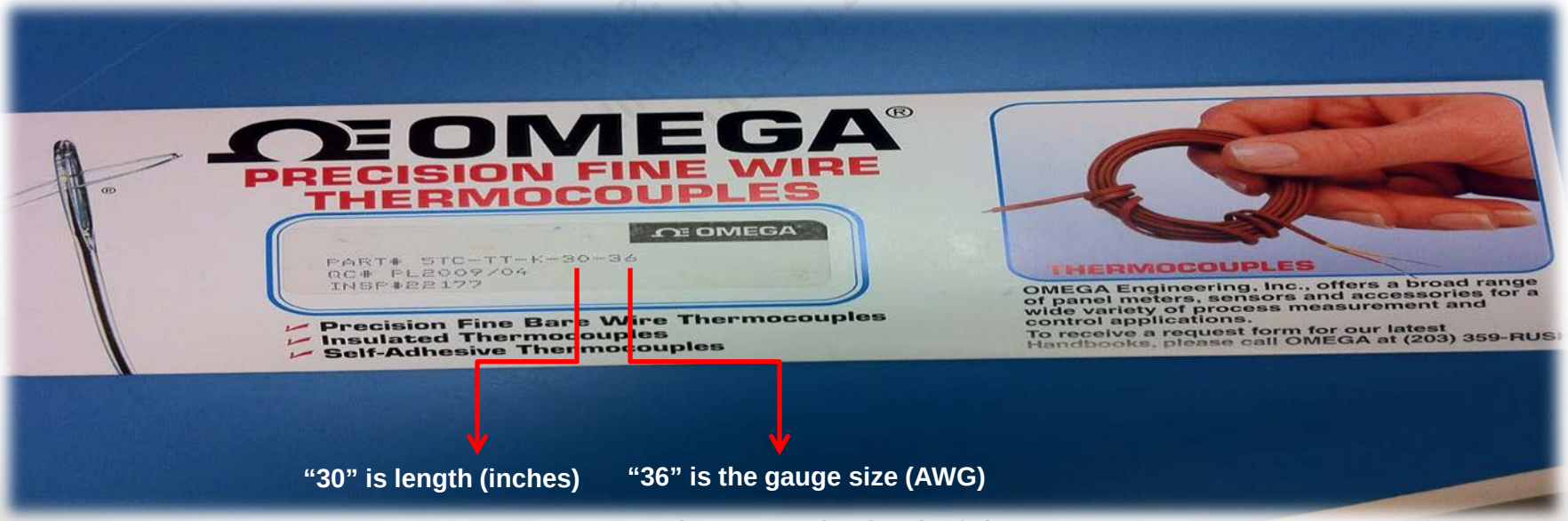
9. After your thermocouple is secured with kapton tape and makes complete contact with the exact middle of the component package:
   a. Squeeze Loctite 444 onto a clean piece of paper.
   b. Snap your wooden cotton swab in half, take the pointed end and coat by rolling its edge in Loctite 444 (see next slide).
   c. **Use a microscope for the rest of the procedure.**
   d. Place the smallest possible amount on the tip and the area where it touches the component. It should look like a small bubble under a microscope.

      This is extremely important. There must only be enough to hold the thermocouple tip rigidly in place (even if the device must be constantly moved). After applying Loctite 444, there must be ***NO space*** between the thermocouple tip and the package.

      If it must be reworked, scrape off the thermocouple, replace, and find another location. This may not be possible to remove depending on the bond. It is best to start off with a brand new thermocouple. The prior location is ruined and ***cannot be used again*** for thermocouple placement. Loctite cannot be removed without destroying the PCB.
   e. Immediately open your accelerator fluid and very slightly touch the Loctite 444 on the thermocouple/ component with the brush. This will quickly accelerate the curing process.
   f. Carefully remove the kapton tape.
   g. Make sure the thermocouple junction (that is not covered by glue) does not come into contact with metal, i.e., PCB shield, before reassembly.
   h. If needed, place thermocouple against the board and add Loctite 444 so it is secured to the PCB. This will strengthen the overall bond of the thermocouple (see slide 13).
   i. Place thermocouples in as many other locations as desired.
   j. If more than one thermocouple is used internally, route all to the same exit point *tightly* as close as possible and secure the outer bundle with the kapton tape rolled around it, zip-tie, or both.

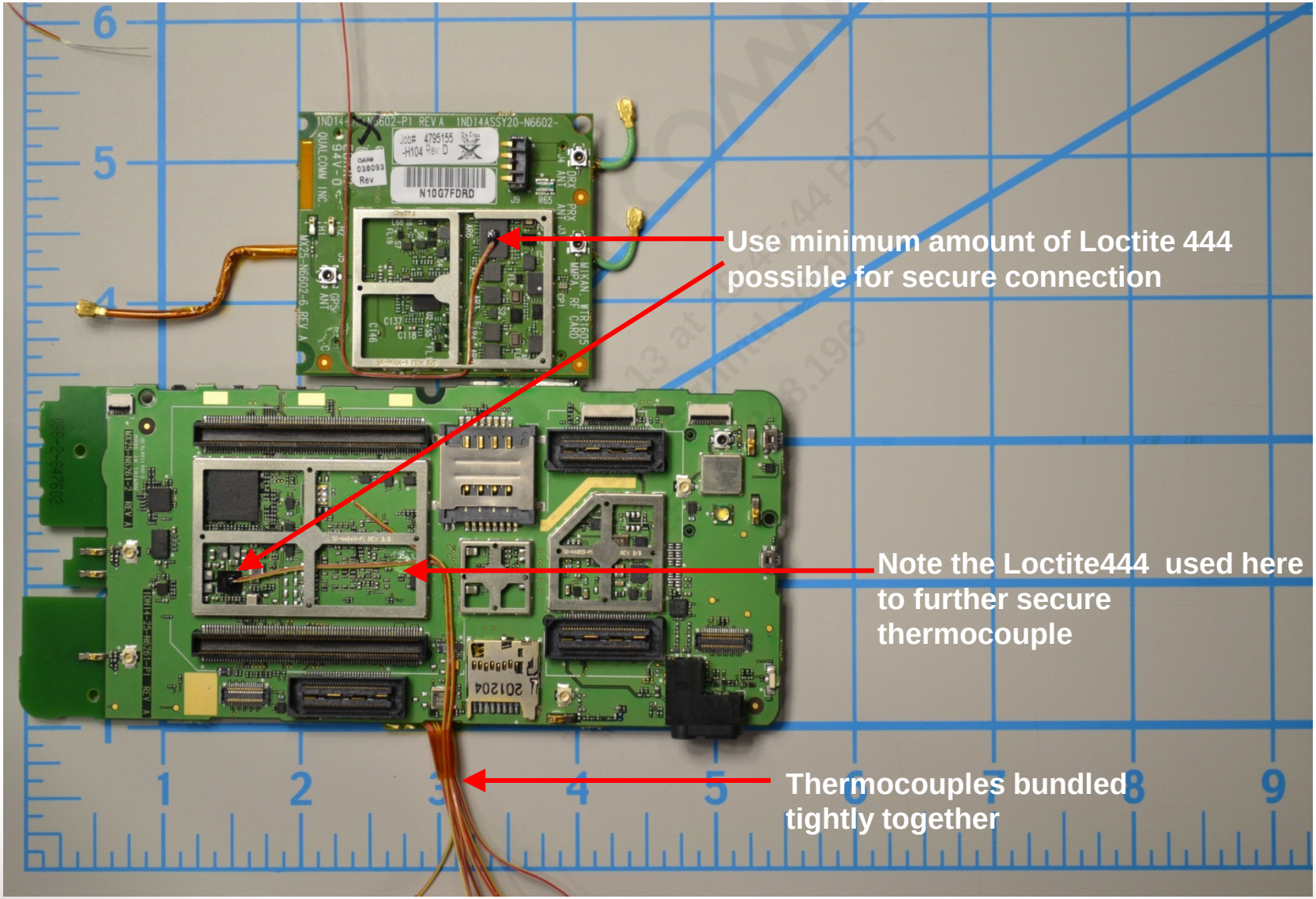
Thermocouple Materials



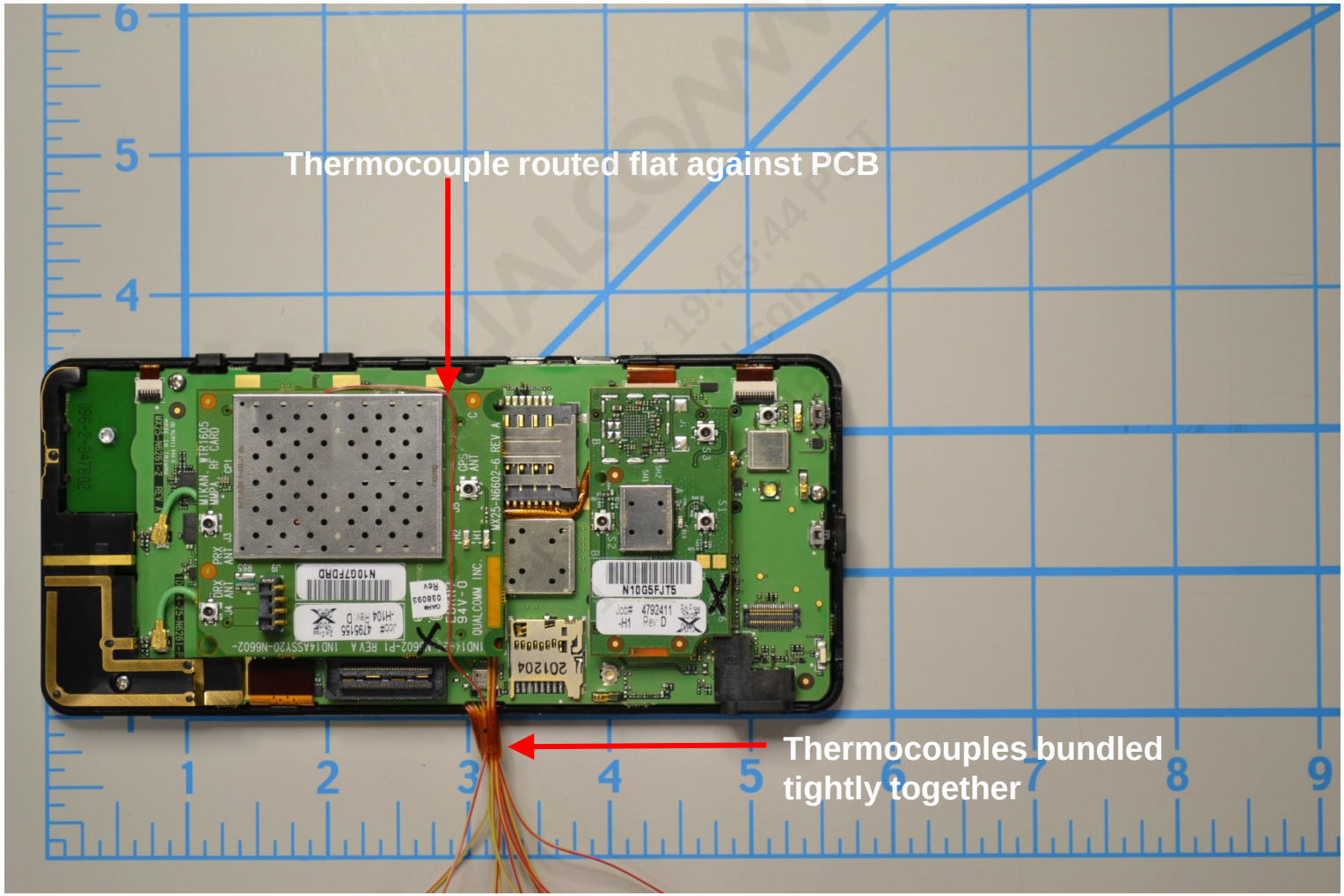


Omega K-Type 36AWG 30” Thermocouples (pack of 5)

Internal Thermocouple Attachment



Thermocouple Routing



Reassembly and Data Logger

1. Reassemble PCB with the housing assembly and secure all connections.
   - It may be necessary to cut a hole into the bundle exit point on the front or back housing. You do not want to snap the assembly together on the thermocouple as it may break and destroy your work!
   - Do not yet bundle the rest of the thermocouples together.
   - Decide in which order you want the thermocouples to be placed in the Data Logger. Write down this order of placement.

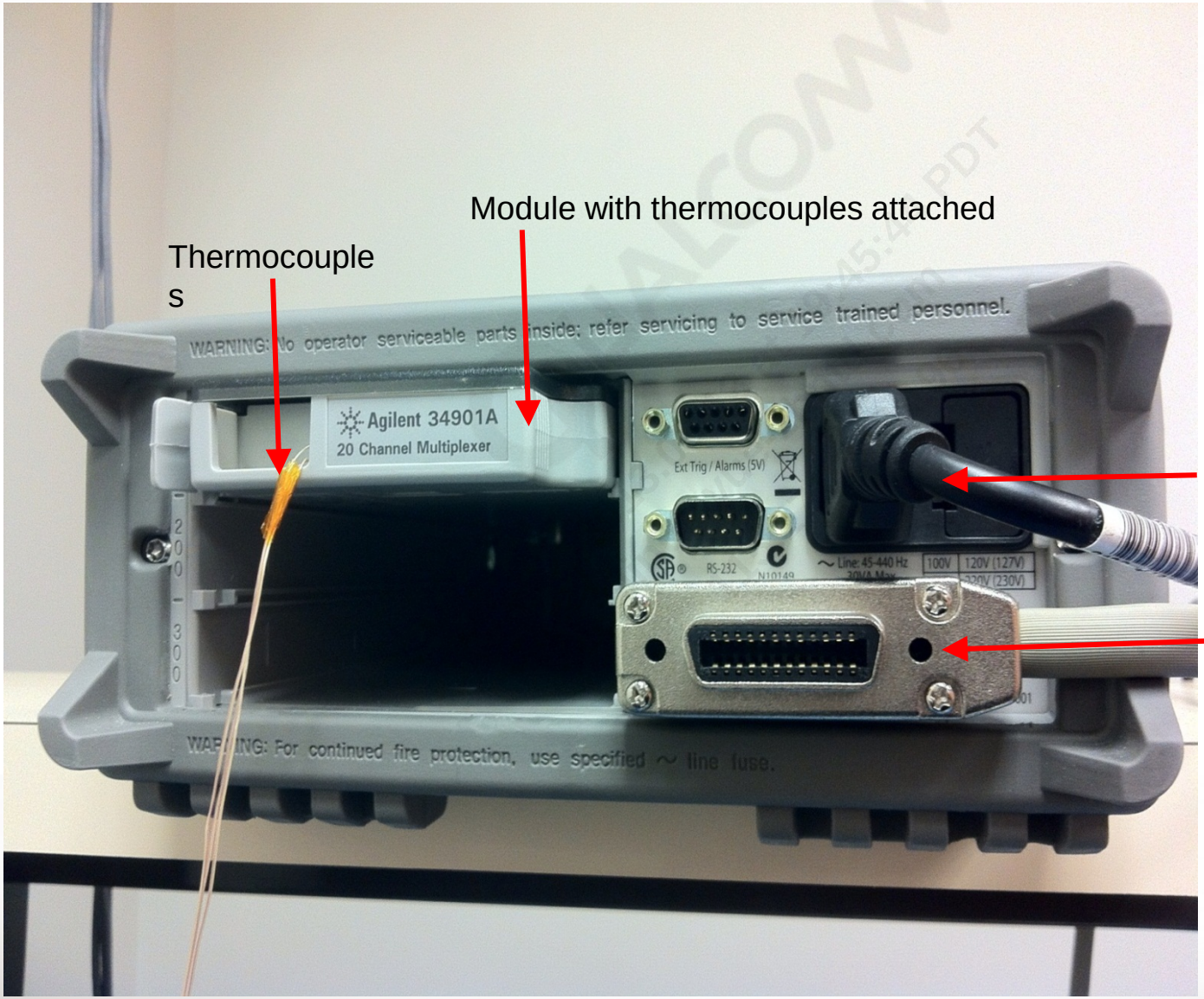
   Note: Also, see *Getting Started Guide* from Agilent.

2. Open data logger 20-channel multiplexer cover with a screwdriver or pen, pushing the latch forward (be careful or you will need to replace the module).
3. With the correct mini flathead screwdriver, unscrew applicable screws in the Agilent multiplexer module.
   - Below each screw is an opening, to which you place the metal end of the thermocouple. Each opening contains a piece of metal that secures the thermocouple in place.
   - Unscrew until you see this piece of metal go completely down.
   - Each channel in the multiplexer is labeled with an H (HI) and an L (LO). The yellow end of the thermocouple is HI, red is LO.
4. It is easier to insert both ends at once, holding the body of the thermocouple with one hand and use a mini screwdriver until the metal piece goes up and secures the thermocouple in place.
5. Do the same for the other lead while still holding the body with one hand.
6. Repeat for all thermocouples.

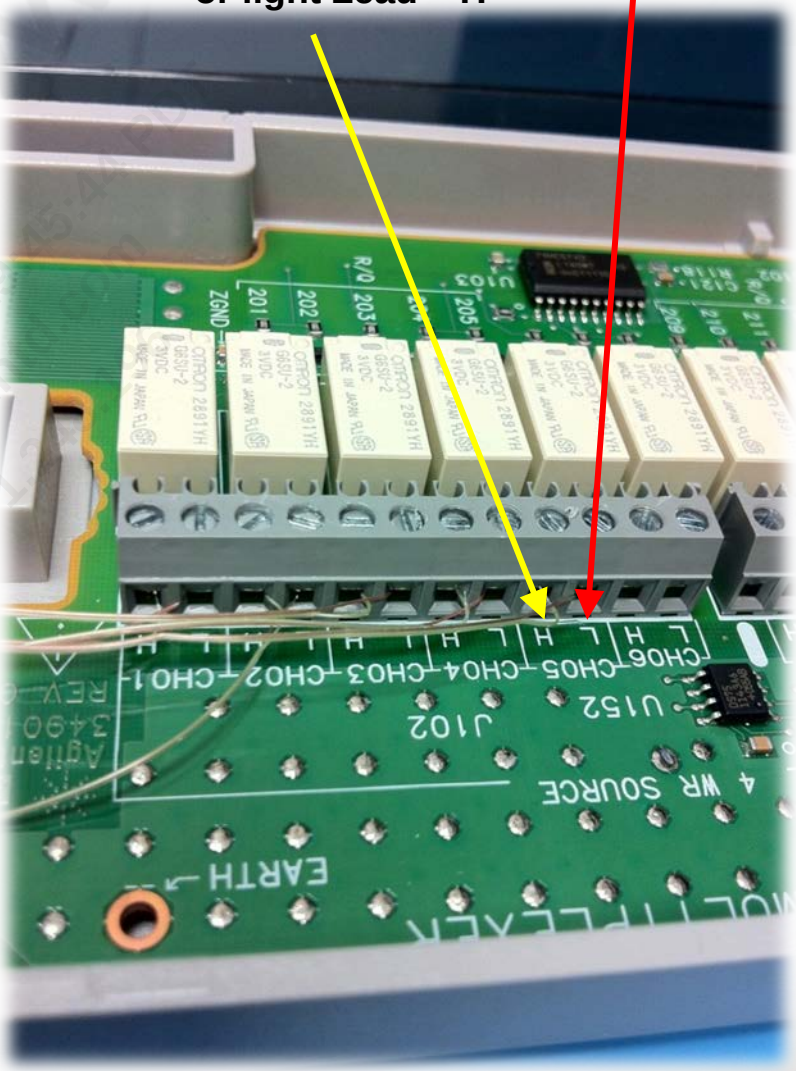
Verification and Common Setup Errors

- Verify with a digital multimeter
  - Place your hot and ground leads separately, with one for HI and the other for LO, for each channel. Polarity is not considered, i.e., positive lead contacts the screw at CH01 HI, and ground lead contacts the screw at CH01 LO.
  - Only place multimeter leads at the screws, *not* at the thermocouples themselves.
  - You are only verifying that you see a temperature reading.
  - Also check that the yellow lead is the first in the channel.
  - If there is an OPEN reading, then your thermocouple HI and LO may not be in the same channel. Extract and correct.
  - It also may indicate a break in your thermocouple, which ruins your work and must be replaced.
  - If temperature readings on data logger jump around, it may indicate a loose thermocouple. Extract and correct.

Agilent Data Logger (with 20-Channel Multiplexer Module)

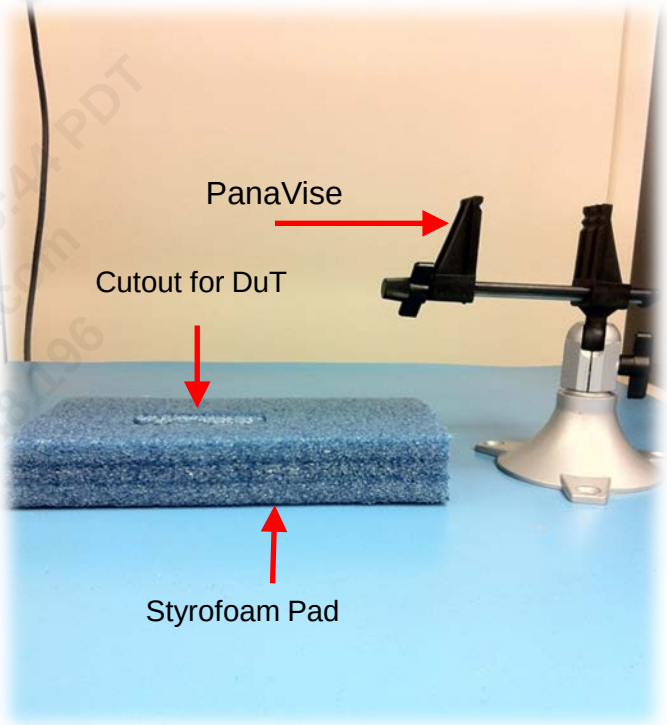


20-Channel Multiplexer Modules (Data Logger)

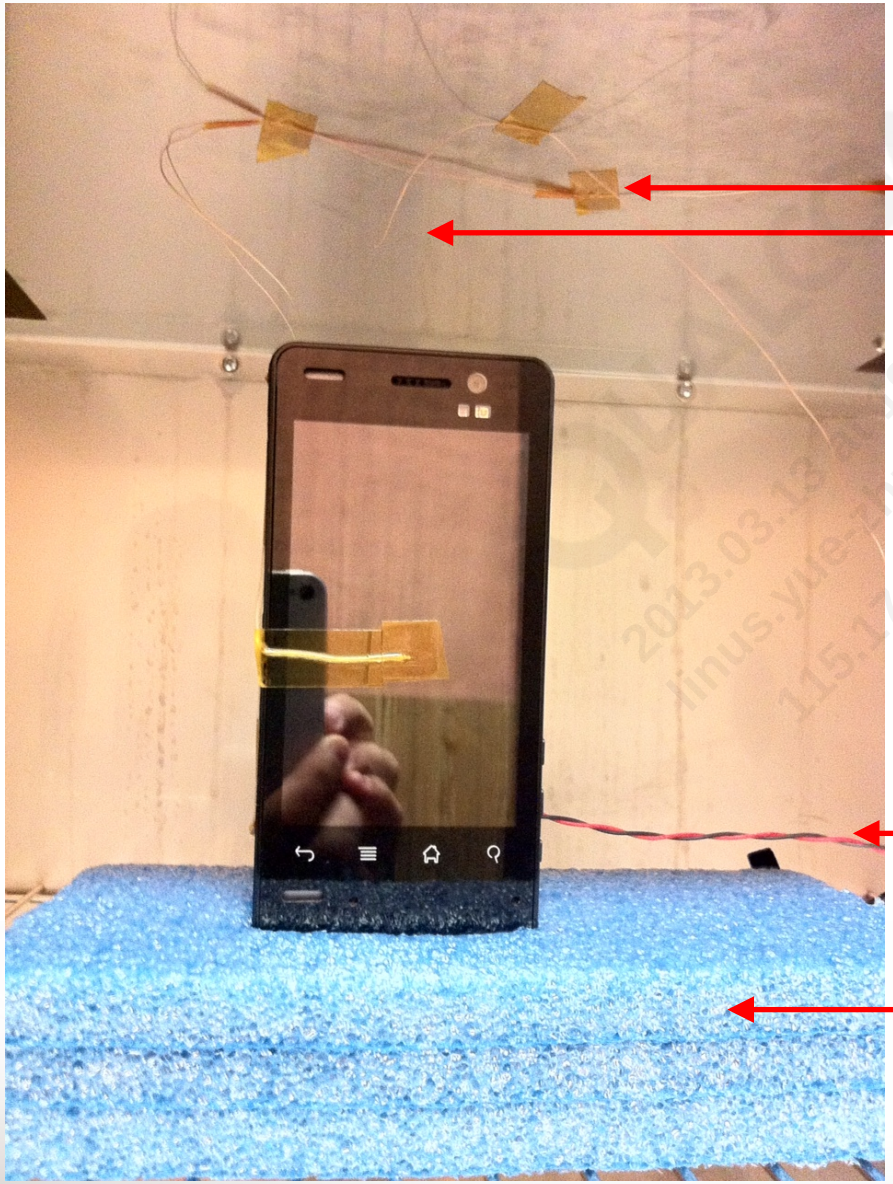


Temperature Chamber Setup

1. Use a large temperature chamber that has the ceiling clearance to hold your PanaVise (a holding/clamping tool) and DUT, with ambient thermocouple hanging down 1 inch above the device. If not, use a styrofoam block, then cut out an area of the styrofoam so that you can place the device to secure it upright (it also works if you want to rest it in landscape orientation).
2. Place fake battery, device with thermocouples, and USB cable inside the chamber.
3. Turn on the temperature chamber and set the temperature to 25°C.
4. Turn off the air flow before you are ready to test.



Temperature Chamber Setup (cont.)



Thermocouples taped to ceiling

Thermocouple measures ambient temp (~1 in away from DUT)

Fake battery leads from DUT to power supply

Styrofoam pad or any holding structure with insulation between the chamber and DUT

Data Logger Application

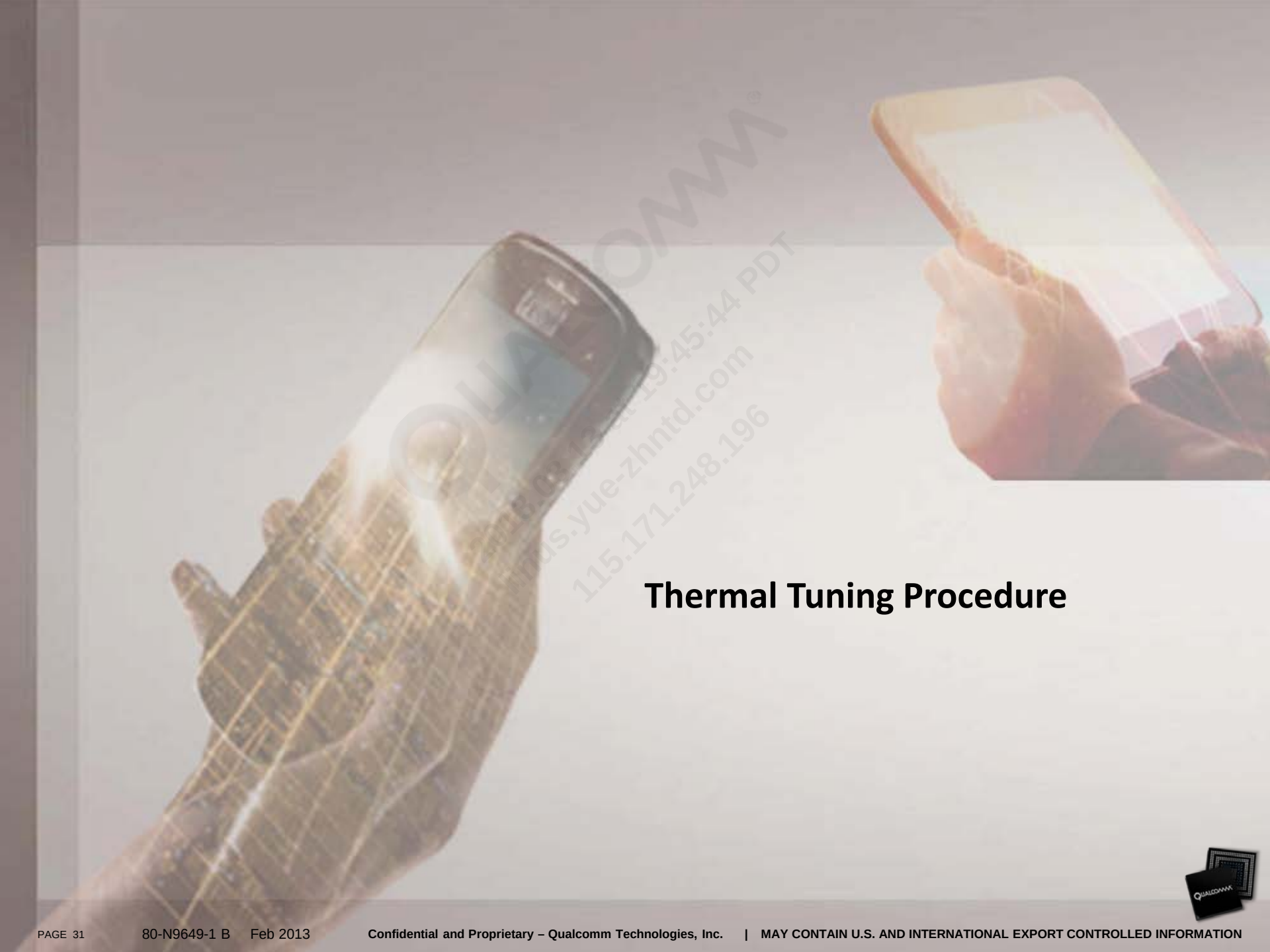
1. Insert as many multiplexer modules as you want to have available into Data Logger (maximum of 3, minimum of 1).
2. Click **Configuration→New**. Label this configuration.
3. Select **Application Mode→Connected to Instrument**.
4. Select Add or Remove Instruments→**Add Instruments.**
   - Click **Find Instruments**.
   - A search will begin for your module. Once it has correctly found your module(s), check the box and click **Enter**.
5. Below will appear 34901A: 20-Channel Armature Multiplexer.
6. The top module compartment is 100, middle is 200, and bottom is 300 on data logger.
7. Check the boxes under the Scan column for the number of thermocouples you wish to monitor.
8. The order of thermocouples must correspond to the exact order in the module, e.g., 101 – LCD, channel 01 in module must have the HI and LO leads of the thermocouple connected to the LCD.
9. Select the space corresponding to the desired channel under the Name column, and give your thermocouple a name.

Note: Some of this information is available in the Benchlink Data Logger 3 Getting Started Guide.

Data Logger Application (cont.)

10. In the Function column, select **Temp (Type K)** for Type-K thermocouples. Verify that in Res column, it shows C (Celsius).
11. You at least need four thermocouples, one for LCD at CPU, Back cover, internal thermocouple on PoP memory, and ambient.
12. The Scan and Log Data tab should now be populated with the information given in step 11.
13. In the same tab, under Scan Control heading, click … under the Set column.
14. In this dialog box, select Immediately, make sure Interval (Time Between Scans) under SS: is 1. Also select the By Pressing Stop Scan Button for Stop Scanning option. Click **Apply to all instruments** at the bottom.

Note: Some of this information is available in the Benchlink Data Logger 3 Getting Started Guide.



Thermal Tuning Procedure

Thermal Tuning Procedure Overview

- This tuning procedure will identify a chipset temperature sensor (TSENS) reading that will correlate to whichever item below hits its thermal limit first:
  - Maximum chipset case temperature as defined in the device spec (typically 85°C)
  - Device skin hotspot (typically 45°C)
- When this correlated TSENS temp exceeds the maximum case temperature/skin temperature while running the tests, stop the test and edit the default_config.conf file to reduce the “thresholds” temperature values at steady state.

Thermal Tuning Procedure

1. Place the DUT into the temperature chamber at 25°C.
2. Ensure that the thermal mitigation is enabled.
3. Read the thermocouple, the temperature value should be ~25°C since the ambient is at 25°C.
4. Turn on the DUT.
5. Connect the micro USB cable.
6. Open a command prompt on the PC and enter the case-sensitive command adb root.
7. Disable Wi-Fi and enable Airplane mode.
8. Go to Settings→Display settings and turn on the brightness to maximum.
9. In Display settings, set sleep mode/screen timeout to Never.
10. Open a command prompt and type “adb root”, “adb shell”, and look for “root@android”. Keep the USB cable plugged in.
11. Start TSENS and thermocouple logging simultaneously.
12. Start the Agilent Data Logger for thermocouple temperature logging.
13. Open another command prompt and type“adb shell”. Type “/data/perf_logging 1000 7200000 &” to start TSENS temperature logging.
14. Wait 1 min to allow everything to synchronize.

Thermal Tuning Procedure (cont.)

15. Run Dhrystone on each CPU core (this heats up the device as fast as possible), e.g., for a 4 core device, run Dhrysone 4x by typing “adb shell”, then “/data/dhrystone.sh &”, press Enter, press Up arrow, and then click Enter. Do this two more times (to initiate the test on all 4 cores).
16. Log thermocouple and TSENS temperatures until the chipset exceeds its maximum case temperature (typically 85°C) *or* until the skin hotspot temperature rises more than acceptable limits (typically 45°C) *or* the system crashes.
17. If the system crashes before maximum case or skin hotspot conditions are reached, then go back to step 15. However, run Dhrystone on one less core to reduce the temperature, e.g., run Dhrystone on 3 cores instead of 4.
18. Pick the TSENS that closely tracks the skin hotspot/case temperature and make sure that this sensor is not on the CPU (Krait).
19. Edit the default thermald-8xxx.conf file (xxx=064 for APQ8064, etc.) as follows:

[tsens_tz_sensorX]					(Temp sensor # on the Chipset Die)
Sampling	1000				(Temp sensor sampling rate in ms)
Thresholds	90	95	100	120	(Enable Temp in°C)
Thresholds_clr	85	90	95	115	(Disable Temp in °C)
Actions	cpu	cpu	cpu		shutdown
Action_info	1512000	1296000	918000	5000	(CPU Clock Frequency)

20. If the skin hotspot temperature is way below the acceptable limits, increase all thresholds and threshold_clr values by 5°C and return to step 15. If the skin hotspot temperature exceeds above the acceptable limits, decrease all thresholds and threshold_clr values by 5°C and return to step 15.

Thermal Tuning Procedure (cont.)

21. Edit the default thermald-*8xxx*.conf file (xxx=064 for APQ8064, etc.) as follows:

    If temperature is low on the device skin, we need to increase all temperature thresholds by 5°C.

[tsens_tz_sensorX]					*(Temp sensor # on the Chipset Die)*
Sampling	1000				*(Temp sensor sampling rate in ms)*
Thresholds	***95***	***100***	***105***	*120*	*(Enable Temp in °C)*
Thresholds_clr	***90***	***95***	***100***	115	*(Disable Temp in °C)*
Actions	cpu	cpu	cpu		shutdown
Action_info	1512000	1296000	918000	5000	*(CPU Clock Frequency)*

    If temperature is high on the device skin, we need to decrease all temperature thresholds by 5°C.

[tsens_tz_sensorX]					*(Temp sensor # on the Chipset Die)*
Sampling	1000				*(Temp sensor sampling rate in ms)*
Thresholds	***85***	***90***	***95***	120	*(Enable Temp in °C)*
Thresholds_clr	***80***	***85***	***90***	115	*(Disable Temp in °C)*
Actions	cpu	cpu	cpu		shutdown
Action_info	1512000	1296000	918000	5000	*(CPU Clock Frequency)*

22. If the TSENS temperature no longer increases over time and the skin hotspot temperature limits are within acceptable limits, tuning is finished.

Thermal Tuning – Thermald-8xxx.conf File Example

```
[tsens_tz_sensorX]
Sampling          1000      (Temp sensor sampling rate in ms)
Thresholds         75   78   81   84   87   90    (Enable Temp in ℃)
Thresholds_clr     72   75   78   81   84   87    (Disable Temp in ℃)
Actions           cpu  cpu  cpu  cpu  cpu  shutdown
Action_info   1296000 1188000 918000 756000 648000 5000   (CPU Freq in Hz)
```

Increasing temp decreases CPU clock rates

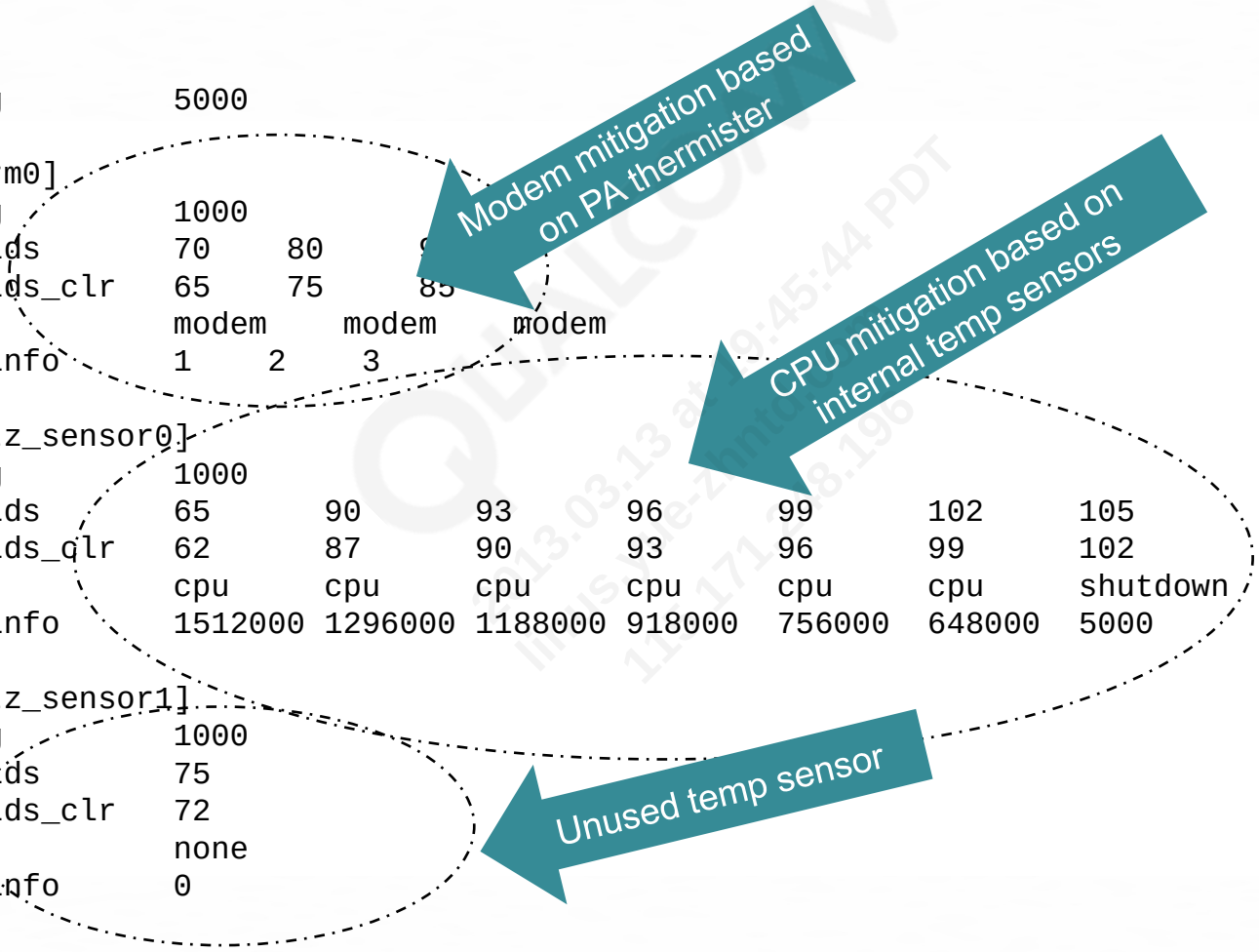
Default thermald.conf File (Customer Must Edit)

```
debug
sampling          5000

[pa_therm0]
sampling          1000
thresholds        70     80      9
thresholds_clr    65     75      85
actions           modem     modem     modem
action_info       1     2     3

[tsens_tz_sensor0]
sampling          1000
thresholds        65       90       93       96       99       102      105
thresholds_clr    62       87       90       93       96       99       102
actions           cpu      cpu      cpu      cpu      cpu      cpu      shutdown
action_info       1512000  1296000  1188000  918000   756000   648000   5000

[tsens_tz_sensor1]
sampling          1000
thresholds        75
thresholds_clr    72
actions           none
action_info       0
```



Default thermald.conf File

```
[tsens_tz_sensor2]
sampling         1000
thresholds       75
thresholds_clr   72
actions          none
action_info      0

[tsens_tz_sensor3]
sampling         1000
thresholds       75
thresholds_clr   72
actions          none
action_info      0


[tsens_tz_sensor4]
sampling         1000
thresholds       75
thresholds_clr   72
actions          none
action_info      0
```


Purchasing Data Acquisition (DAQ)/Switch Unit

- Purchase your DAQ with your 20-channel multiplexers
  - DAQ – See [R1]
  - Free software download – See [R2]
- Under Supporting Documents, halfway down the page, there is a link for Benchlink Data Logger 3 Getting Started Guide. This covers everything from the IO libraries to hardware and software.
  - Ignore instructions that deal with the buttons on the front. This is all controlled by the application on your PC/laptop.
  - The only thing you need to do with the front panel is press and hold the Power button the first time you power it up.
  - You do not need to ever power down this device.

Thermal Lab Setup

Thermal Lab Setup

Assembly/Disassembly/Rework Bench						
Equipment/Tool	**Description**	**Manufacturer**	**Manufacturer Model/Part #**	**Vendor**	**Vendor Part #**	**Q Contact**
Technician Toolbox	Total of 36 Tools Included:	SMS	1001-Q	Solder Master Supply	1001-Q	Test Equipment
Adjustable Wrench	6" Adjustable Wrench with Red Vinyl Grip, 15/16" Capacity	Crescent	AC16C	Stanley Supply & Services	402-051	Test Equipment
Adjustable Wrench	4" Adjustable Wrench	Iron Bull	N/A	Solder Master Supply	N/A	Test Equipment
Plier/Cutter	4-1/2" Transverse End Cutter Pliers	Xcelite	EC54-J	Stanley Supply & Services	190-142	Test Equipment
Plier	Electronic Pliers, Round Jaw 4.5"	Xcelite	RN54	Stanley Supply & Services	114-809	Test Equipment
Plier	Combinational "Slip Joint" Plier 6"	Crescent	H26C	Stanley Supply & Services	403-684	Test Equipment
Plier	Groove Joint Plier 7"	Crescent	R27C	Stanley Supply & Services	114-808	Test Equipment
Wire Stripper	T Stripper, 16 to 26 AWG, Stranded Wire	Ideal	45-121	Stanley Supply & Services	118-568	Test Equipment
Cutters	Angled Cutter	Erem	2475E	Stanley Supply & Services	447-800	Test Equipment
Pick	Angle Stainless Steel Probe, 5-1/2" Long	Menda	35617	Stanley Supply & Services	151-166	Test Equipment
Forceps	STRAIGHT NOSE 5.5" SEIZER	Xcelite	42HV	Stanley Supply & Services	151-017	Test Equipment
Tape Measure	1.5" x 10' Measuring Tape	Lufkin	L610	Solder Master Supply	N/A	Test Equipment
Screwdriver	Regular Phillips Screwdriver, #1 Tip, 3" Blade, 6-5/8" Overall	Xcelite	X101	Stanley Supply & Services	115-589	Test Equipment
Screwdriver	Regular Phillips Screwdriver, #2 Tip, 4" Blade, 8-1/8" Overall	Xcelite	X102	Stanley Supply & Services	115-591	Test Equipment
Screwdriver	Slotted Screwdriver, Regular Style, 1/8" x 2"	Xcelite	R182	Stanley Supply & Services	115-525	Test Equipment
Screwdriver	Regular Phillips Screwdriver, #0 Tip, 2" Blade, 4-1/2" Overall	Xcelite	X100	Stanley Supply & Services	115-588	Test Equipment
Screwdriver	Regular Slotted, 1/4" Tip, 4" Blade, 8-1/8" Overall	Xcelite	R144	Stanley Supply & Services	115-520	Test Equipment
Screwdriver	Regular Slotted, 3/16" Tip, 6" Blade, 9 1/2" Overall	Xcelite	R3166	Stanley Supply & Services	115-533	Test Equipment
Scissors	4 1/8" Embroidery Scissors	Cozic	KHS-105	Solder Master Supply	N/A	Test Equipment
Tweezer	Tweezer, Style 00, 4-3/4" long	CHP	00-SA	Solder Master Supply	N/A	Test Equipment
Tweezer	Tweezer, Style AA	CHP	AA-SA	Solder Master Supply	N/A	Test Equipment

Thermal Lab Setup (cont.)

Assembly/Disassembly/Rework Bench						
Equipment/Tool	**Description**	**Manufacturer**	**Manufacturer Model/Part #**	**Vendor**	**Vendor Part #**	**Q Contact**
Wire Unwrapping Tool	24-32AWG/Counter Clock Wise Direction	JDV Products	HU93	Solder Master Supply	N/A	Test Equipment
Pin Vise	Double End Pin Vise	Euro Tool	PIN219.00	Stanley Supply & Services	125-362	Test Equipment
Drill Set	61-80 - .0390-.0135 Drill Set	Euro Tool	DRL-240.00	Solder Master Supply	N/A	Test Equipment
Chip Puller	Static-Dissipative PLCC Extractor	C.K.	2371	Stanley Supply & Services	126-453	Test Equipment
Cutters	Slim Tapered Head Diagonal Cutter	Swanstrom Tools	420-Jensen	Stanley Supply & Services	419-318	Test Equipment
Cutters	Miniature Diagonal Semi Flush Electronic Cutter, Round Nose	Xcelite	MS54	Stanley Supply & Services	115-074	Test Equipment
Wire Stripper	No Nik Wire Stripper 32AWG	No Nik	NN012	Stanley Supply & Services	4-303	Test Equipment
Desoldering Pump	Static-Free Desoldering Pump with Aluminum Barrel	Edsyn	SS350	Stanley Supply & Services	114-412	Test Equipment
Screwdriver Set	6pc. Miniature Screwdriver set	Euro Tool	SCR-900.00	Solder Master Supply	N/A	Test Equipment
Midget Wrench Set	10pc. Midget Combination Wrench Set (5/32-7/16")	Armstrong	25-600	Solder Master Supply	N/A	Test Equipment
Precision Knife	Precision Knife and 5 Blades	X-Acto	X3001	Stanley Supply & Services	119-336	Test Equipment
Steel Ruler	6" Precision Rule w/ Conversions (Standard/Metric/English)	Kristeel	401 A 5	Solder Master Supply	N/A	Test Equipment
Needle File Set	12-pc. Mini File Set	Euro Tool	FIL-990.00	Stanley Supply & Services	401-442	Test Equipment
Long Nose Locking Pliers	6" Long Nose Locking Pliers with Wire Cutter	Crescent	C6NV	Stanley Supply & Services	424-525	Test Equipment
Hex Wrench Set	L-Wrench Hex Set 12pc .050-5/16	Bondhus	12136	Stanley Supply & Services	174-435	Test Equipment
Needle Nose Pliers	Electronic Pliers, Long Nose, Serrated	Xcelite	LN55	Stanley Supply & Services	114-781	Test Equipment

Thermal Lab Setup (cont.)

Tools (not included with toolbox)						
Miniature Torx Set	6-Piece Miniature Torx Screwdriver Set	Wiha	26790	Stanley Supply & Services	115-218	Test Equipment
Pen Vac	Pen Vac Kit With 4 Tips	Excelta	PV-HV	Stanley Supply & Services	435-541	ESOS
Cutting mat with scale	X-Acto 18"x24" Self Healing Cutting Mat w/ 1" scale grid	X-Acto	X7762	Stanley Supply & Services	403-392	ESOS

Thermal Test Equipment

Data Module	20 Channel Multiplexer (2/4-wire) Module for 34970A/34972A	Agilent	34901A	QC		Test Equipment
Data Logger	Data Acquisition / Data Logger Switch Unit	Agilent	34970A	QC		Test Equipment
GPIB PCI card	Interface Card, NI PCI-GPIB NI-488.2 WIN 7/VISTA/XP/2000 ROHS	National Instruments		ESOS	—	ESOS
GPIB 2M Cable	Cable,Shielded IEEE-488 (GPIB/HPIB) Metal Hood 2M	N/A		ESOS	—	ESOS

Consumables and Materials

PanaVise 201 JR.	Vise head rotates a full 360° and pivots 210°	PanaVise	201	Stanley Supply & Services	400-231	Test Equipment
Thermocouples	36 gauge K-type 6' thermocouples	Omega	5TC-TT-K-36-72	Test Equipment Supply Supply WT-371		ESOS
Swabs	6" Cotton Tipped Applicators (Qty.100)	-	-	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Epoxy Adhesive	50/50 Epoxy/Hardener (Pre-packaged) Adehesive	AngstromBond	AB9226	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Instant Adhesive	Cyanoacrylate (Loctite 444)	Loctite	12292	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Instant Adhesive Accelerator	Tak-Pak Accelerator 7452 (Used w/ Loctite 444)	Loctite	18490	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Kapton Tape	Kapton Tape 1/2"	3M	5419	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Kapton Tape	Kapton Tape 1/4"	3M	5419	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Kimwipes	Lint Free Cleaning Wipes 4.4" x 8.4" (Box Contents 280 Wipes)	Kimberly-Clark	N/A	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Cleaning Brushes	For Cleaning at the PCB/PCA Level (Custom Cut by KG)	N/A	N/A	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Wooden Applicators	For Applying Liquid Adhesives or Support Wire While Adhesive Cures	N/A	N/A	Test Equipment Supply Supply WT-371	N/A	Test Equipment
Replacement x-Acto Blades	Replacement X-Acto Blades 100/pkg.	X-Acto	X611	Stanley Supply & Services	119-362	Test Equipment
DMM	True-rms Industrial Logging Multimeter with TrendCapture	Fluke	Fluke 289	Stanley Supply & Services	444-379	Test Equipment

Benchmark Setup and Run Instructions

- glBENCHMARK 2.5 EGYPT HD (download from Google Play using the device)
  - Open the application and select Performance Tests.
  - Run “adb shell” and then “setprop persist.debug.glbench.time 9000” to freeze a frame (it will rerender in a continuous loop).
  - Check the box by the first EGYPT HD test (it will say ETC1 underneath it) and click Start.
- AnTuTu 3.0.1 or later (download from Google Play using the device)
  - Open the application.
  - Select Start Test.
  - Select only CPU tests (no 2D/3D Graphics). Start the test.
  - After the test completes, log the score and immediately start the test again.
  - Repeat test 5x (6 runs total).

Benchmark Setup and Run Instructions (cont.)

- DHRYSTONE or similar (contact QTI for questions)
  - Type “adb shell”, then “/data/dhrystone.sh &”, enter, press Up arrow, and click Enter. Do this two more times. This will run Dhrystone a total of four times (quad Dhrystone).
  - Close the chamber door and observe thermocouple temperatures via Data Logger on your PC.
- The TSENS temperature can be observed while under test in one of two ways:
  - Type “adb shell”, then type “cat /data/tsens_logger.csv” and the TSENS data will show in the command prompt. Repeat this step for more TSENS data, or
  - Type “adb shell”, then type “cat /sys/devices/virtual/thermal/thermal_zone<tsens number>/mode”.
    - Should display Enabled
    - “cat /sys/devices/virtual/thermal/thermal_zone<tsens number>/temp” will display temperature
    - --Only tsens_0 will be enabled until its threshold is crossed (based on config file).
  - At completion of test, click Play on Agilent Data Logger to stop logging.
  - Open another command prompt and type “adb pull /data/tsens_logger.csv <destination path>.

References

Ref.	Document	
Qualcomm Technologies		
Q1	*Application Note: Software Glossary for Customers*	CL93-V3077-1
Q2	*Thermal Design Checklist*	80-VU794-21
Q3	*Design For Thermal: Key Requirements Why What Where When*	80-VU794-24
Q4	*Thermal Management of MSM8660/MSM8260/APQ8060 Devices*	80-VU872-16
Q5	*Thermal Protection Algorithm Overview*	80-VT344-1
Q6	*Application Note: MDM8200 Thermal Protection Algorithm*	80-VJ372-14
Q7	*Application Note: MDM9600 Thermal Protection Algorithm Details*	80-VP146-15
Q8	*Application Note: MDM9200 Thermal Protection Algorithm Details*	80-VP145-15
Q9	*Application Note: MDM8220 Thermal Protection Algorithm Details*	80-VP144-15
Q10	*MSM8960 Thermal Mitigation Algorithm*	80-N8633-1
Q11	*MDM9x15 Thermal Mitigation Algorithm*	80-N8633-2
Q12	*APQ8064 MDM9615 Thermal Mgmt Algorithm*	*80-N8633-3A*
Q13	*Agilent Data Logger 3 Getting Started Guide*	
References		
R1	DAQ	http://www.home.agilent.com/en/pd-1756491-pn-34972A/lxi-data-acquisition-data-logger-switch-unit?cc=US&lc=eng
R2	*Free Software*	http://www.home.agilent.com/agilent/software.jspx?cc=US&lc=eng&ckey=778242&nid=-33257.922596&id=778242

Questions?

https://support.cdmatech.com