CBA II West Mountain Radio Battery Tester

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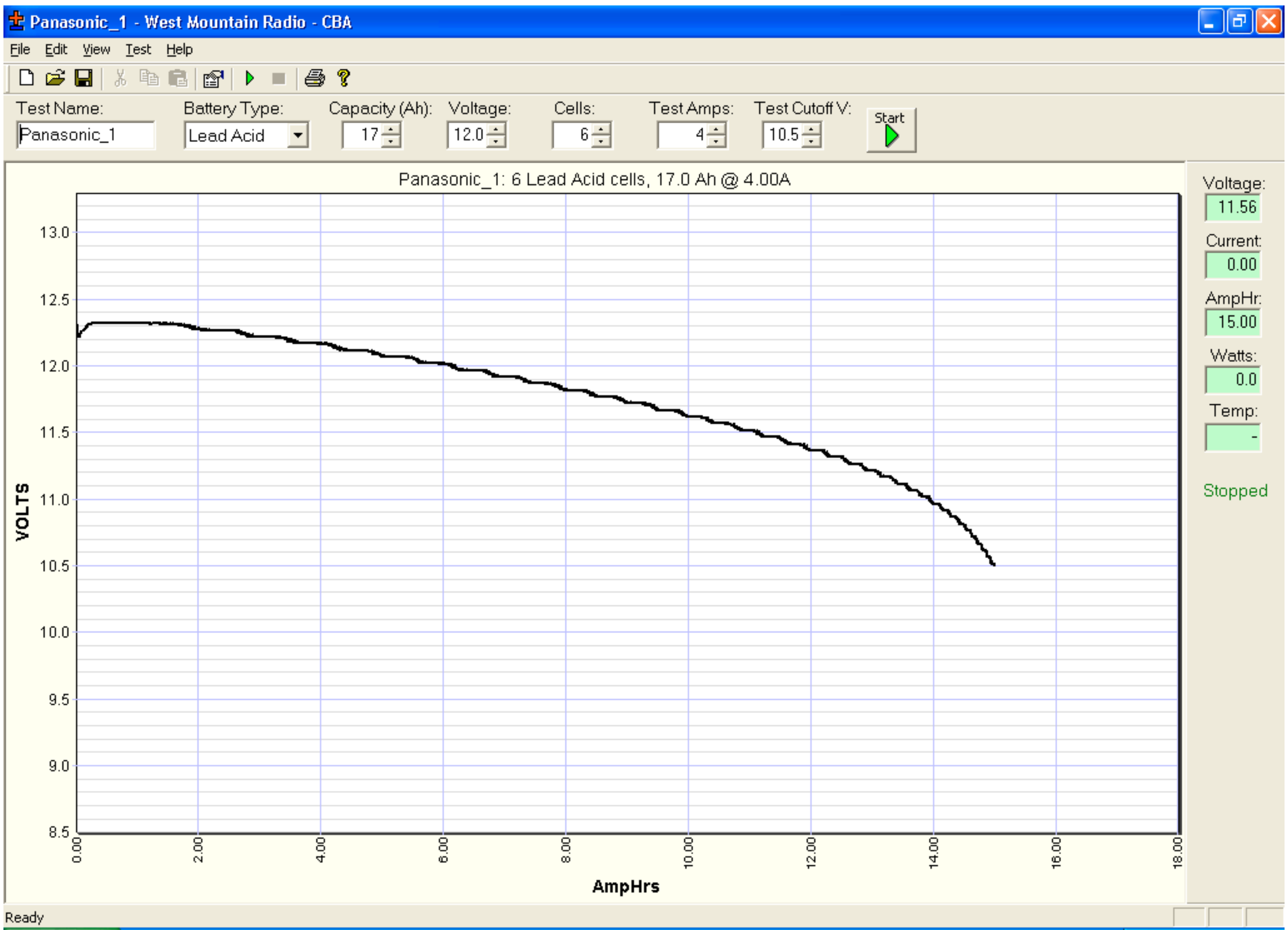
4/10/05

First impressions:

Here's the first plot I took with the CBA II battery capacity tester. This was the 2-year old battery that I used in earlier crowbar fault current experiments. The battery demonstrated about a 17 milliohm source impedance under a 200A discharge pulse.



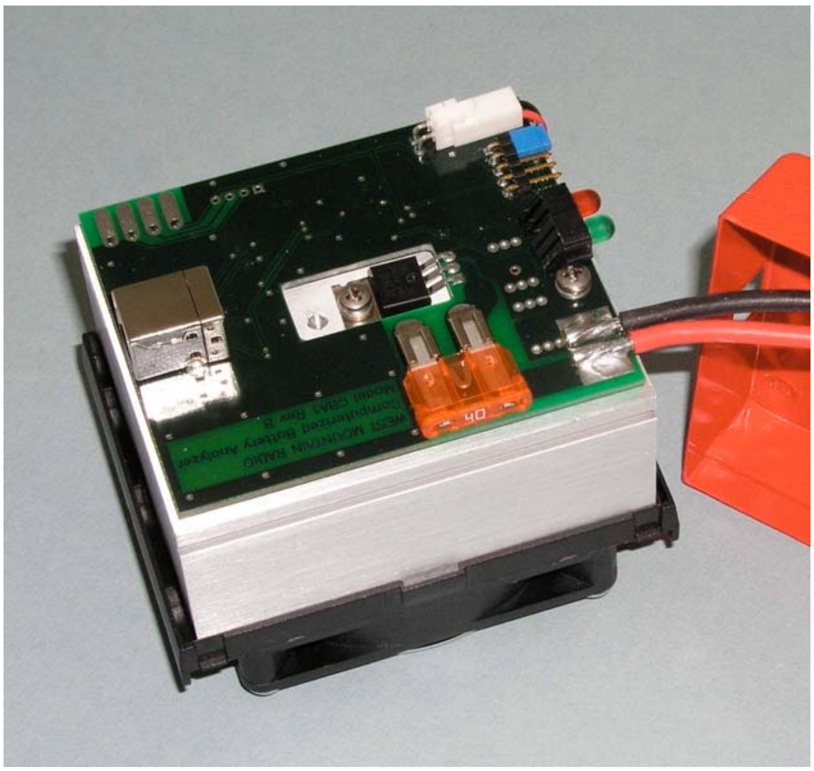
As you can see here, when discharged to simulate a 4A e-bus load, the ol' beast trudged along for 15 a.h. worth of output. Given that it's rated for 17 a.h. under a 20 hour rate, it seems that this battery might still be performing at or near new specifications for capacity in spite of disappointing value of source impedance.

I put it on a charger and set up to do a test on one of my little 2.0 a.h., 24 volt test batteries. Got an unusual amount of sparking as I clipped the test set to the battery under test. Hmmmm . . . doesn't look good. Double checked the connections and after finding that polarities and setups were correct, I connected it up solid and went to the computer screen to initiate a test. Before I could touch the keyboard, a warning sign came up telling me that the CBA II was drawing too much current and that the test could not continue. I disconnected the battery but noticed the very unique odor of burned semiconductor molding plastic.

Took the lid off the CBA II and could tell that the power transistor in the middle of the heatsink had been much too hot.

So, while the first experiment was impressive, something didn’t survive long enough for a second test.

Will contact West Mountain Radio for instructions to return for diagnosis and repair.



I opened the "smoked" CBA III . . . here's a picture of the internals.

Turns out that the little guy in the center is an International Rectifier IRL2910. Ratings for this device can be found at:

http://www.irf.com/product-info/datasheets/data/irl2910.pdf

Experiments described later in this document suggest this device is JUST BARELY CAPABLE of performing under the range of test conditions advertised for the CBA II. I am mystified as to the selection of this part when there are so many others offered by International Rectifier and others that would do the job.

By the way. The plastic on the IRL2910 was so damaged as to make the printing unreadable under ordinary light. I carry a blue-white LED pocket light in my nerd-pack. There's a quality of this light source that I've discovered makes otherwise hidden surface features visible. In this case, shinning the light on the uniformly black surface of the transistor raised the letters out of the "fog" and they became quite readable.

Here's the poop on the IRF2910 power transistor.

Of particular interest are the thermal resistance ratings at the bottom where junction to case is .75 C/w and case to sink is .5 C/W. CBA II is rated for up to 100 watts continuous load in a battery test. The transistor's junction temp cannot be allowed to go above 175C. So, 100W times 1.25 C/W says that the heat sink must stay below 175 – (100 X 1.25) = 50C

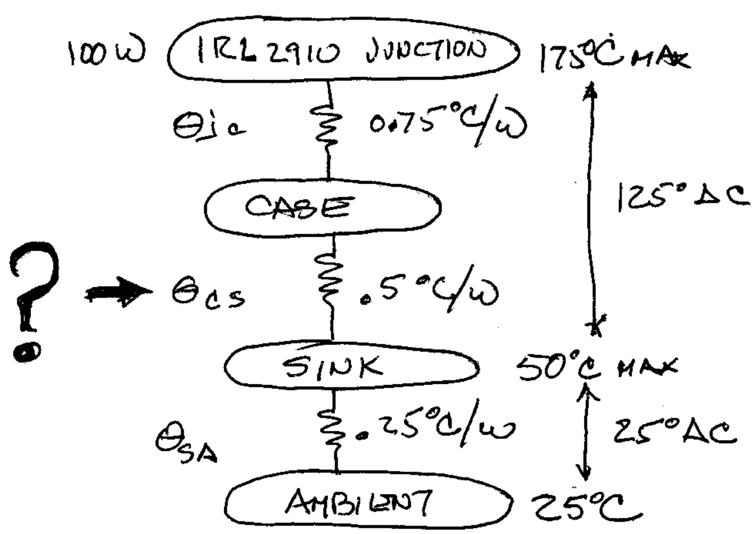
Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V	55	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10V	39	
I_{DM}	Pulsed Drain Current ①	190	
P_D @T_C = 25°C	Power Dissipation	200	W
	Linear Derating Factor	1.3	W/°C
V_{GS}	Gate-to-Source Voltage	± 16	V
E_{AS}	Single Pulse Avalanche Energy②	520	mJ
I_{AR}	Avalanche Current①⑤	29	A
E_{AR}	Repetitive Avalanche Energy①	20	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 175	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting torque, 6-32 or M3 srew	10 lbf•in (1.1N•m)	

Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	——	0.75	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.50	——	°C/W
$R_{\theta JA}$	Junction-to-Ambient	——	62	°C/W

Hmmmm . . . seems reasonable. Their heat sink has lots of fins on it and has a fan to help keep it cool. The thermal model for this arrangement looks like this:



The designer appears to have taken a textbook design problem, assumed a perfect world and ended up with a product guaranteed to have a high failure rate.

The thermal model has marginal headroom for ambient and production variables. How about hot day ambient? And in particular, are there production processes in place to guarantee Theta-CS to be at or below 0.5 C/W?

In the case of my unit's failure, ambient was below 25 C but the transistor failed in seconds after initiating a 24 volt, 2A (48 watt) battery test cycle. My suspicion is that the power transistor was not bolted down tightly –OR- had insufficient thermal compound under it.

To the workbench:

Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V	209⑥	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10V	148⑥	
I_{DM}	Pulsed Drain Current ①	840	
P_D @T_C = 25°C	Power Dissipation	470	W
	Linear Derating Factor	3.1	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy②	1970	mJ
I_{AR}	Avalanche Current	See Fig.12a, 12b, 15, 16	A
E_{AR}	Repetitive Avalanche Energy⑦		mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 175	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting Torque, 6-32 or M3 screw	10 lbf•in (1.1N•m)	

Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	——	0.32	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.24	——	
$R_{\theta JA}$	Junction-to-Ambient	——	40	

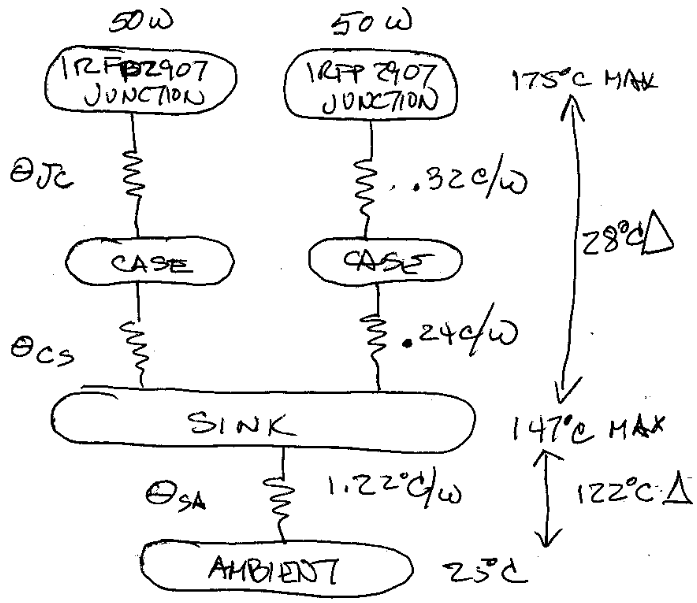
Let's explore the capability of the CBA II with a really good thermal model in the load transistor.

A transistor I stock for really abusive tasks is the IRFP2907 with a max ratings chart that looks like this:

I took a pair of these and mounted them on a heatsink from the junkbox like this. For sheet see:

http://www.irf.com/product-info/datasheets/data/irfp2907.pdf

MosFets parallel very nicely because when they get hot, their on-resistance goes up. If one is getting substantially hotter than the other, it sheds some load to the other transistors in the group.

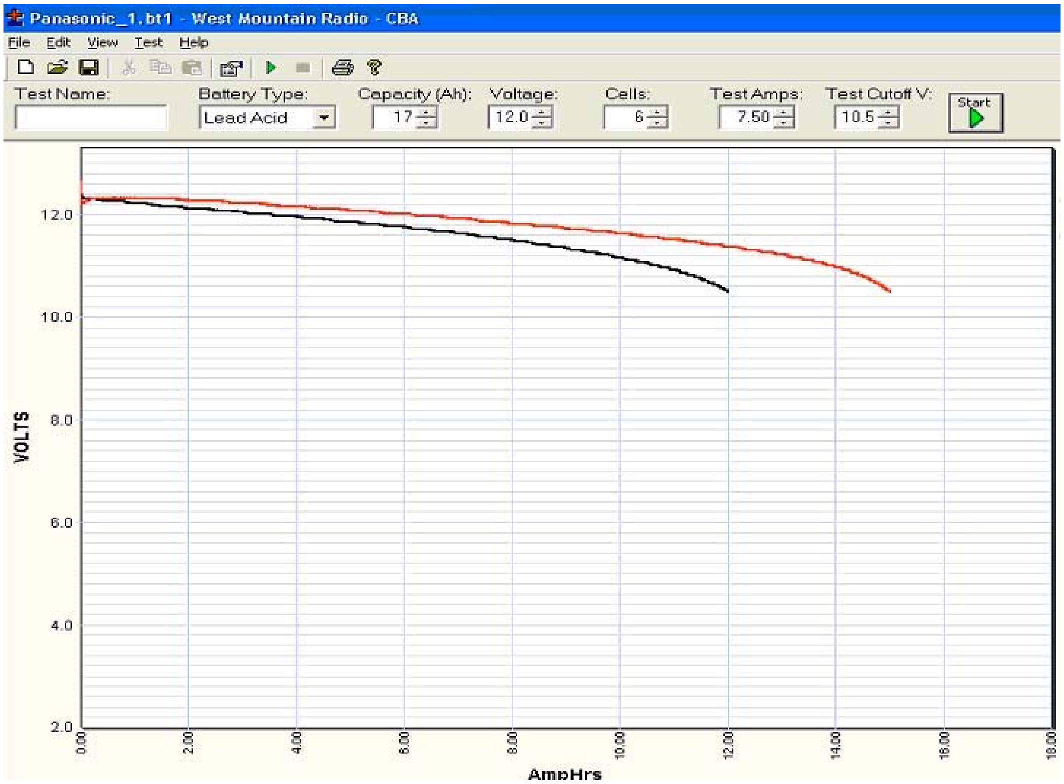


The thermal model for this experiment looks like this.

Running two transistors in parallel has the following advantages. Energy dissipation and thermal stress between heatsink and junction is shared. Temperature differential between sink and junction is cut in half. Observe also the superior thermal resistance values for these transistors from junction to case of 1.25 C/W for the IRL2901 versus .56 C/W for the IRFP2907. This experiment drops the 100W junction temperature rise over heatsink from 125C to 28C.

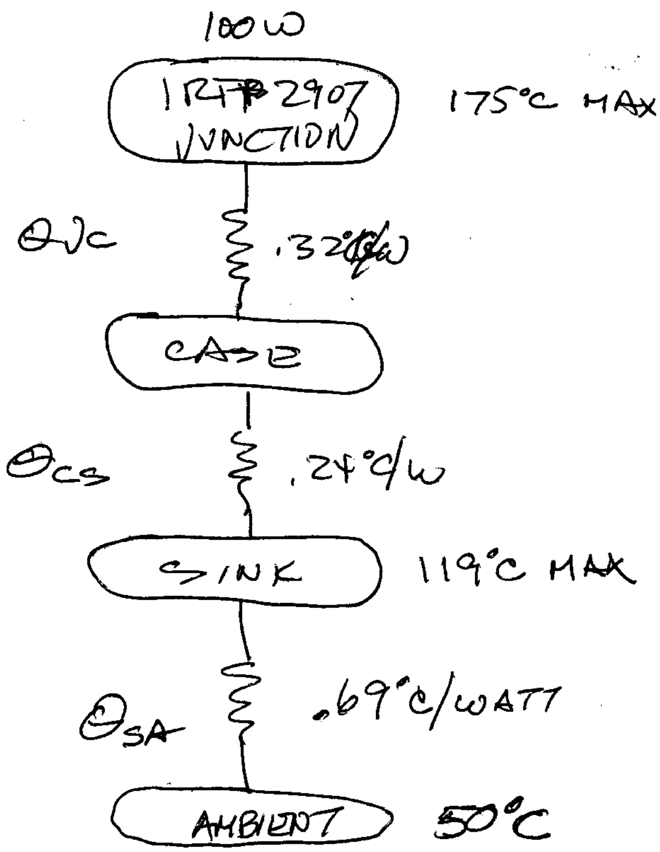
This makes our heat sink's job much easier. Instead of having to demonstrate a thermal resistance of .25 C/W, we can get by with a 5x larger value of 1.22 C/W.

Okay, let's run some batteries down. I set up a test on the 17 a.h. bench battery.



First at 4A (48 watts) and then at 7.5 amps (92 watts). Curves for these two tests are shown here.

During the test, my heatsink with a really good fan on it rose to 60 degrees C or a rise of 35C above ambient. 35/92 yields .38 degrees C per watt and the last thermal study says we only need 1.22 degrees C/W. Plenty of headroom. Can we do this with one IRFP2907 transistor? Let's see.



Yup, looks like we can. This study says that a total thermal resistance of 1.25 C/W will keep the junction from melting in a 50C environment. Our boss-hog heatsink with a fan is giving us about half that value.

I suspect that the fan/heatsink combination supplied with the CBA II is equal to or better than .69 C/W.

Conclusion: The CBA II as received here was marginal in terms of its thermal management and had marginal headroom for production variability in Theta C-S. The amount of thermal compound seemed adequate but the transistor is held to the heatsink with a 3MM screw that may well have not been torqued down tight enough.

Bottom line is that my tester failed when I tried to use it at about one-half the upper limit of the device's rated power loading of 100W.

This product is supported with some cool software and will probably work as advertised for the majority of users. There's a higher than acceptable risk for production variability in assembly to compromise the thermal management and take out the load transistor. If it were my product, I'd certainly substitute a TO-247 device for the TO-220 device just to get the better terminal resistance values for junction to sink. Note: No matter how many watts the transistor is rated for, it cannot achieve those ratings without getting the heat out of the device. This means that thermal resistance management is more important that picking a device with a higher dissipation rating.

If you own one of these critters and would like to use it for testing at or near max power (100W). Do some exemplar tests early. Get a 12v battery and do a 7.5 amp discharge. It wouldn’t hurt to do several cycles. If it doesn’t smoke, then the transistor installation is probably good. If it smokes, you can return it under warranty. The software is rigged to prevent abusive operation so they can’t claim that your negligence hosed it. If you want to remove the red plastic cover and check torque on the transistor mounting screw, it wouldn’t hurt. Personally, I’m going to take my experimental model with boss-hog heatsink, fan and dual load transistors and box it up in another enclosure. I intend to use this for LOTS of max power testing and it’s my personal wish to operate it with a much better thermal management headroom than the original designers intended.

Bob . . .