QuantAsylum QA450 User's Manual
Programmable 4/8 Ohm Load

SW Release 1.11

January 2019

Safety Notice

- This device is not designed for working on potentially dangerous voltages.
- This device is not designed for working on high energy circuits.
- Know and understand the voltage and current limits for each input
- See additional safety notices throughout this document.

Limited Warranty

This product has a limited warranty for 6 months from the time of purchase. During this time, a device failure that occurs under normal operating conditions will be replaced or repaired for free, not including shipping. Generally, you will be responsible for shipping to us, and we will be responsible for shipping it back to you.

Devices that have suffered a failure due to operation in excess of specified parameters can usually be repaired for a nominal fee.

The contents of this document are provided "as-is" and may be changed or updated without notice. The specifications on a particular product may also be changed at any time and without notice as we seek to improve a product or improve availability of a product.

The limit of our warranty will not exceed the value of the product purchased under any conditions.

Contents

Legal

In the Box

Your QA450 box contains the following:

- QA450 Programmable Load
- Power supply and Speaker connectors that mate with the QA450. These are installed on the QA450 and can be removed by gently pulling.

Installation software, this manual, and application notes for the analyzer are available on the web at http://www.QuantAsylum.com.

Important Things to Understand

Ground Reference

The QA450 USB interface shares a ground with the PC. The load portion and current sensing portion of the analyzer does not. You should measure, and from time to time confirm, that the BNC grounds are electrically isolated from the USB grounds.

This isolation is limited to 50V. Do not connect the QA450 to a product that has its ground reference more than +/-50V from the PC ground.

Current Sense Inputs

The QA450 has a 3-wire current sense connector (S+ from power supply, S- to DUT, and DUT GND) for monitoring the high-side DC supply of an amplifier. The voltages on the S+ pin of this connector must not exceed 50V DC and must be greater than 5V to ensure switching control. The DUT GND pin of this connector must be connected to your DUT ground. All of these pins are isolated from the PC/USB ground. Isolation is measured to be >10 GOhm at 1 KV.

WARNING: Do not plug/unplug an amplifier power supply when using the current sensing AND the green DUT LED is active. On very large amplifiers, this can cause hundreds of amps to flow for hundreds of microseconds which may destroy the high-side switch. Always ensure the green LED is off before connecting amplifiers. See the second below

Load Inputs

The load inputs are isolated from the PC/USB subsystem and also from the current sense subsystem. You will connect the amplifier outputs to the L- and L+ inputs for the left channel, and the R- and R+ inputs for the right channel.

Depending on your specified settings, the QA450 will present either a 4, 8 or open load to the amplifier.

When 4 or 8 ohm loads are selected, attenuated (by 6 dB) versions of the speaker signals will appear at the BNC outputs of the QA450. For example, the L- speaker input will appear at the L- BNC output, attenuated by 6 dB.

If you are using a single-ended amplifier, then the negative load inputs the QA450 must be connected to the DUT ground.

QA450 Programmable Load Features

The QA450 features:

- Programmable load values of 4, 8 or infinite (open) ohms.
- Current sensing of amplifier DC supply.
- On/off control of the DC supply via high-side PMOS switch
- Power handling up to 300W (duration limited)
- Current limiting of supply for accidental shorts (trips when >15A for more than 2mS)
- Soft-start, allowing gentle turn-on of the amplifier DUT
- First order filter to limit the slew rate of "filterless" class D amplifiers

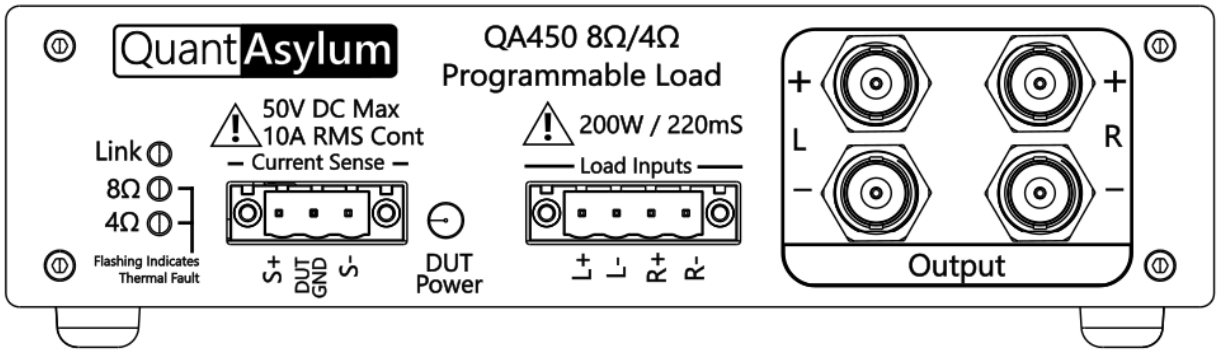
We hope you enjoy your purchase! Check back from time to time for new software updates.

QA450 Front Panel

This section covers the various connectors on the analyzer and reviews the input and/or output characteristics of these connectors.

Front Panel Summary

The front panel is shown in the picture below. From left to right, the following items are explained.



LEDs

Link LED This LED indicates the QA450 is connected to the PC and talking to the QA450 application.

8 Ohm LED This LED indicates the QA450 is presenting an 8 ohm load at the load inputs

4 Ohm LED This LED indicates the QA450 is presenting a 4 ohm load at the load inputs

DUT Power LED This LED indicates if the high-side switch is enabled or not. If the LED is flashing rapidly, then soft-start is in process.

If both the 8 and 4 ohm LEDs are flashing, then it means the QA450 has reached a thermal limit. This is not harmful to the QA450. When this happens, the QA450 will open the relays automatically and ensure the load inputs are removed from the internal load resistors.

Current Sense Inputs

The QA450 uses an isolated Hall sensing device to measure the power supply DC. The positive terminal of the amplifier's DC power supply flows into the S+ pin on the front panel, is sensed by the Hall sensing device, and then flows out of the S- terminal to the amplifier (see Appendix I Connection Diagram). The Hall sensor used is an Allegro Micro ACS711, with +/- 15A of measurement range. On the QA450, only positive current (from DC supply to the amp) are reported. If a negative current is measured, it is clamped at 0 amps.

For the high-side PMOS switch to work, the DUT GND must be connected. Additionally, the voltage controlled by the switch must be at least 5V (S+ to DUT GND) and not exceed 50V (S+ to DUT GND). If the voltage is too low (less than 10-15V), the PMOS switch cannot be fully turned on. If the voltage is too high (more than 50V) internal components may be overstressed and could fail. The QA450 is designed to operate continuously at 50V and can withstand normal transients excursions above 50V.

The current sensing is not required to be used. For example, if you are testing Class D amplifier boards, it might make sense to use the current sense and power the boards from a fixed external supply. But if you are testing finished amplifiers that run from AC, then the DC measurement provided by the QA450 isn't useful and can be skipped.

ATTENTION! DO NOT CONNECT THE CURRENT SENSE CONNECTOR WHEN THE DUT LED IS ON!

Do not swap amplifier boards when the DUT LED is on!

If your power supply and amplifier both have massive capacitors, and you connect the amplifier while the DUT power is enabled, then potentially hundreds or even thousands of amps can flow through the high-side switch and cause it to fail as the charge is re-distributed

The Current Sense connector on the QA450 is a Molex 39536-0003. The mating connector is a Molex 39534-0003. This connector has a rating of 300V and 15A per pin.

Do not exceed the 10A RMS rating or 15A max rating of the Current Sense subsystem.

DUT Power Soft Start

When the DUT Power is activated, the DUT Power LED will flash rapidly for 1 second. This indicates that soft-start is underway. During soft-start the DUT amplifier is connected to the high-side rail (S+) through a 10 ohm resistor. This allows amplifiers with very large filter caps to charge at current levels that won't stress components in the power supply, the QA450 and the DUT amplifier. A large amplifier might have 10 mF of bulk capacitance. The RC time constant of the 10 mF and 10 ohm is 100 mS. Thus, the one-second soft-start allows 10 time constants of soft-start to elapse before bypassing the soft-start resistor. See the discussion below on Faults for more analysis.

Load Inputs

The load inputs are where the amplifier/DUT will connect. The loads are switched internally by relays rated for 12A at 250VAC and 12A at 24VDC. The loads are DC coupled, but it's expected that ONLY AC signals will be presented to the QA450. Given the QA450 maximum ratings, the voltage on the load inputs must not exceed 50VAC RMS

The maximum currents at the QA450 maximum ratings occur when the load is set to 4 ohms at 300W. This corresponds to an 8.66A RMS current.

The Load Input connector on the QA450 is a Molex 39536-0004. The mating connector is a Molex 39534-0004.

Do not exceed the 200W for 220 mS rating of the Amplifier Load subsystem.

BNC Outputs

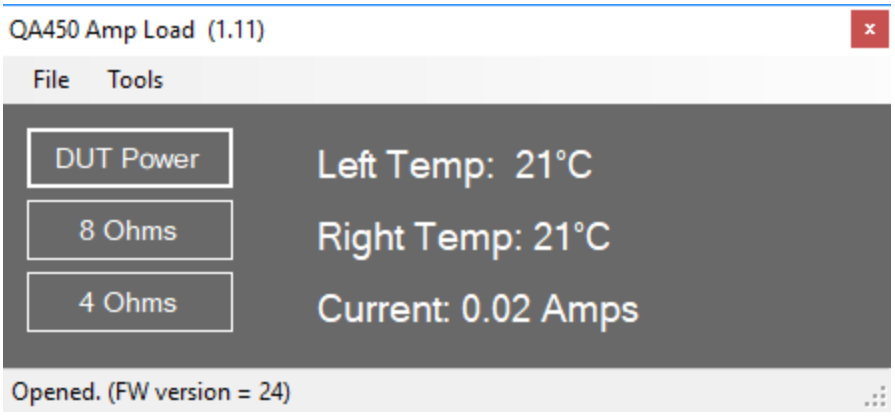
The BNC outputs are attenuated version of the load inputs. The attenuation is 6 dB. This means if your amplifier is 10 dBV = 3.16Vrms (as measured with DVM in AC mode across L+ and L-) and the QA450 load is set for 8 ohms, then the QA450 will be dissipating (3.16^2)/8 = 1.24W. The BNC outputs will measure 6 dB lower, which would be 4 dBV = 1.58Vrms

The first order low-pass filter in the QA450 has its corner at 34 KHz.

QA450 Software

The QA450 will appear on your PC as a "HID" device with a USB VID:PID of 0x16C0:0x4E2C. It doesn't need drivers. It will show up in the Device Manager as a "HID-compliant vendor-defined device."

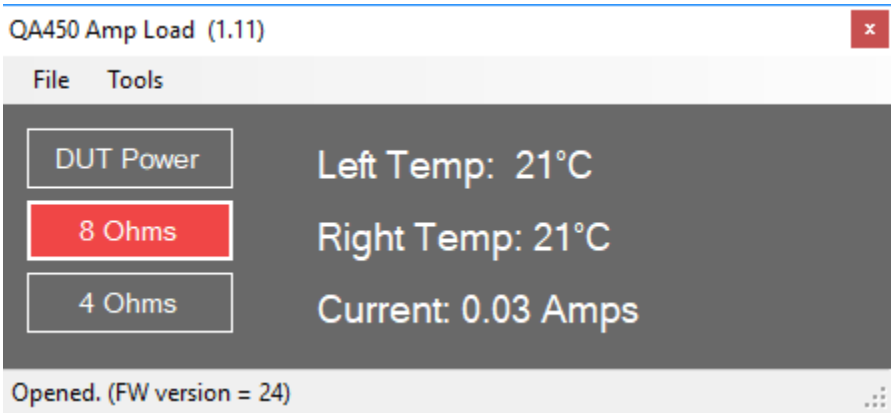
When you first plug in the QA450 device, Windows should spend a bit of time configuring the device. Download and install the QA450 application from Github. After launching the application, you should see the following UI:



In the title bar, you can see the version of the software, shown here as 1.11. In the status bar, we can see the hardware device is "opened" and that this is firmware version 24. You will be alerted if the firmware version is incorrect and given a chance to re-flash the QA450 hardware. It is important to NOT use the application if the firmware version is reported as incorrect as malfunctions could occur.

When the QA450 and application are "talking", should see the "LINK" LED on the QA450 hardware illuminated.

If you press the "8 Ohms" button, you will hear a "click" from the QA450 relays and the application will report the 8 ohm load is active as shown below. At this point, you can use a DVM to measure across the L+ and L- Load Input pins and confirm that 8 ohms is being presented. You can repeat the experiment for 4 ohms, too, and also for the right channel.



Pressing an illuminated load button again will turn the loads off. When both the 4 and 8 ohm buttons are off, then the QA450 presents an "infinite" or open load to the amplifier. Note that when the QA450 is open, the QA450 +/- outputs are meaningless. That is, the input signals cannot be measured when the loads are disconnected.

Application Temperature Sensing

On the right side of the QA450 application, you can see the temperature for both the left and right channels. Generally, under normal operation, these temperatures must remain under 60C. Above 60C or below 5C, the QA450 will disconnect the loads and require time to cool down or warm up. The sensors are very accurate and respond very quickly. Generally, as long as you do not impart more than 300W of power per channel, you do not need to worry about harming the QA450. It will self-protect. The temperature readings are provided for information only.

Application Current Sensing

The QA450 reports the current measured by the Current Sensing subsystem. The resolution is around 30 to 40 mA. That is, you will see readings jump by perhaps +/- 20 mA. For high-power amplifiers that might draw 10A or so, this generally isn't a problem. Of course, if you want to measure an amp with a max current of 100 mA, then this resolution can contribute significant errors.

DUT Power

The DUT POWER button is used to the turn on the high-side PMOS in the QA450. When enabled, the S+ and S- will be connected by a low impedance of 25 mOhms or so. This is Rds(on) of the high-side PMOS pass device.

If the QA450 application is closed or stops responding, or if the QA450 is disconnected from the USB, then the QA450 will automatically open the load relays and disable the load power.

Fault Conditions

If absolute current exceeds 15A for more than 2 milliseconds, the high-side PMOS will be disabled. A fault will be reported on the QA450 application and the USB power must be removed and re-applied to clear the fault and restore normal operation.

If the DUT GROUND wire is lost due to broken lead or disconnect, then you will lose the ability to turn the DUT POWER on, and it will revert to OFF if currently ON. The DUT POWER LED will still appear functional, however.

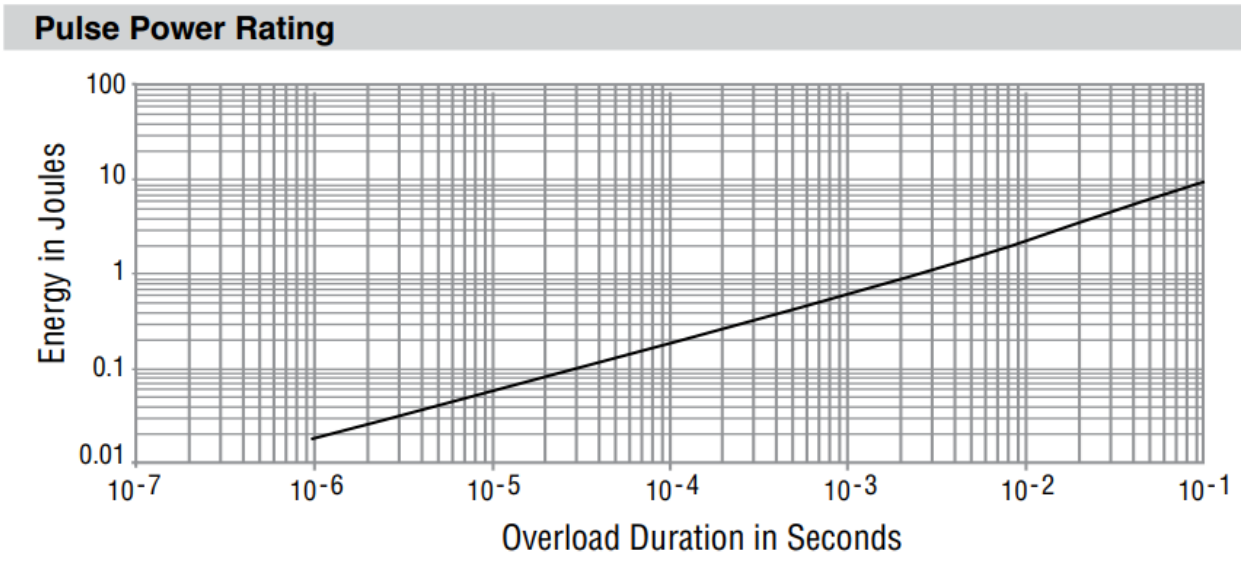
QA450 Load Resistors

The QA450 uses a special type of load resistor called a "Pulse Withstanding" load resistor. These are specially formulated resistors built on metal substrates designed to handle extremely large pulses of power for very short periods of time. They are non-inductive.

An example resistor used for the QA450 is the Bourns PWR163 series. The QA450 has 16 of these resistors—8 per channel. When presenting an 8 ohm load, four 2 ohm resistors per channel are used (4S1P). When presenting a 4 ohm load, eight 2 ohm resistors per channel are used (4S2P). There are half as many resistors used when presenting an 8 ohm load versus a 4 ohm load. This has implications for maximum power handling.

The PWR163 resistors are each rated to handle 25W when the case temperature is 25C. That 25W figure is de-rated by about 15% as the backplate temperature reaches 50C. If the resistors are near room temperature and the QA450 is configured for 4 ohms (8 resistors), then you can hit the load with 8 * 25 = 200W for several seconds until the thermal protection kicks in. The temperature will quickly rise over several seconds and further de-rating will be necessary as it increases. When the resistor temperature exceeds 60C, the QA450 will self-protect and disconnect the loads.

The PWR163 spec also shows the pulse power rating, reproduced here:



For 1 second, the spec has prescribed 25J (25W * 1sec @ 25C). For 100 mS, we see a single load resistor can handle 10J of energy. Note that 1J = 1W for 1 second, and thus 10J = 100W for 100 mS. So, the array of 8 resistors (when configured as a 4 ohm load) can handle 800W for 100 mS. If using as an 8 ohm load, this this figure is 400W for 100 mS.

Tabularizing the observations above, we see the following:

Sample Rate	FFT Size	Pulse Duration (sec)	Max Joules per R	Max Power per R	Max P into 4 Ohms	Max P into 8 ohms	Irms Current 4 ohms	Irms Current 8 ohms	Vrms 4 Ohms	Vrms 8 Ohms
48K	2K	0.085	9.7	114.6	916.7	458.4	15.1	7.6	60.6	60.6
48K	2K	0.085	9.7	114.6	300.0	300.0	8.7	6.1	34.6	49.0
48K	4K	0.13	10.5	80.8	646.2	323.1	12.7	6.4	50.8	50.8
48K	4K	0.13	10.5	80.8	300.0	300.0	8.7	6.1	34.6	49.0
48K	8K	0.22	12.0	54.5	436.4	218.2	10.4	5.2	41.8	41.8
48K	8K	0.22	12.0	54.5	300.0	218.2	8.7	5.2	34.6	41.8
48K	16K	0.38	14.7	38.6	308.6	154.3	8.8	4.4	35.1	35.1
48K	16K	0.38	14.7	38.6	300.0	154.3	8.7	4.4	34.6	35.1
48K	32K	0.72	20.3	28.2	225.9	112.9	7.5	3.8	30.1	30.1

The table above shows regions that may overstress the QA450 and should be avoided. For example, the resistors would survive an 85 mS burst of audio—which is a 2K FFT @ 48Ksps—at 114W per R. This would deliver 916W into the load. But this would result in 15.1A of connector current and 60Vrms. These overstresses are marked in red. Limiting the max load power to 200W for 220 mS into 8 ohms and 4 ohms provides a reasonable reliability margin. This is an 8K FFT.

The temp sensing on the QA450 has a lag. If the load resistors are hit with 800W for 100 mS, then the temperature of the resistor active area will climb very quickly while the temp sensor located 2-3 mm away from the resistor body will remain unchanged. Because of this lag, the 200W figure must not be exceeded as the QA450 won't be able to protect itself quickly enough. But at power levels below 200W, the QA450 can fully protect itself and you don't need to worry about harming the QA450.

Audio Bursts

The QA401 Audio Analyzer operates on bursts of audio. It is these bursted modes where the utility of the QA401 and QA450 combine to allow thorough testing at high power levels.

The QA450 is obviously not the platform you'd chose for burning-in amplifiers. But a test suite that has an average power level of 4-5W can run continuously without stressing the QA450.

Low Temperature Operation

The temperature sensors used on the QA450 are absolute sensors with a tolerance around +/-1%. The QA450 firmware expects to see a temperature of at least 5 degrees. This ensures the sensors are properly communicating with the CPU. If the ambient temperature is near 5 degrees, the QA450 will not allow load control.

Soft-Start

The QA450 is designed to enable very low-cost audio testing bays. The idea is that expensive lab-grade programmable power supplies can be replaced with commodity open-frame power supplies. For example, a 1KW fixed 48V power supply with fixed current limiting is under $100, while a 1 KW adjustable lab supply with programmable current limiting costs several thousand dollars.

To make use of these low-cost fixed supplies in a test environment where a new board is being fixtured for test every minute, the ability to control the power supply is needed. If the supply is left on continuously, when the operator "plugs in" the board to be tested extremely high currents will flow as the massive amplifier capacitors charge. These currents can easily reach hundreds of amps, overstressing components.

The QA450 provides an "on/off" switch for supplies up to 50V. This allows a commodity fixed power supply to be used in the test bay. While the operator is connecting the amp to be tested, there won't be any arcing or high currents flowing because the power to the amp is off due to the QA450 switch.

When instructed to turn on, the QA450 will always apply a 1 second "soft start" where the amp is connected to the power supply through a 10 ohm resistor. During this time, the massive amp capacitors can charge though the 10 ohm resistor. After 1 second, the 10 ohm resistor is bypassed and the amp is directly connected to the supply. This happens automatically when the QA450 power switch is enabled.

If the amp has bulk capacitance greater than 10 mF or so, then the 1 second soft start time may not be enough. Assume for a moment you are running an amp with 50 mF of bulk capacitance. When the power switch is turned on, an RC circuit comprised of the 10 ohm soft-start resistor and the 50 mF bulk capacitance begins to charge. One time constant will be 10 * 50 m = 500 mS, and thus after one time constant the voltage will have risen to 31.6V. At that point, the 10 ohm is bypassed and the current increases rapidly leading to an overcurrent condition.

If you have more than 10 mF of bulk capacitance, and you are getting overcurrent warnings when turning on the switch, contact us at the support alias and we can work to help solve the problem.

Thermal Considerations

The QA450 is NOT designed for sinking 10's of watts for long periods of time. The QA450 cannot dissipate the heat that comes from those power levels. The QA450 is designed for high-speed testing of amplifiers. That is, you will subject the amplifier to many short bursts of audio, typically around 1-2 seconds each. The power levels of these tests may be anywhere from milliwatts to hundreds of watts.

The average power you subject the QA450 to must be around 5-10W or so. That is, if you compute the watt*second product of your tests, and then divide that by your total test time (including operator change over to the next amplifier), then the average should be around 5-10W to ensure continuous operation. This depends somewhat on your factory. If you keep the factory near 25C with good airflow you can be closer to the 10W figure, otherwise, the 5W figure might be more appropriate.

The table below shows what a test plan might look like. Test #1 would subject the board to 300W for a short test of THD at max power (300W). Test 2 might look at THD at 100W, and test 3 perhaps 50W.

Subsequent tests would focus more on noise measurements, IMD, and other parameters at a typical listening level.

Finally, "switchover" in the table below refers to the time it takes an operator to remove the amplifier that was just tested and replace it with another amplifier. The 20 second figure used in the table below suggests a very fast switchover operation, most likely automated and extremely high volume. The test flow below suggests a 15 hour (2-shift) production of 1200 amplifiers tested per day per test bay.

Test Number	Watts	Duration	Processing	Total Bay Time	Watt Seconds
1	300	0.4	1	1.4	120
2	100	0.4	1	1.4	40
3	50	0.8	1	1.8	40
4	1	2	1	3	2
5	1	2	1	3	2
6	1	2	1	3	2
7	1	2	1	3	2
8	1	2	1	3	2
9	1	2	1	3	2
10	1	1	1	2	1
Switchover	0	20	0	20	0
				44.6	213
Test Time wo switchover:		24.6		Average Power	4.78 Watts

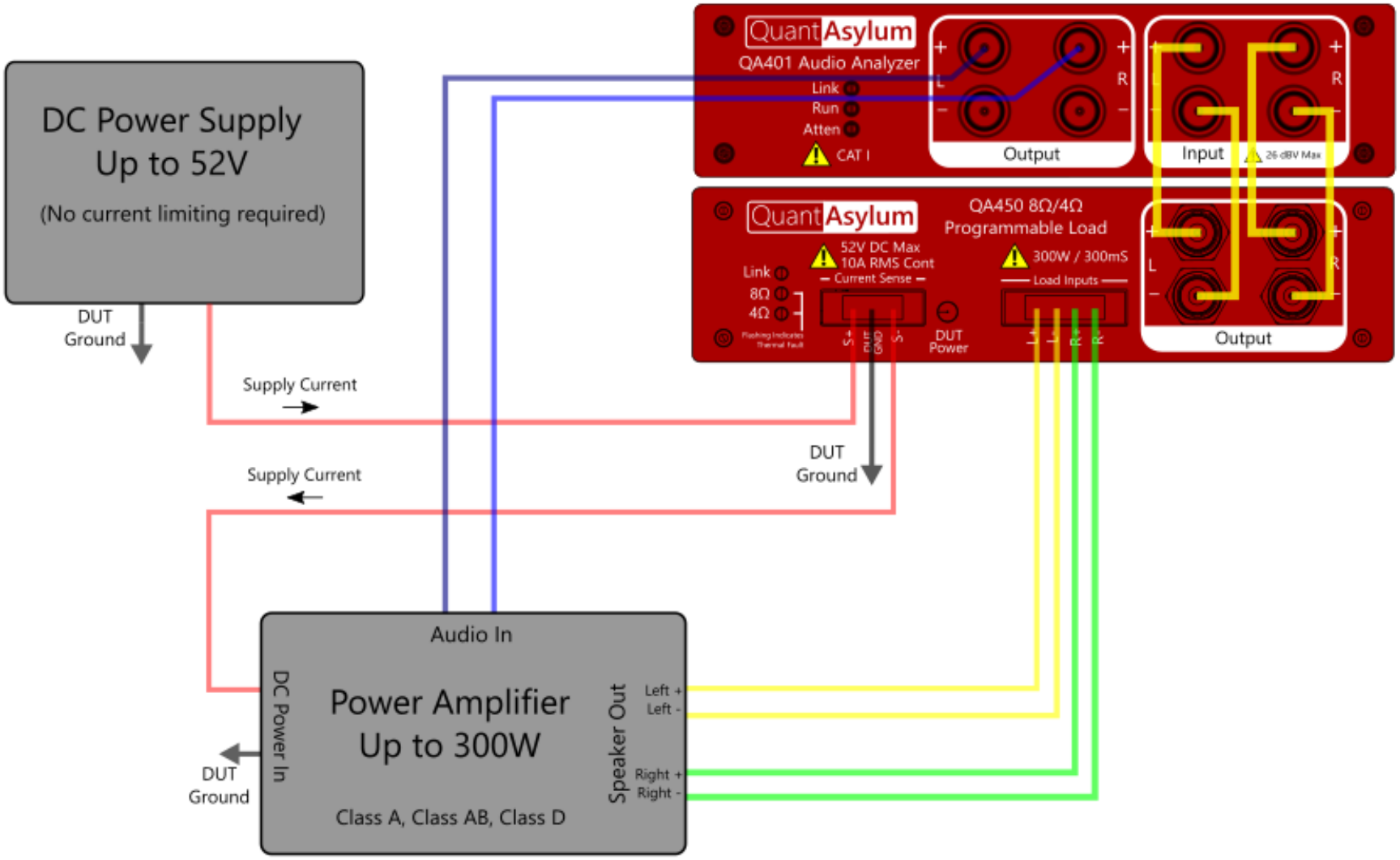
Impact of Switchover

The impact of switchover time is significant in the average power calculation. If the switchover time is 2 minutes, due in part to an operator managing several bays and a fully manual switchover, then the average power drops to 1.5W.

In summary, you need to plan your thermal budget ahead of time to ensure the QA450 can meet your needs. Hitting the thermal targets above will ensure continuous operation without having to wait for cooldowns.

Because the QA450 can also report the temperature to other applications via the REST web interface, it's also possible to program your test flow to wait for the temperature to fall below a threshold before you begin testing a new amplifier.

Appendix I: Typical Connection Diagram



Appendix II: QA450 Specifications

Current Sense Inputs	
S+ Max Voltage (normal operation)	50V (relative to DUT GND)
S- Max Voltage (normal operation)	50V (relative to DUT GND)
USB Isolation	>10 GΩ @ 1KV
Max Current	10A RMS continuous, 15A peak
Trip Current	>15A for 2 mS
Soft Start	10 ohm for 1 second
Load Inputs	
Load Options	4 and 8 ohms
Max Voltage on any pin	50Vrms AC relative to DUT GND
Max Current on any pin	10Arms
Max Power into Load Inputs	200W per channel for 220mS
Load Tolerance	+/- 5%
USB Isolation	>10 GΩ @ 1KV
Output	
Attenuation	6 dB
Frequency Response	F3db = 34 KHz
Output Impedance	~100 ohms
General	
Interface	USB, 12Mbps
Power	USB, < 500 mA
Ambient Operating Temperature	15 to 30C