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STMTHERM THERMAL STIMULATOR

STMTHERM Thermal Stimulator Unit (SCU) and TSD191 Transducer Probe (Thermode)

The STMTHERM is a thermal stimulator that can deliver a range of hot and cold temperature stimulation to a subject and can be used to identify participant thermoreceptor response thresholds for a variety of applications. The STMTHERM consists of two parts, the Stimulator Unit (SCU) and the included TSD191 Thermal Stimulation Transducer (Thermode).

The TSD191 has a 30 mm x 30 mm contact area and includes a hook-and-loop strap to hold it in place. The STMTHERM is an "open-loop" thermal stimulator, so there is no temperature feedback incorporated into the design. Accordingly, the STMTHERM behaves similarly to a conventional voltage stimulator where the electrical applied stimulus is a function of drive level and associated loading. In the context of the STMTHERM, the thermal stimulus temperature at the Thermode contact area is impacted by the heat-carrying capacity of the stimulus area.

Precision Temperature

To obtain an accurate measure of the specific stimulus temperature at the stimulus area, BIOPAC recommends use of the SKT100C Skin Temperature Amplifier Module and TSD202A Temperature Transducer, where the TSD202A is placed between the Thermode and the stimulus area.

Closed Loop Control

"Closed loop" control allows continuous temperature readings between the Thermode and the stimulating surface to deliver precision stimulation. The STMTHERM device does not have "built-in" closed loop control of temperature, but closed loop control can be achieved with an extended setup configuration that adds the SKT100C Skin Temperature Amplifier and TSD202A temperature probe. STMTHERM plugs into STM100C and STM100C is set to I/O 15 as input.

Using this setup, precise probe temperature readings are available at any given time. Control channels in Acq*Knowledge* are then used to modulate the input voltage sent to STMTHERM, to maintain loop control, by monitoring probe temperature.

The STMTHERM is controlled via a voltage signal (Peltier thermoelectric method) and the Thermode temperature can be increased or decreased in a linear or step-change fashion. The STMTHERM also has two manual pushbutton test modes that deliver a five-second step increase or decrease, respectively, to the present stimulus temperature.

The analog control input signal range is ±10 volts, where negative voltages lower the temperature of the Thermode and positive voltages increase the temperature of the Thermode. An LED indicator on the front of the SCU turns red when the Thermode is being heated and blue when it is being cooled. The intensity of the LED indicates the relative amount of heating/cooling being applied via the control voltage.

The SCU interfaces directly to one of the AMI100D or HLT100C analog output ports for MP160 Systems, an HLT100C-MP150 analog output port for MP150 Systems, or with added OUT6 for MP36/MP36R Systems. The SCU can be controlled using Acq*Knowledge* software "Stimulator Setup" or "Manual Control" features.

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Output interface: Use the Thermode (TSD191) to deliver temperature stimuli to participants. The transducer has a thermal stimulation area of 30 mm x 30 mm and includes a three-meter cable. The transducer incorporates a heat sink and cooling fan. Proper operation of the TSD191 requires that the fan airflow not be obstructed.

WARNING: When applying thermal stimulus to skin, DO NOT set the STMTHERM control voltages at the -10 V or +10 V limits for longer than 5 seconds.

STMTHERM THERMAL STIMULATOR Specifications

(Includes Stimulator Control Unit (SCU) & TSD191 Thermal Stimulation Transducer (Thermode)

SCU Weight	470 grams
Dimensions	Enclosure: 15.4 cm (wide) x 15.8 cm (deep) x 4.8 cm (high)
Cable **MP160** **MP150** **MP36/36R**	to AMI100D or HLT100C, 6-pin, RJ11, 2 meters long to UIM100C analog out or HLT100C-MP150 via RJ11 via OUT6 (DSUB9 to RJ11) adapter
Control	- via Acq*Knowledge* arbitrary waveform stimulator window or external voltage source (range ±10 V) - via "HOT PULSE" and "COLD PULSE" manual pushbuttons (each generates a 5 second thermal stimulus at 50% of maximum level; equivalent to ±5 V fixed-step control voltage drive)
Fuse	3.5 amps
Power Supply	AC400 (12 V @ 5 amps)
Control Voltage Range	±10 V (via HLT100C, AMI100D, MP36/36R, Acq*Knowledge* or external voltage source)
Operation	Voltage controlled thermal stimulation (Peltier thermoelectric)
Dynamic Range	±10 V (20 V p-p) maps to 67.5° C p-p unloaded
Max Rate of Change	For 20 V p-p input, ΔT/°sec max is 7.6° C/sec

The STMTHERM can be easily controlled via the **Manual Control** window in Acq*Knowledge* software (MP1xx menu > Show Manual Control).
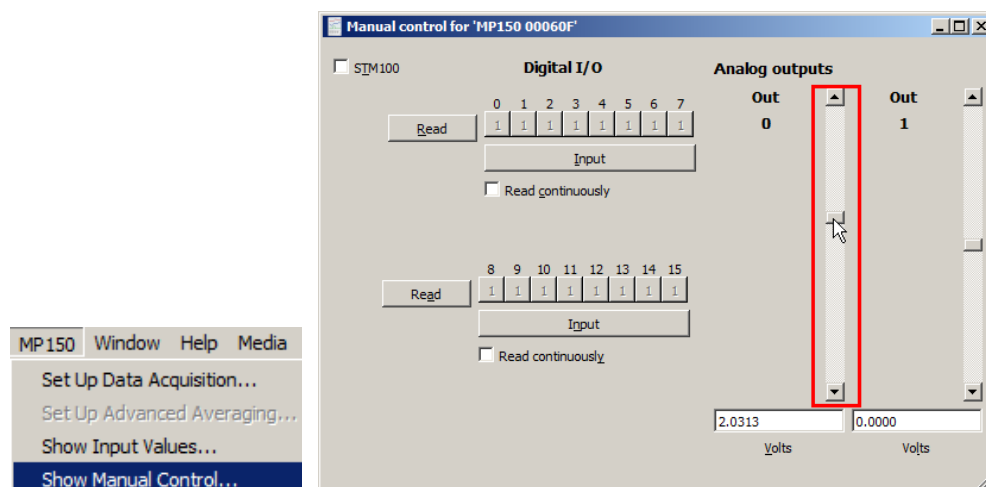
Acq*Knowledge* Manual Control Window

Adjust the vertical voltage slider to change the stimulus temperature. Up to two STMTHERM Systems can be used with a single MP160/150 System.

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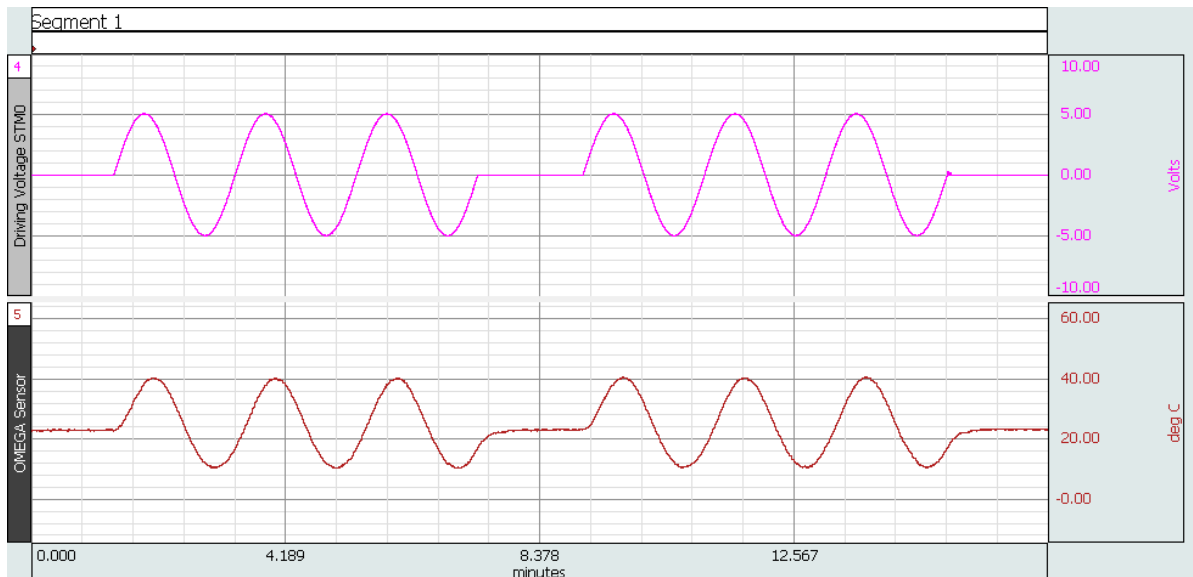## Characteristic Voltage vs. Temperature Curves

Figure 1: STMTHERM driven by a sine wave (top trace) with voltage limits of ±5 V and frequency of 0.008333 Hz. Peak thermal signal (bottom trace) = 40.3 ºC; minimum signal = 10.3º C. Delay between drive signal and thermal response ~ 9 – 10 sec.
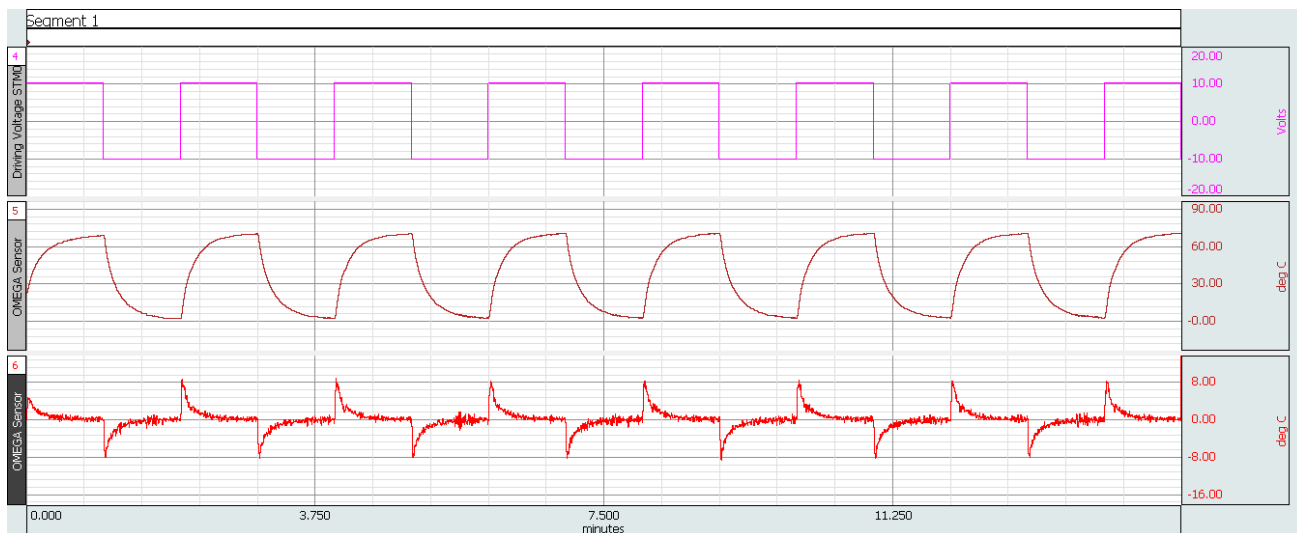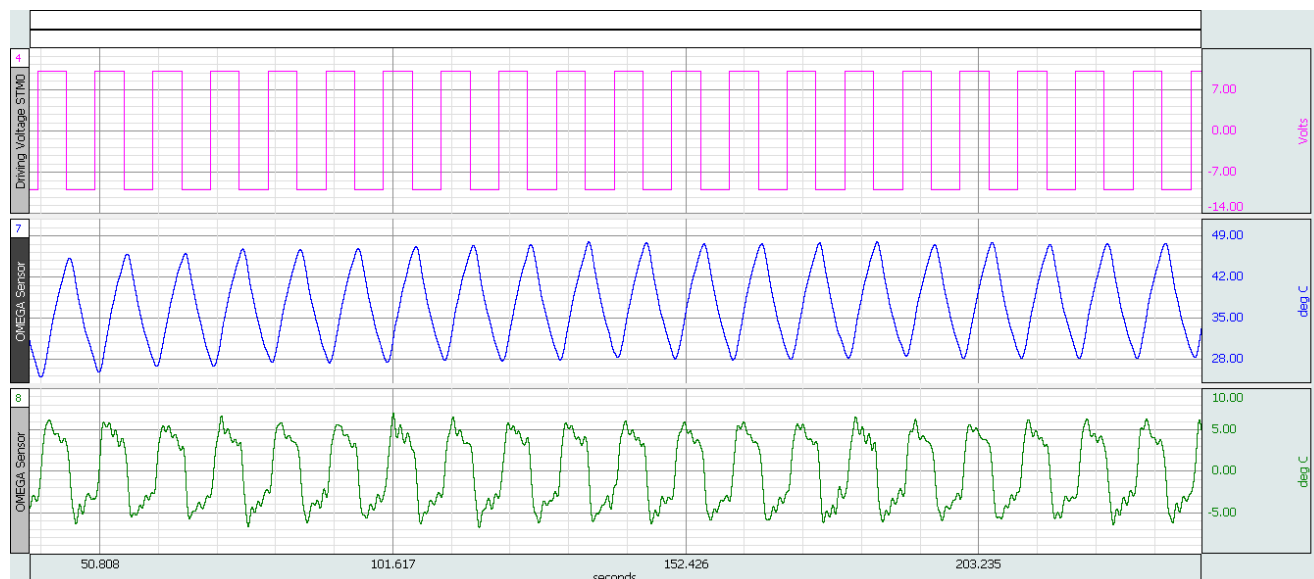

Figure 2: Unloaded response (no skin contact, using non-contact thermal imager) of the STMTHERM to ±10 V stimulus waveform for High Temperature Range. **Stimulus cycle is 1 minute +10V, 1 minute -10 V.**

The **peak derivative of the response is ~ 7.6 (°C/sec)** and the **output temperature swing Δ = 67.51 (°C)**.

Top curve: stimulus, middle curve: response, bottom curve: derivative of response.

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Figure 3: Unloaded response (no skin contact, using non-contact thermal imager) of the STMTHERM to ±10 V stimulus waveform for High Temperature Range. **Stimulus cycle is 5 sec +10 V, 5 sec -10 V.**

The **average derivative of the response is ~ 4.3 (°C/sec)** and the **output temperature swing Δ = 19.84 (°C)**.

Top curve: stimulus, middle curve: response, bottom curve: derivative of response.
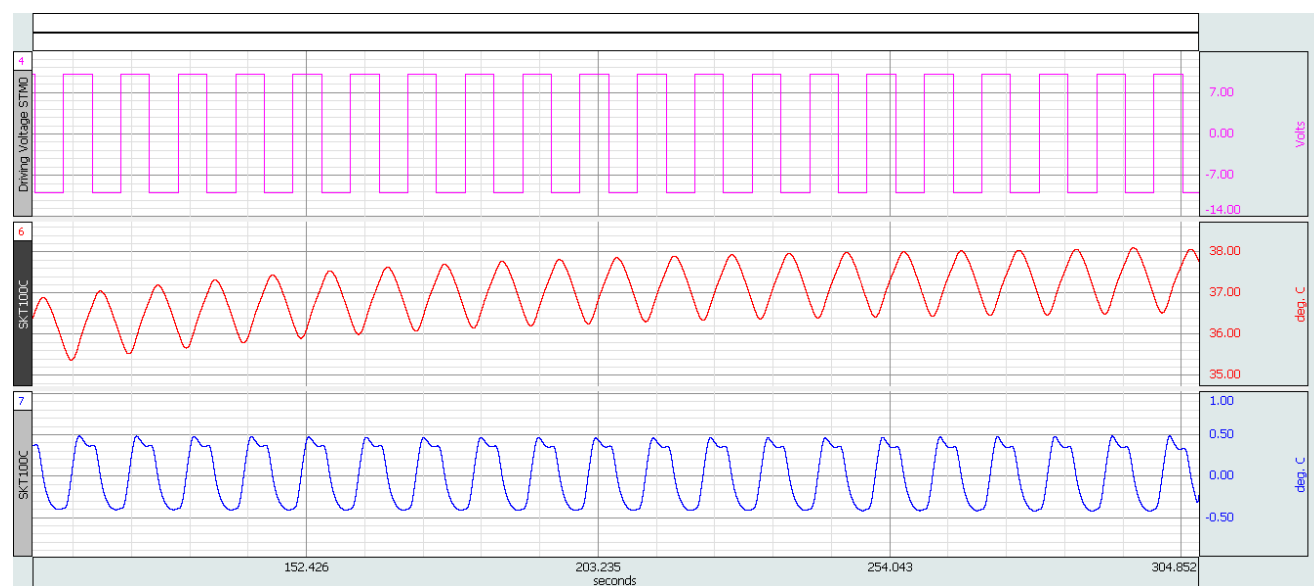

Figure 4: Loaded response (skin contact using TSD202A thermistor) of the STMTHERM to ±10 V stimulus waveform for High Temperature Range. **Stimulus cycle is 5 sec +10 V, 5 sec -10 V.**

The **average derivative of the response is ~ 0.393 (°C/sec)** and the **output temperature swing Δ = 1.64 (°C)**.

Top curve: stimulus, middle curve: response, bottom curve: derivative of response.

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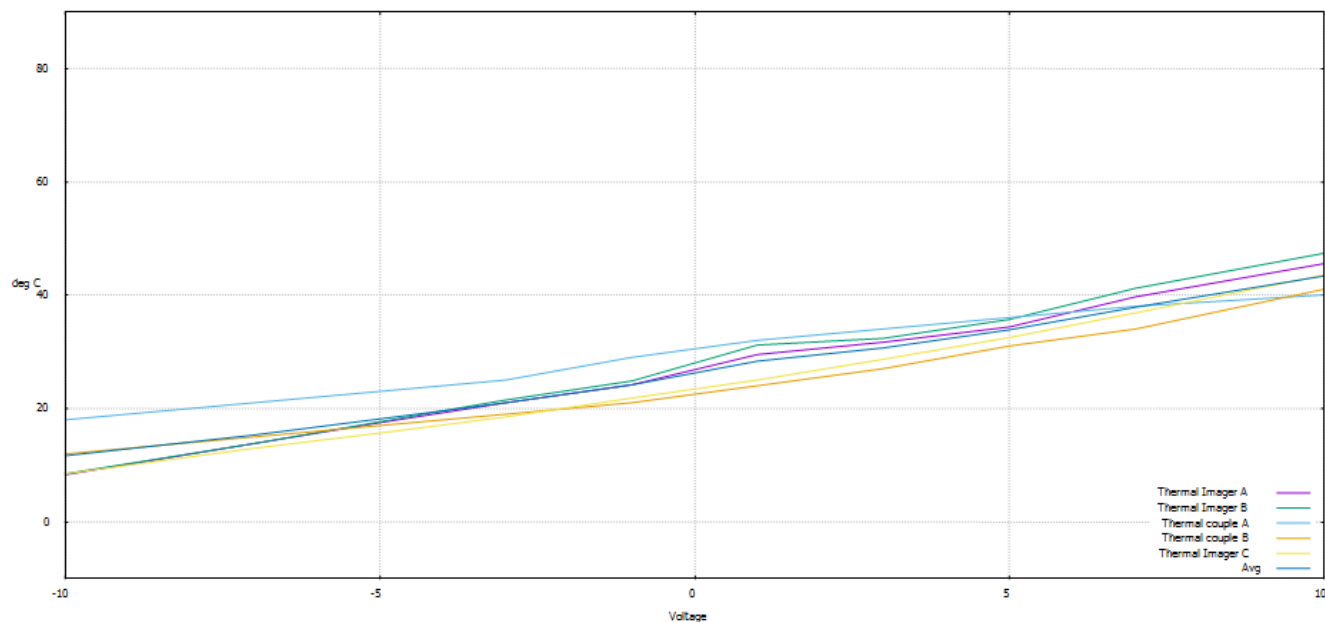
Figure 5: STMTHERM Temperature Curves (Low Temperature Range)
Measured Performance Unloaded
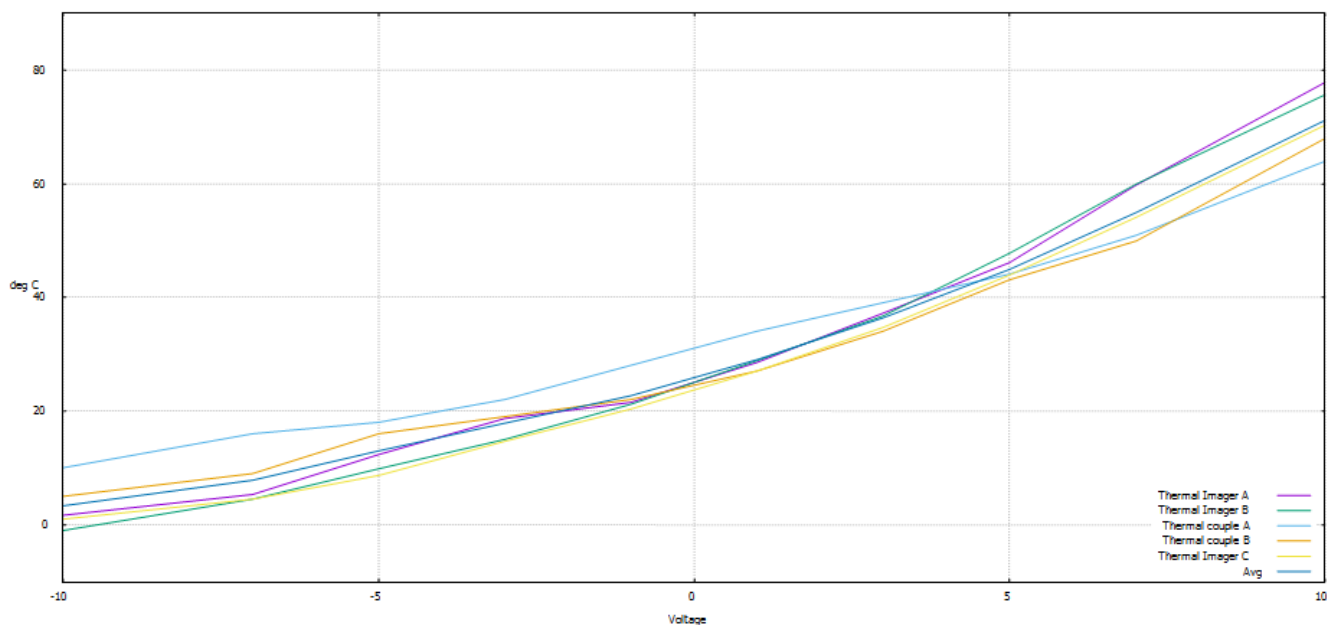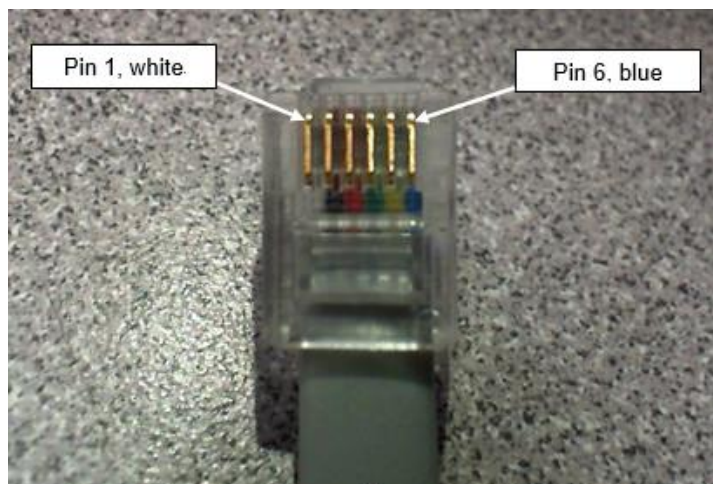

Figure 6: STMTHERM Temperature Curves (High Temperature Range)
Measured Performance Unloaded

Temperature Curve Legend

Thermal Imager A	Ryobi IR non-contact temperature probe
Thermal Imager B	FLIR IR imager
Thermocouple A	Thermocouple probe (Fluke meter) – Trial 1
Thermocouple B	Thermocouple probe (Fluke meter) – Trial 2
Thermal Imager C	OMEGA OS35 IR non-contact temperature probe

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STMTHERM RJ11 Pin-Outs

STMTHERM RJ11 connector (tab is underneath the pins):

Pin 1	White
Pin 2	Black → Signal ground
Pin 3	Red
Pin 4	Green → Vc input (±10 V control voltage range)
Pin 5	Yellow
Pin 6	Blue