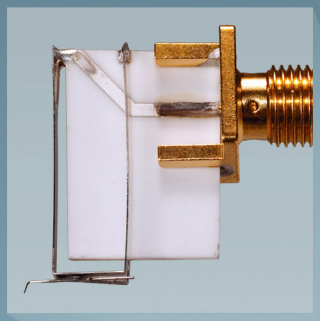
APPLICATION NOTE

Continuously Variable Temperature Probes

Now take continuously variable temperature measurements in your Lake Shore probe station

Developed in collaboration with TOYO Corporation of Japan, Lake Shore's new patented Model ZN50R-CVT probes allow you to measure through temperature sweeps without the need to lift and re-land your probes each time you adjust temperature. The probes automatically compensate for probe arm temperature expansion of thermally anchored probes, significantly improving measurement reliability and enabling measurement automation over wide temperature ranges.



- Convenient, precise measurement without probe tip movement
- Improved repeatability by elimination of repositioning errors
- Labor and time savings with uninterrupted or unattended variable temperature measuring
- Enables continuous data measurement rather than measurement intervals
- Interchangeable with standard ZN50R probes

The accuracy of your device temperature is key

Lake Shore's probe stations take thermal management to the next level, providing a measurement platform you can really trust.

Thermal probe anchoring Lake Shore probe stations include special thermal anchoring to throttle unwanted heat sources. In probe stations without comprehensive thermal anchoring, the device under test may be much warmer than the sample stage itself (and of unknown temperature). Precise device characterization requires a good understanding of the device's actual temperature. To avoid injecting unwanted heat into the sample device via the probe arms, the arms must be thermally anchored. Otherwise, reporting device temperatures based just on a sample stage sensor can lead to erroneous results.

Temperature sensors Lake Shore probes are cooled to the sample stage temperature to minimize heat load to the device under test. Lake Shore sensors on the sample stage, probe arm, and radiation shield provide an accurate thermal profile of the test environment confirming minimal impact on the actual device temperature.

Compensating probe Thermal management of the arm means that compensation must also be made at the probe to offset any arm movement during variable temperature experiments. Without a compensating probe, significant ramping of sample stage temperatures may result in contact quality changes during device measurements, possibly shifting the tip enough to leave its contact pad.

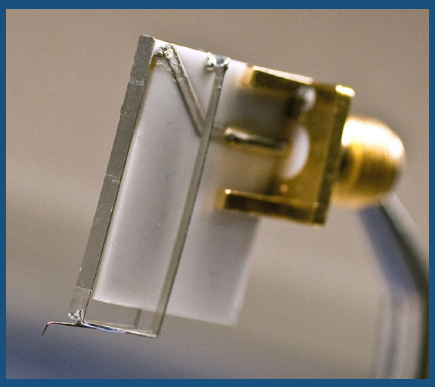


Figure 1
Lake Shore's patented CVT probes allow continuous measurements over temperature ranges without lifting and re-landing
U.S. Patent Number 8,327,727

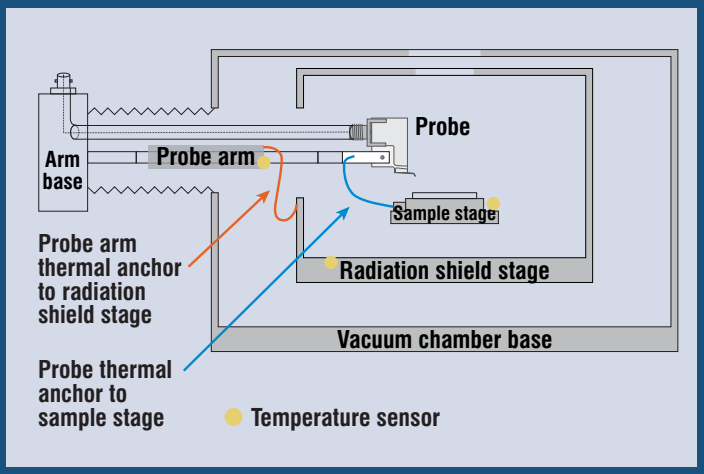


Figure 2
The thermal anchors in Lake Shore probe stations (shown above in the Model TTPX) increase sample temperature accuracy

Adjusting for probe travel while making measurements easier

With probe arms thermally anchored to the sample stage, a standard probe tip may move as much as 400 μm as the sample stage warms from 4.2 K to room temperature. This prevents you from making automated variable temperature measurements, as probes have to be lifted and re-landed for any significant temperature transition.

Stable tip position Lake Shore's patented CVT (continuously variable temperature) probe design absorbs probe arm movement caused by thermal expansion and contraction. The result is a stable probe tip landing position throughout variable temperature cycling.

Continuous measurements CVT probes allow you to perform continuous variable temperature measurements, which means faster and more automated experiments. You spend less time adjusting probe positions and more time conducting research. Retrofittable onto existing platforms, CVT probes enhance the overall functionality of your Lake Shore probe station by making many of your measurements easier and more convenient to perform, as well as enabling new measurement applications.

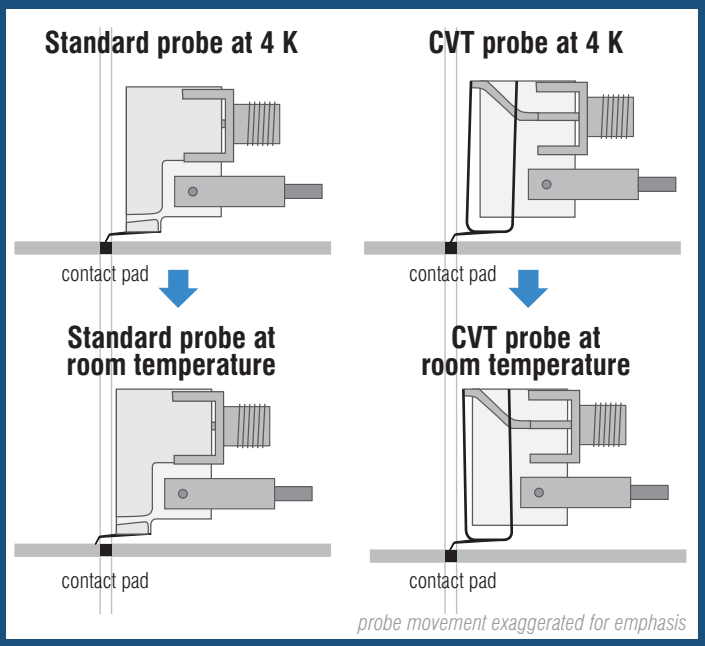


Figure 3
In a comparison between standard ZN50R probes and the new CVT probes, you can see that the standard probes would need to be repositioned before the arms expand enough to move them off the landing position. The CVT probes flex and maintain contact with the desired location.

Increased efficiency plus new measurement types

Fast and convenient The new CVT probes allow you to take continuously variable temperature probe station measurements without the inconvenience of lifting and repositioning your probes each time you make significant changes to sample stage temperature. Simply configure your measurement, program the sample stage temperature rate of change in your temperature controller and walk away.

Increase measurement functionality In addition to improved efficiency and faster results, measurement uncertainty is greatly reduced and the overall functionality of your probe station is enhanced. Measurements including Hall effect, gated Hall, gated current/voltage (IV), anomalous Hall effect (AHE), magnetoresistance (MR), deep level transient spectroscopy (DLTS), capacitance/voltage (CV), photoluminescence and Seebeck effect are much easier and more convenient to perform.

Patented CVT tip measurement results

Figure 4 demonstrates the real-world measurement performance of the CVT probes. Hall mobility versus temperature was derived, comparing the CVT probes to Lake Shore standard ZN50R probes. Measurements were taken on a Lake Shore Model CPX-VF 2.5 T vertical field superconducting magnet based probe station. The ZN50R probes were lifted during temperature changes and re-landed once the temperature settled, requiring fourteen different operator interventions. The CVT probes were landed at 20 K and left on the sample through the temperature range of 20 K to 300 K with no operator intervention. For both experiments, temperature was ramped in point-by-point mode: the setpoint was changed, temperature allowed to settle, and measurements were taken.

When landed properly and used with proper contact pads, the CVT probes virtually eliminate the inconvenience of material contraction issues due to temperature changes, expanding the functionality of your Lake Shore probe station.

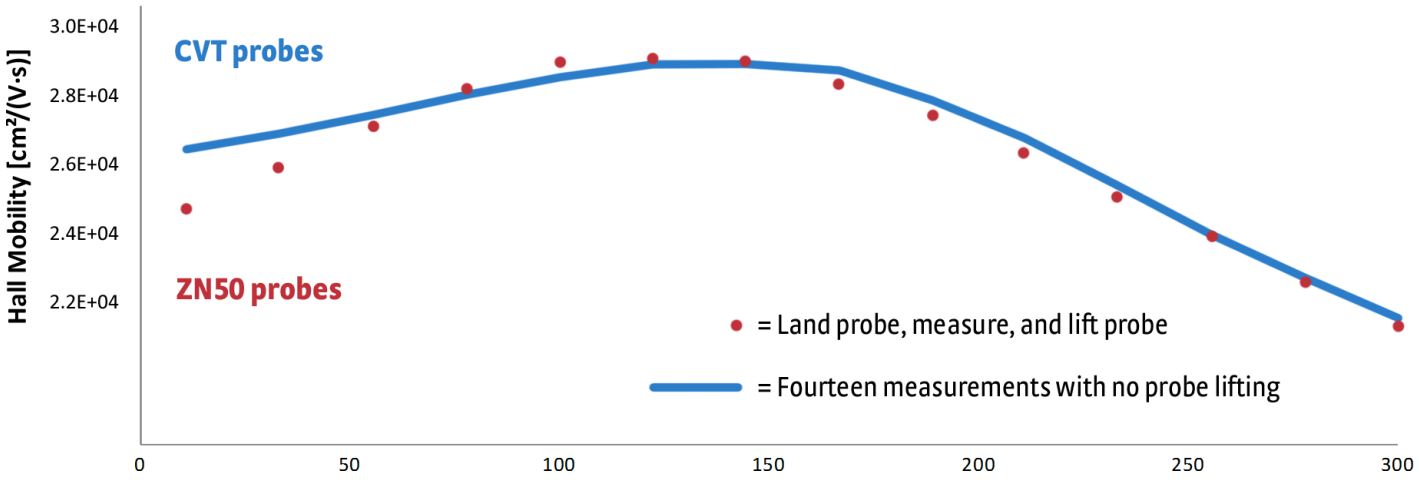


Figure 4 **With patented CVT probes you don't have to constantly lift and re-land during measurements**

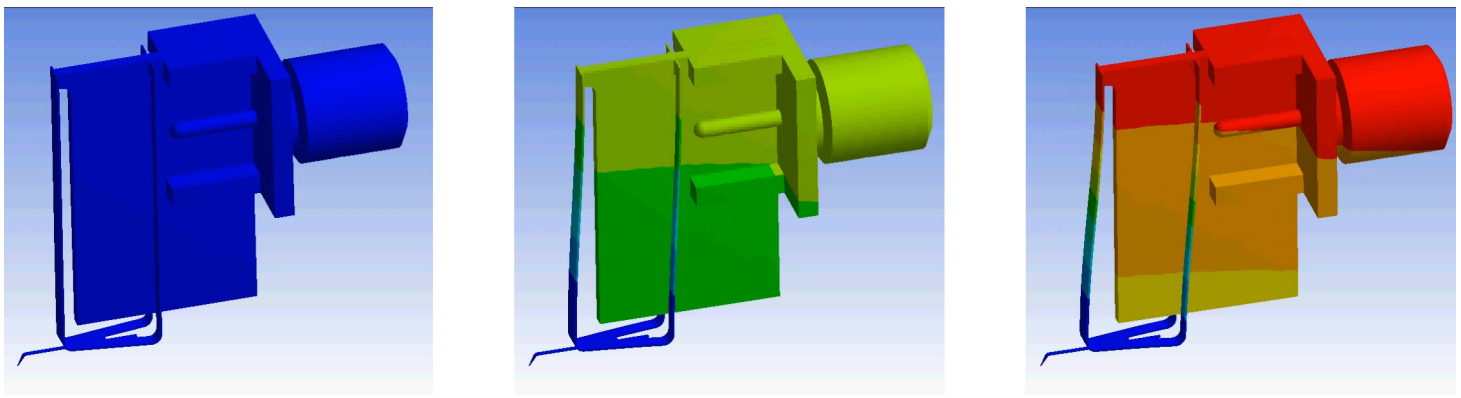




Figure 5 **Simulation of the patented probe, showing the distribution of stress as the body moves**

Model ZN50R-CVT Specifications

Operational sample stage temperature range with tip landed

	Probe station model	
	CPX, CPX-VF, CPX-HF, CRX-VF	TTPX, EMPX-HF, FWPX, CRX-6.5K, CRX-4K, CRX-EM-HF
Probe		
ZN50R-CVT-25-W	Δ400 K	Δ150 K
ZN50R-CVT-10-W	Δ200 K	Δ100 K
ZN50R-CVT-25-BECU	Δ200 K	Δ100 K

Landing pad on sample

Performance typical on gold plated copper landing pads. Softer or harder pad material may affect temperature range achieved.

Probe tip compliance

Tip motion <5 μm in the x, y and z directions for the x direction arm travel given in the table

DC/RF probe frequency range

Tungsten with cryogenic coaxial cable	0 to 50 MHz
Tungsten with semirigid coaxial cable	0 to 1 GHz*†
BeCu with cryogenic coaxial cable	0 to 50 MHz
BeCu with semirigid coaxial cable	0 to 1 GHz†

†S21 > -10 dB up to 1 GHz, except for a (-40 dB) spike between 400 MHz and 800 MHz depending on probe model and placement; S11 < -3 dB up to 1 GHz

Insulation resistance	>100 GΩ (signal to guard in a guarded measurement)

Use the Cernox® reference kit to measure accurate sample stage temperature

Good science demands known experimental conditions. In some cases sample temperature can vary widely from the set measurement temperature. The reference Cernox substrate

sensor chip mounted to a sapphire substrate with landing pads. The sensor is connected to two landing pads so that the temperature can be read using four probes. This simulates the thermal loading of a sample during probing, allowing you to accurately measure sample stage temperature.

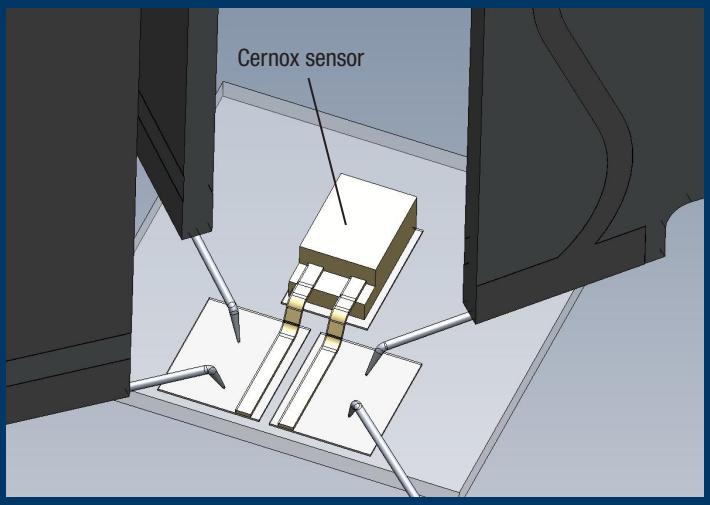


Figure 6 **Probe tips landed on the measurement pads of the Cernox reference substrate**



Lake Shore CRYOTRONICS
a DwyerOmega brand

Ordering Information

The patented Lake Shore CVT tips are easy and inexpensive to integrate into your probe station.

CVT probes can be added in place of standard probes in the field without expensive upgrades or retrofit kits.

Part number	Description
ZN50R-CVT-10-W	10 μm radius, tungsten, up to 1 GHz*
ZN50R-CVT-25-W	25 μm radius, tungsten, up to 1 GHz*
ZN50R-CVT-25-BECU	25 μm radius, beryllium copper, up to 1 GHz*
PS-REF-CRX	Reference Cernox substrate

**Maximum frequency is 50 MHz with ZN50C-G or ZN50C-T cable. Maximum frequency is 1 GHz with HMWC-XX-00K cable.*

All specifications are subject to change without notice 110926