MSCTI Questions

FAQs (MicroScale Conductivity and Temperature Instrument)

Q. What is needed to connect a MSCTI to a personal computer?

A. The MSCTI produces two analog output voltages, one proportional to conductivity and one non-linearly proportional to temperature. These voltages range from -5 Volts to +5 Volts. These can not be directly connected to a personal computer.

Connection to a personal computer requires that the customer supply an analog-to-digital converter. This is usually a card that plugs into the personal computer in some way. since the MSCTI has only 1% accuracy and can output signals only up to about 800 Hz, a fast, high resolution analog-to-digital converter isn't necessary. 12 bit conversion is acceptable.

For example, an inexpensive analog-to-digital converter card is the PCI-DAS6023 available from Measurement Computing (www.measurementcomputing.com). There are many other sources of similar converters.

Q. Looking at some of the tests we have done with the probe, we sometimes (not always) see a large jump in the voltage that happens only once. This can be a change in reading of the order of 0.5V higher up in the voltage range (eg. from around 2.3 to around 2.8 V) while the probe is submerged in a sample at room temperature that is not undergoing any rapid changes in temperature or salinity. Before and after the jump, the readings were quite stable.

A. Please examine the sensor carefully. As the temperature of water gradually warms the air dissolved in it tends to come out of solution and grow bubbles on any available surface. If bubbles grow on the sensor tip then it appears to the sensor as though a fresh water zone is gradually forming. This would show up as a gentle negative trend in output voltage which you might not notice. When the bubble finally bubbles off you'll see a positive jump as the conductivity around the probe tip returns to the correct value. Just a guess.

Another thing to watch out for: The probe shaft must be immersed into the solution to provide electrical grounding, or electrical grounding must be provided in some other manner. By 'electrical grounding' I mean that an electrical connection must exist between the solution and either BNC shell on the back of the MSCTI. Provide one and only one. You may see 60 Hz in the data if you provide more than one ground, and instability in the measured conductivity if you provide none.

Q. When we are keeping the MSCTI in solution, if the overrange lamp is on, how do we know whether it is because of conductivity overrange or temperature overrange.

A. Measure the C and T outputs. The light will correspond to the output that is greater than 4.5 volts.

Q. What exactly the phase error indicates? In which situations, it will be on?

Phase error indicates large phase shifts in the electrical current flowing through the C sensor electrodes. If the C sensor electrodes become contaminated (usually via oil films on the water surface) then this light will come on. It tends to come on as more current flows through the C sensor and therefore the C voltage output is higher. It is completely normal for the phase error light to be on when the voltage output of the conductivity channel is greater than +4 Volts. If the phase error light is on and the C output is less than 0 volts (the output valid range is -5 to +5 volts) then something is wrong with the C sensor. If the phase error light is on and the C output voltage is 0<cout<+4 then the sensor is marginal but can be used.

Q. How the space response (given in specifications) helps in finding out the accurate conductivity of the measuring solution? Like for temperature specifications, can you give the time response (in seconds) of the MSCTI in conductivity measurement?

T sensors essentially average the T signal in time. They have a time response. C sensors respond nearly instantly in time but essentially average the conductivity nearby the sensor. This is a spatial response.

The C sensor has about 4 cycles/cm spatial response (the point where averaging reduces the rms measurement by 1/2 power). The C electronics has a time response of about 800 Hz. If you wish to convert spatial response to time response then multiply by fluid velocity. For example if the fluid passes the C sensor at 1 meter/second, the C sensor's effective time response is:

Time response (cycles/second) = space response (cycles/cm) * 100 cm/m * 1 m/sec = 400 cycles/second. Since 400 cycles/second < 800 cycles/second electronics response the spatial response of the C sensor establishes the overall response of the system.

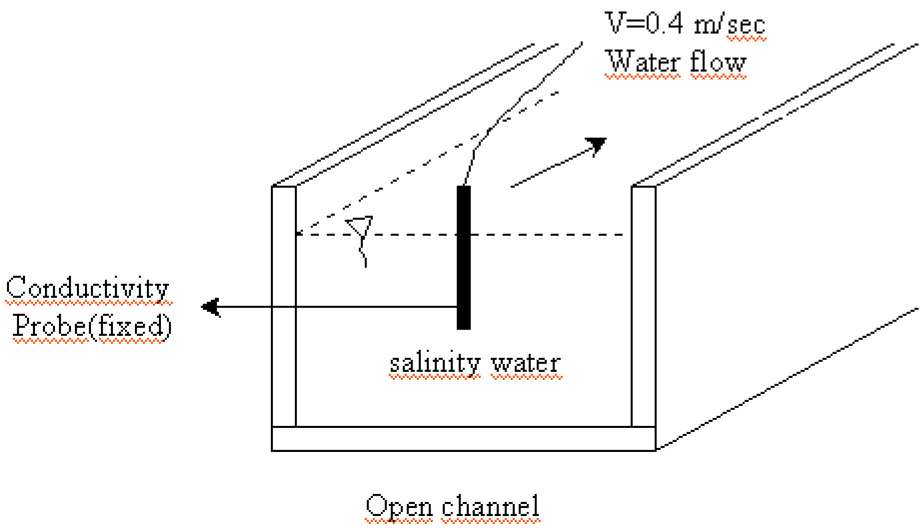
If the fluid flows at 10 meter/second then the C sensor response is 4000 cycles/second but unfortunately the electronics doesn't respond this fast so the overall system response is 800 cycles/second due to the electronics limitation.

So, within the bandwidth of the electronics (800 Hz), the C sensor time response depends upon how quickly you move new fluid into it's averaging volume.

Note that 10 meter/second fluid velocity will surely break the sensor. 1 meter/second is the maximum fluid velocity and even this may break some sensors depending on manufacturing variation. Most customers use fluid velocities that are much slower.

If you would like more detailed information please read Chapter 5 of Mike's Dissertation which can be found on PME's website.

Q. In our experiment we want to measure conductivity in water flow at 6 points at the same time. We have an open channel to do this experiment. We want to get conductivity values changing by time. Our system is below.



The MSCTI can be used in the way that you show. This is a common situation. 0.4 m/s is not a problem. We can provide the sensor in a straight shaft such as you show in the drawing, or provide it with a 90 degree bend (shafts.htm) so that the sensor can be placed looking into the flow. The MSCTI is designed to measure salty water which is a normal condition in a salt-stratified experiment. Please review our site to insure that you will have sufficient salt in the water for the MSCTI to operate properly. Also, there are many references on the site that contain examples of experiments where the MSCTI has been used. Please have a look at these.

MSCTI measures C and T at one point only. Since the MSCTI is expensive, people normally place the sensor on a movable platform and move the sensor from point to point. This provides multi-point measurements, but at different times. If you absolutely need to measure C at different points but at exactly the same time, then you will need to purchase a MSCTI for each point where you require a measurement.

Q. I am hooking the probe up to a stepper motor so that I can control the motor via a PC. I also need to be able to take N subsequent readings from the probe as it traverses through a depth of fluid. I have read the instruction manual and am not sure of how to go about making sure that the data from the probe can be stored on a PC at each step. Can you drop me any hints as to how to go about this?

First topic is the stepper motor traverse. Be careful that this device doesn't whip the C sensor strongly. This can break the sensor. Arrange it to step slowly and clamp something heavy to the sensor shaft as nearby the sensor as the fluid dynamics considerations will allow. Be prepared to break a sensor if you do not.

As far as getting the data, the MSCTI will output continuous values. Your task is to arrange to collect these values at each stepper motor station. You'll need a method for recording these analog values. These days the normal way is to obtain an A/D converter card that plugs into your PC. Suggest at least 12 bits with a +/-5 volt input range. 16 bits are a little better, but not as much as you might expect given the 1 mV RMS noise (mostly unfiltered carrier) from the MSCTI. 16 bit cards here in the US are in the $500 range from www.computerboards.com. I don't know what you can get locally. Next, you'll need the stepper motor controller and circuits. Hopefully these are also a card within your computer. Last, a program to coordinate stepper motor and A/D. One program, although expensive, is Labtech Notebook from National Instruments. You can find it at www.labtech.com. Computerboards supplies simple software to allow programs written in various languages to control the A/D.

I suspect that you already have the stepper motor. The A/D should be easy as well. Just buy an acceptable one from some supplier. To this point things are just plugged in. The actual implementation of your specific mission is probably not available as an already-written piece of software. Labtech Notebook will do a fine job with the A/D but I don't know if it will easily control the stepper motor. If I had your task, then I'd just use the simple A/D drivers that come with the A/D board, figure out how to control the stepper motor, and then write a custom C-language program to implement the mission. If programming isn't your thing, then I'll bet you can find someone at the university who can do the job. It is not too difficult.

Q. I would like to measure conductivity between rods or fibers in a liquid flow.

Time response for the MSCTI is very fast, roughly 800 Hz. This is limited by the electronics within the instrument. In most experiments, where fluid flow is slower than 1 meter/second time response of the MSCTI is not a limiting factor.

The MSCTI resolves features of approximately 1 mm in size. The actual sensing is described by a complex weighted average of the conductivities within a small volume nearby the sensor, with the weighting function declining to 0 at large distance from the sensor. The "1 mm" distance captures most, but not all, of the sensitive volume.

If your rods or fibers are closer together than a few mm, then the MSCTI sensor will include their presence in its average. If the positions are fixed relative to the sensor, then you can calibrate the whole arrangement and still make useful measurements. To do this you would position the sensor at a fixed point relative to the rods/fibers, then pass different conductivity water through, recording the MSCTI output for each conductivity. If the sensor position relative to the rods/fibers changes, then a new calibration would be required. If the sensor position relative to the rods/fibers cannot be maintained at a fixed point, then the MSCTI output will vary depending upon location of the rods/fibers and also upon the conductivity of the water.

In addition, the MSCTI output will change slightly with time even if water conductivity and rod/fiber position does not. This effect is less than 1% per 8 hours operation and will also depend upon whether the sensor is continuously immersed in water or if it is exposed to air for periods. The presence of oil or other fouling materials in the water will be detrimental to sensor operation.

The sensor is fragile and must not contact the rods/fibers. It can be damaged if contact occurs.

Q. I want to use in my experiment with PIV so the solution has to be mixed with particles of small glass, with aluminum on the outer shell size 20 to 50 micron. Can the probe work fine in that environment?

Sorry, I don't know of anyone who has actually tried it. The smaller conductivity electrodes are close to 50um so the size of the particles is significant. I can think of several events that may occur The conductivity sensor may sense the presence of the particles. I don't know what the aluminum coating will do, but the particle may represent a conductive patch of water or a non-conductive one depending upon the conductance of the aluminum.

The conductivity sensor may be slightly damaged by particle impacts resulting in calibration shifts, but an otherwise operable sensor. This slight damage might be movement of the sensors' electrodes by impact, or abrasion of the sensor electrode's platinum coating. The conductivity sensor may be damaged in a major way by particle impacts. I don't know what will actually happen. A lot will depend upon the velocity of the flow.

Q. I wish to purchase a probe for determining salinity of water in small laboratory tanks. I would envisage a probe with a measuring volume of approximately 1 cm^3 or smaller. We are looking at tanks with salinity variations of around 5 parts/thousand so that very high precision is not essential. Ideally the probe would be temperature compensating, or measuring, so that salinity can be determined or read directly.

This system can be used to compute salinity and definitely has a measurement volume that is much less than 1 cc. Beware of the drift specification for conductivity. The spec is 1% of the measured conductivity over 8 hours time. It really does drift, although experience has shown the figure is more like 1/2% over 24 hours. At constant temperature, conductivity translates more-or-less directly to salinity so if you are at say 35 ppt you can expect about .35 ppt drift in a day's time. Typically the temperature measurement is fairly stable, but you need to include it in your error budget if you expect thermal variation. Customers must provide calibration of the MSCTI because of the conductivity sensor drift although we can provide calibration of the temperature channel by special request at additional charge.

Q. have just tried the MSCTI as you suggested. I put the sensor into water and record a few hundred measurements: the variations between measurements were about 30-40 mV (maximum range). Is it ok ?

Sorry, I can't answer this question. Conductivity systems make errors as a % of the conductivity they are measuring. 30 mV with MSCTI output of -3 Volts is much worse than 30 mV with MSCTI output of +3 Volts.

Variations you see can come from temperature. Expect temperature to contribute about 2% per degree C of variation. This is to say if you measure a conductivity of 30 mS/cm and the temperature increases 1 degree C without the salt content changing, then you'll measure 30 * 1.02 mS/cm.

When expressing 30 mV measured a V output Volts, find percent by

percent change = 100% * (30 mV/(V+5))

since MSCTI puts out -5 Volts at zero conductivity.

Q. How many times do I have to repeat the T and C sensors calibration? For examples: after 1 h, after 24 h, after a week?

MSCTI should hold about 1% accuracy for 8 hours. It will actually do better, more than 24 hours for 1%. However sub-1% errors are random and occur on hourly time scales. It tends to drift more in the first 1/2 hour after being turned on. A convenient calibration interval is daily. More frequent cals probably won't get you much better than 1%. Less frequent cals will sacrifice some accuracy. Experiment a little with calibrations.

Q. When I repeat a calibration, but the ranges of temperature and conductivity are the same, can I leave the T and C gains in the previous position or have I to turn them again?

Always leave T set to the same position as I set it. There is a little yellow bit of tape over the hole to remind you not to change it. If you change it, then nothing bad happens but you'll lose the temperature cal I did. The temperature sensor will maintain its calibration over long periods. (months and months).

You should pick a MSCTI conductivity potentiometer setting that allows +4 Volt output at the highest C (highest concentration at highest temperature) you expect in you experiment. This gives you a 1 Volt overhead in case you've made a mistake in guessing highest C. Then leave the MSCTI conductivity potentiometer set for the duration.

Q. What is the response time for the conductivity sensor? We are traversing the sensor through a sharply interface between fresh and salt water and are having difficulty picking up the exact position of the interface. I am presently trying to slow the traversing speed and increasing the sampling frequency.

The conductivity microsensor has about 1 mm spatial resolution. I like to think of it as a sphere of 1 mm diameter. You can test spatial resolution by simply lifting the probe out of the water and observing the conductivity reading as the C sensor tip exits the surface. Another way, although more dangerous to the sensor, is to bring the sensor close to the wall of a beaker. In both cases, the wall or air represents a conductivity discontinuity.

C sensors report a volume weighted average of the conductivity in the vicinity of the sensor. The weighting function goes to zero as distance from the sensor grows. The actual spatial resolution is complex.

Travel rate isn't critical in C spatial resolution. Conductivity sensors (and the MSCTI electronics - 800 Hz) respond quite quickly to time-related events. When expressed in space, you should see the same conductivity field independent of how quickly you traverse it - assuming of course that you sample the MSCTI output quickly enough to make the feature visible at rapid travel rates. If you travel quickly enough, then you can present conductivity fields more quickly than the MSCTI electronics can respond, but you'll have to travel faster than 1 meter/second to do this. Otherwise you are limited by the C sensor spatial averaging.

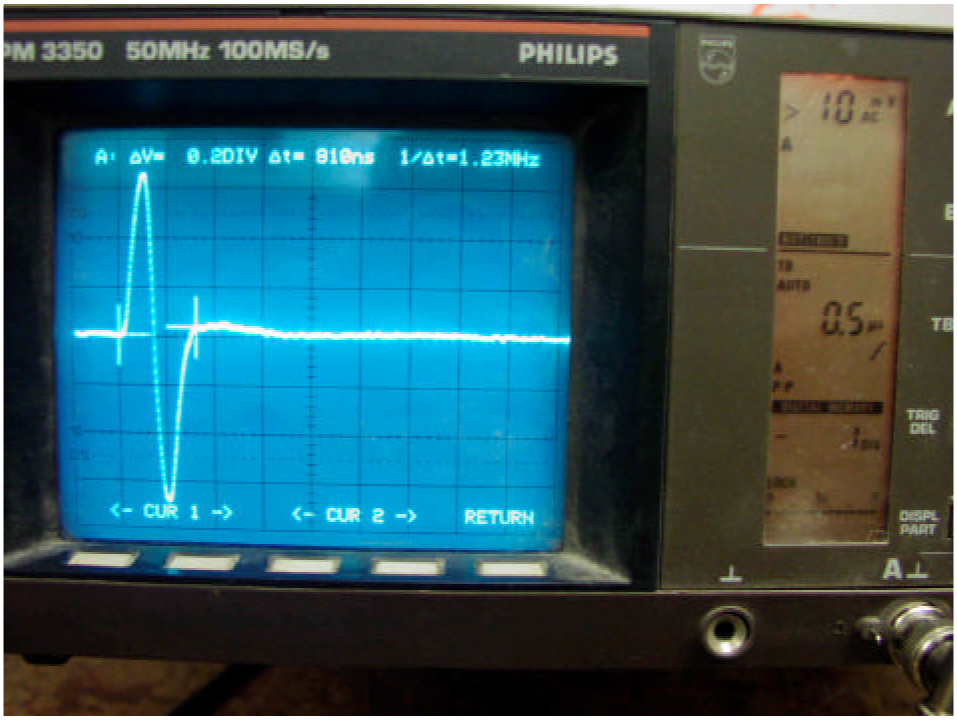
Q: What happens if the sensor is operated in air?

Salt won't crystallize on the sensor if it is immersed so you are OK there. However, if the sensor is lifted into the air then crystallization can occur as the water evaporates. Crystals break up the black plating on the sensor electrodes. Nothing really bad happens, but the calibration can shift a little (< 1%). If you lift the sensor into the air, then take the time to squirt it with distilled water all over to rinse as much salt water away as possible. Also the electronics should be off when the sensor is in air. If the electronics are on as the sensor dries (and therefore doesn't conduct anymore) the electronics can go a little crazy and apply large voltages to the sensor electrodes. Again, nothing really bad happens but the calibration can drift a little.

<u>Questions/comments dealing with the MSCTI noise...</u>

Q. Why do I observe a very narrow pulse of approximately 20 mV amplitude and occurring at 50 uSec intervals on MSCTI C and T output?

This pulse is unintended in MSCTI output and results from activity of internal rectifier circuitry within the MSCTI. If it is a problem it should be filtered out by providing an R-C filter between MSCTI output and customer instrumentation.



User #1 comment: I think all that needs to be said about the 20kHz spikes (distinct from the background 1-2 mV noise) is that a 60mV (p-p) 1 microsecond pulse occurring at a 20kHz rate is normal and that if it interferes with measurements, the user should low pass filter it out, setting the cutoff at ~1kHz. This is only an issue for those connecting your MSCTI to an oscilloscope or A/D board since most voltmeters will automatically "filter out" the pulse through averaging.

Electronic noise of the MSCTI is roughly 2 mV RMS out of a -5 to 5 volt range. This is roughly 12 bits. The instrument bandwidth is 800 Hz. Lower noise can be obtained by band-limiting the instrument to a lower bandwidth. I suggest that you contact ComputerBoards, Inc if you want a low cost a/d. They are located in Mansfield MA, tel: 508-621-1123, fax: 508-621-1094. I seem to remember that they have an inexpensive 16-bit board. I think that you can get 12-bit boards from them for under USD$250.00. I have one of their 12-bit boards.

User #2 question: We are using the probe in a stratified water tank and noticed that either or both probes (temperature and conductivity) are occasionally subject to high levels of noise. The noise is at high frequency (about 400kHz) with a peak-to-peak amplitude of about 1.4 volts. Of course we can filter this out, but the DC level also changes and the occurrence of the noise is random. It can be set off by turning on/off the bridge, by passing through an air/water interface, or by turning on/off some other remote equipment. As far as grounding is concerned we opted for grounding the water via the probe support and all ground connections go to a common node. Would you have any idea as to the origin of this noise and perhaps how to prevent it?

A. High amplitude 400 kHz is definitely not a normal output. I'm not surprised that it causes a DC offset. This will create calibration errors. What are the MSCTI outputs connected to? How long are the cables that make this connection? What is the approximate conductivity of the solution that you are using?

A. First thing to try is to put the sensor in a beaker of salty water, being sure that the probe shaft is immersed. Connect an oscilloscope directly to the instrument output and see if you can see the 400 kHz. If you don't see it, then it has something to do with your experiment.

User #2 comment: We tried out Michael's suggestions and found out that indeed our long cables created the high noise levels. We had tested them initially, but hadn't observed noise at that time. It seems that about 5m is the maximum length before the noise occurs. Thanks for helping us resolve our recent noise problems.