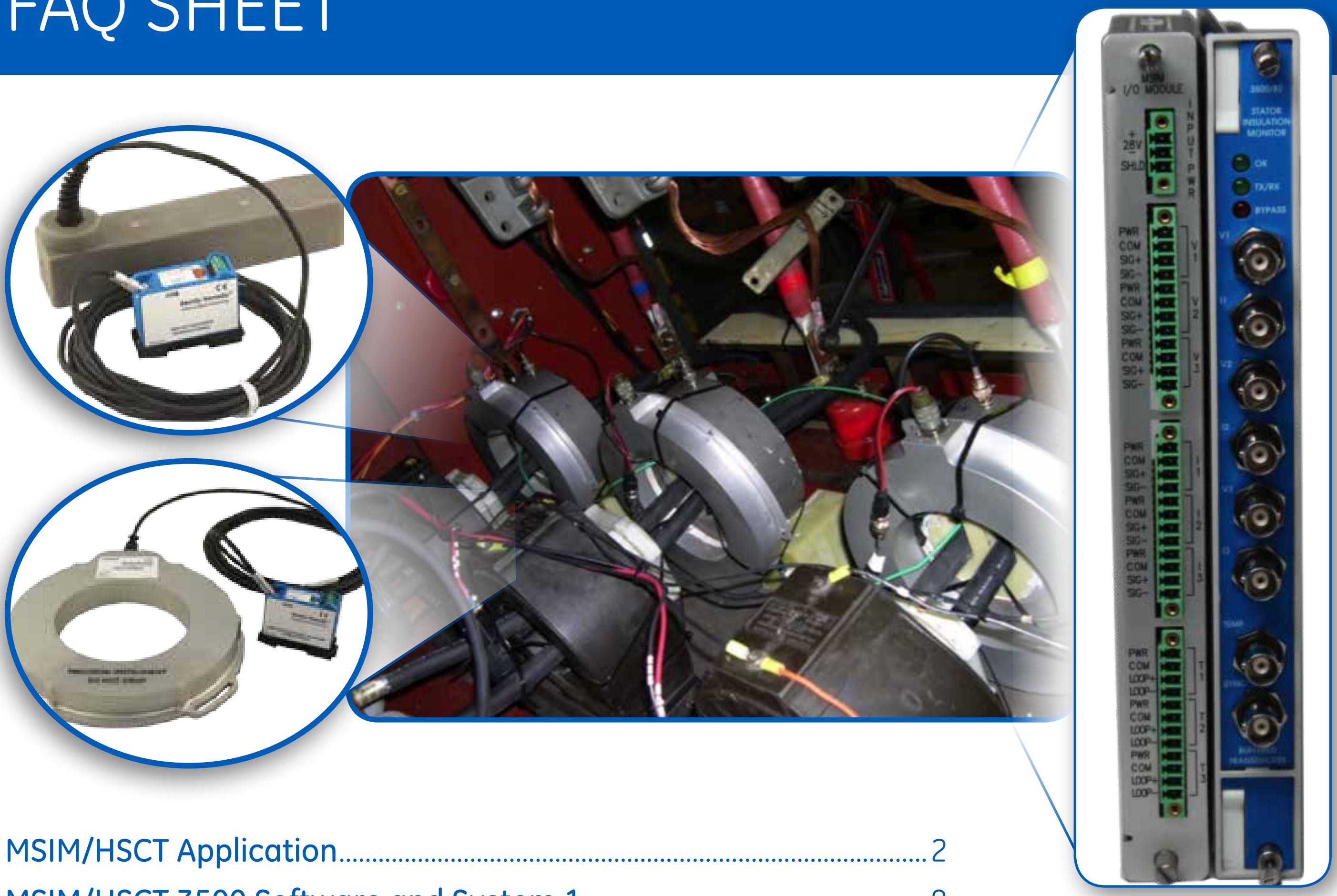
GE Oil & Gas

MSIM and HSCT

FAQ SHEET



MSIM/HSCT APPLICATION

What is MSIM?

MSIM (Motor Stator Insulation Monitor) is a revolutionary system developed to take an online measurement of motor leakage current and Capacitance and Dissipation Factor (C&DF) on large, 3-phase, AC, Induction, and Synchronous motors. This measurement is new to industry and for the first time allows the motor insulation condition to be reliably measured while the motor is in service, running at speed, and at temperature, under load.

Previously industry relied heavily on offline motor testing which required the motor (and the process) to be shutdown and otherwise taken offline. Consequently this testing is not performed frequently enough to be useful to motor or process operators (polling indicates an average of 3-6 year interval can be typical). Additonally some of the offline tests that characterize the motor insulation which are performed at low current, high voltage conditions, are known to damage the motor insulation.

Industry has also relied on limited online testing using Partial Discharge (PD) technology. This technology also has disadvantages in that the results often require a highly trained engineer or PhD to effectively interpret. Often when an expert has interpreted the results and predict a motor failure, the suspect motor has continued to run for years without problems. Clearly industry needs a better tool.

MSIM Features:

Online measurement – no need to shutdown the motor or process.

Direct measurement – Direct physical measurement, no need for algorithms or expert interpretation of complex data.

Industry Accepted Measurements - C&DF and leakage current compare to traditional offline testing parameters

More Realistic Measurement Conditions – Insulation measurements are made online, at temperature which is a much more realistic measurement to make compared to offline testing.

No motor damage – the measurement is completely passive in nature using voltage and high sensitivity current measurements.

Early warning of insulation failure – Ability to detect insulation failure weeks or months before the failure occurs.

Easy Integration – Compatible with Bently Nevada 3500 Machinery Protection System

Software compatible – Compatible with Bently Nevada System 1 software

Easy Alarming – Alert and Danger alarming available in 3500 and System 1 software

DCS and plant system compatible – Compatible with DCS and plant systems using Modbus and OPC protocols.

Hazardous Area Approvals – CSA Zone 2, ATEX/IECEx Zone 2

What are the Voltage, Current, or Horsepower Limits for MSIM?

MSIM is currently compatible with motors up to 7.5kV and 1,000 amps. Assuming an 85% power factor the system is compatible with motors up to about 10.4MW (14,000hp) nameplate power.

Is MSIM compatible with Variable Frequency Drives (VFD) or Solid-state drives?

MSIM is not currently compatible with VFD-driven motors or solid-state drives of any kind. The motor must be fixed-speed or “line-driven”. Note: varying loads are ok, things such as variable speed transmissions, clutches, etc. are compatible as long as the motor is fixed-speed.

Is MSIM compatible with Soft-Starters?

In most cases the answer is yes. However any soft-starter application should be reviewed by Bently Nevada before specifying the MSIM system.

Is MSIM compatible with Generators?

In theory yes, however most large generators will violate the current and voltage limits of 1,000 amps and 7.5kV of the current product.

Is the MSIM System Compatible with Synchronous or Induction Motors?

The MSIM system is compatible with both synchronous and induction motors, provided that the motor meets the voltage and current requirements of the MSIM product. MSIM is not compatible with VFDs or solid-state drive technology.

Is the MSIM System Compatible with DC Motors?

No, the MSIM system is primarily intended for Induction or Synchronous motors.

I Already Have Motor Protection CTs, Why do I Need HSCT or MSIM?

There are generally two types of protection current transformers (CTs) found on large motors used in industry. Overload protection CTs and differential protection CTs.

Overload protection CTs are very common and are almost always already installed in large motors to protect the motor from over-current, and subsequent damage. The trip current is typically chosen to be slightly higher than the Full Load Amps (FLA) of the motor. These overload protection CTs are tied to a shutdown system that will trip the motor off line in the event of an over current event. Overload protection CTs are regular type CTs (not the differential type) designed to measure line currents only and are not effective at protection against ground wall (line-to-ground) motor failures. These CTs can be used on 3-lead motors or 6-lead motors (Wye-connected).

Differential protection CTs are installed on larger, higher voltage, more critical motors. The differential protection CTs are installed on Wye-connected motors where 6-leads are available and are designed to protect against ground wall (line-to-ground) motor failures. 6-lead motor termination is generally specified where equipment owners/operators want the additional protection against ground wall insulation failures that differential CTs offer.

Protection CTs in general are low-cost and usually perform their “protection” job very well. The problem is that these are the last line of defense when a motor has already failed. In the case of differential protection CTs, they protect people and equipment from collateral damage that may occur from operating a motor with an open line to ground, such as arcing, fires, explosions, etc. They are typically tied to a shutdown system (like GE MultiLin) that will shut the motor down as a safety precaution. Typically after this has happened as a result of stator insulation problems, the process must remain down (unless spared) and the motor must be re-wound or replaced. A stator insulation failure of this nature gives no warning, no measureable increase in temperature, no vibration, and no noise, nothing to indicate a problem until it is too late.

The HSCT on the other hand, is a high-sensitivity instrument that is able to trend leakage current online, something that until now has never before been accomplished outside of a laboratory on an industrial machine. With this trend and appropriate alarming, industrial operators can realize weeks or months of early warning that a failure is imminent. With this knowledge the plant operations can inform management as to the likely availability of the equipment/process, and make effective plans and preparations so that the machine repair or replacement can take place in a safe, controlled manner.

What Type of Motor Faults Can Be Detected with The MSIM System?

The MSIM system is capable of early detection of phase-to-earth, sometime referred to as “phase-to-ground” faults (insulation failures to earth ground). The MSIM system is not capable of detecting phase-to-phase faults (insulation failures between one phase to another), however phase-to-phase faults are not as catastrophic as phase-to-earth faults and phase-to-phase faults very often become phase-to-earth faults that are detectable by the MSIM system. Additionally, motor operations may continue for quite some time with a phase-to-phase fault. A motor with a phase-to-ground fault must be shut down and removed from service immediately. The early detection of phase-to-ground faults is the value that MSIM provides.

Can the MSIM 3500/82 Be Used for Protection?

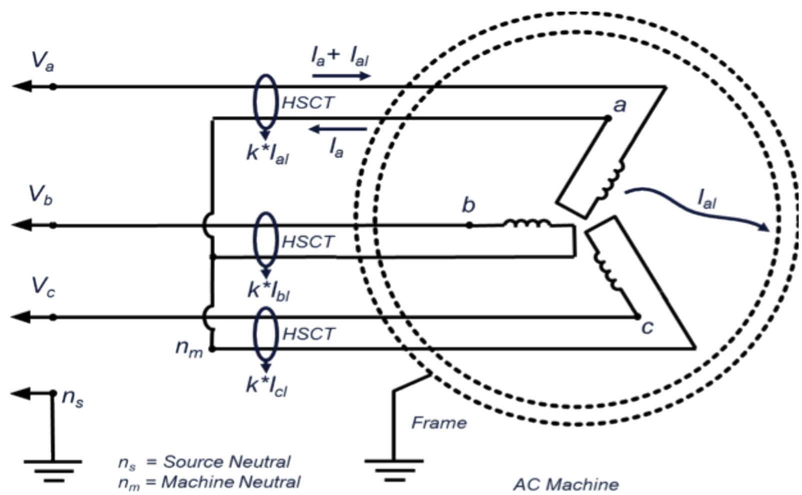
No. Although the 3500/82 can drive relays on the 3500/33 and /32 relay cards, it is recommended to only use these for annunciation.

What Type of Motor Wiring is Compatible with MSIM and HSCT?

MSIM is compatible with externally wye-connected motors only. Most large, critical, industrial motors are Wye-connected. Very simply each phase of the 3-phase motor must have all phase leads AND all neutral leads available and the HSCT must encircle both for each phase (see diagram below for an example of HSCT installed on an externally wye-connected motor).

Note: *some installations will use 1, 2, or 3 wires for each phase. Regardless of how many wires are used for each phase, all phase wires and neutral wires for each phase must pass through the HSCT for proper installation. The reason many installations use multiple wires is that it is more cost-effective and convenient to run 2 or 3 smaller conductors for the same phase as opposed to 1 very large wire. Smaller wires are also much easier to handle and install.*

MSIM is not compatible with motors where the neutrals are terminated inside the motor. Many small motors are connected in this way.



Occasionally very large motors (and generators) that are externally-wye connected will have separate motor connection boxes, one for the three-phase power coming from the supply, and a separate one for the three neutral lines leaving the motor. In a case like this HSCT cannot be used because the phase and neutral leads are located in separate junction boxes and are thus not available to be routed through a single HSCT sensor.

What About Other Online Technologies Such as Partial Discharge Analysis (PDA)?

Partial Discharge Analysis has been around for years and has seen acceptance in industry for high voltage, critical applications, especially when a plant wants to monitor a large high-voltage distribution system. However, the partial discharge phenomena is only a reliable indicator largely at motor/system voltages of 6.6kV and higher. Below this the partial discharge phenomena falls off, along with the effectiveness of PDA (which is based on the phenomena).

The second (and larger) problem with PDA lies in the interpretation of the results. It is recognized by some large oil & gas companies that have invested heavily in PDA, that a PDA expert (or experts like PhDs) are needed to interpret the results of the data. Even when the investment is made in PDA equipment and experts, the results are still not reliable enough to satisfy the needs of the industry. Often a PDA expert has indicated that a failure is imminent for several plant assets, only to have those assets run continually for years with no problem.

In this case MSIM gives what is needed, a direct measurement of a single variable that is a direct indicator of insulation health, leakage current (in addition to capacitance and dissipation factor). This variable can be setup in a system (in many cases an already existing system) such as 3500 and System 1 to alarm on changes (increases) in leakage current to notify plant operators of impending problems, no "expert" needed.

What About Offline Motor Testing? How Does it Compare to MSIM and HSCT?

Offline motor testing has been the staple for motor testing for many years and has some advantages.

1. Offline motor testing is well-accepted and is typically portable. A single portable test unit can be used to test many motors.

2. It also offers true insulation condition measurements such as Capacitance and Dissipation Factor.

3. Some offline test units, in addition to insulation tests, can perform other helpful tests of the motor.

There are also some disadvantages.

1. Offline testing (as the name implies) must be performed while the motor is offline and out of service. Many customers in power generation, oil & gas, and other markets must run their motors for 3, 4, 5 years or more without shutting down, essentially requiring them to "run blind" with respect to the condition of their motor insulation. As mentioned previously a pending insulation failure gives no warning, no rise in temperature, no change in vibration, nothing to indicate the motor insulation will fail.

2. Several of the offline tests are high voltage, low current tests. High voltage tends to tax (or damage) the insulation. This means that the testing is invasive and when the motor insulation fails, the offline testing, over time, likely contributed to the failure. But motor owner/operators have been forced to use this testing as it was often their only effective alternative to track the condition of the motor insulation.

3. The offline insulation testing occurs as previously stated while the motor is offline. Hence the insulation testing occurs at ambient temperature, no load (or only simulated load). Since MSIM is an online test that occurs at load, at temperature, it is a superior test.

   For a human being this would be like performing a heart stress-test while the person is at rest. As we know, a better method is to perform a heart stress-test while the person is engaged in an activity like jogging as this gives the true heart performance under stress.

MSIM and HSCT address all of these disadvantages.

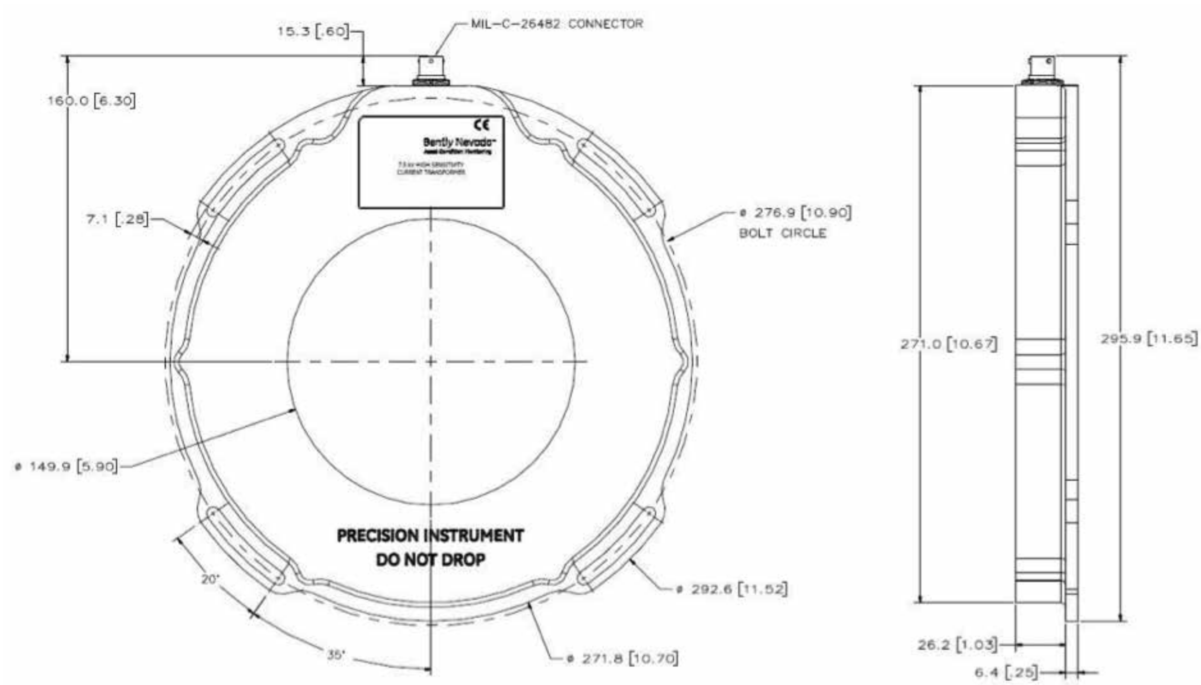
What Hazardous Areas Will the HSCT, HVS, and Interface Modules be Approved For?

CSA Zone 2 / Class I, Div 2 for North America

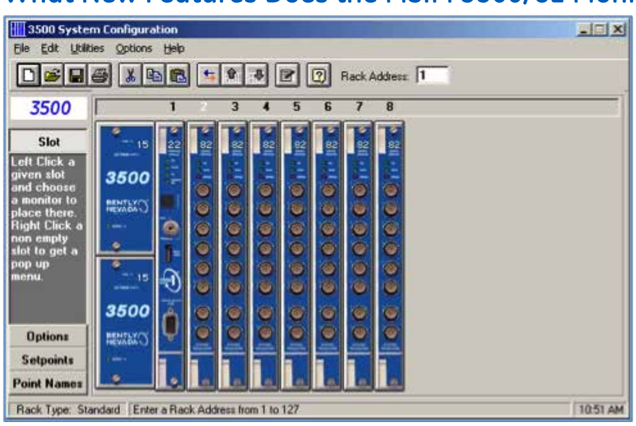
ATEX / IECEx Zone 2 for Europe and international (those that accept IEC)

Is there a lower-limit to the size of motors that MSIM is compatible with?

No, there is no lower-limit to the size of motor that MSIM is compatible with. However the lower voltage limit of the HVS sensor is currently 2,000 volts. Additionally, some lower voltage motors do not have enough space in the motor connection box to allow for HSCT and HVS installation. For reference each HSCT is roughly ϕ11.65 in (ϕ 269mm). Each HVS is roughly 10.5 in (267mm) long and 2in (50mm) square (see outline drawing below).



What New Features Does the MSIM 3500/82 Monitor Have?



The 3500/82 Monitor is the most advanced 3500 monitor ever created. Some of the monitor features:

1. First 3500 monitor with onboard memory. The 3500/82 has two 1 gigabit flash modules. One module is used to store historical data, and the other is used to store data to generate the temperature compensation model.
2. Storage of system data at 6 minute intervals, 1 minute intervals while learning.
3. 20 years of onboard data storage.

4. Data export to .CSV file using 3500 Configuration Software.
5. Temperature compensation and advanced monitor learning.
6. First monitor with full diagnostic capabilities (dynamic variables + phase in one monitor)
7. The MSIM provides the following Static PPLs:

For Voltage (Channels 1, 3, 5):

- 1F Voltage Amplitude
- 1F Voltage Phase

For each of 3 phases of leakage current (Channels 2, 4, 6):

- Direct Leakage Current
- 1F Leakage Current
- 1F Leakage Current Phase
- Temperature Compensated leakage current (filtered at 1F)
- Temperature Compensated Dissipation Factor (filtered at 1F)
- Change in Leakage Current (from user-configured reference point)
- Change in Dissipation Factor (from user-configured reference point)

For temperature (Channels 7-10):

- (3) Temperatures
- Average Temperature

For line frequency (Channel 11):

- Conditioned line frequency

What temperature Inputs are Required for the MSIM HSCT?

Each MSIM system must include motor stator temperature inputs for proper temperature compensation. Most large motors have up to 3 temperatures available for each phase. Often these are wired into a DCS system, data acquisition system, PLC, local display, or protection system (such as the Bently Nevada 3500 system). Spare stator temperature leads should be available from the motor for the MSIM system. It is recommended that three stator temperatures are wired into the MSIM system; however a minimum of one or two stator temperatures is sufficient for correct operation.

If stator temperatures are not directly available from the motor because they have been routed into a local PLC or similar device it should be determined if the device has a recorder (or 4-20mA) output that can be connected to the MSIM 3500/82 monitor.

The MSIM system comes complete with a Temperature Interface Module (BN P/N 350824, shown on the left) which will accept RTD or thermocouple input and 4-20mA output for the 3500/82 monitor.

Alternatively, if the site has motor stator temperatures already wired into the 3500 system using a 3500/61 Temperature Monitor (with recorder outputs), these temperatures can be directly wired from the 3500/61 monitor I/O module to the 4-20mA temperature inputs on the back of the 3500/82 monitor without a need for the Temperature Interface Module.

If the customer has a 3500/60 Temperature Monitor (without recorder outputs) with the desired motor stator temperatures, it is recommended that the 3500/60 monitor be upgraded to a 3500/61 as part of the MSIM installation project.

What actions can customers take to prevent a motor stator insulation failure?

Aside from keeping the stator insulation clean and away from high temperatures and moisture, no actions can be taken to repair or mitigate insulation failure. Unlike some machinery malfunctions that involve rotor dynamics where machinery operators may change machine loading, speed, lube oil, or other parameters; there are no action that the motor operator can take to stave off a motor stator insulation failure. The motor will still need to be shut down, removed from service, and replaced or re-wound once the failure has occurred. The value in the MSIM/HSCT system is that it provides trending of the leakage current and C&DF so that a customer will have months of advanced warning of motor stator insulation failure, allowing them to take actions to line up resources and make plans to repair or replace the motor.

What can cause leakage current to increase?

In addition to the degradation of the motor stator insulation, there are other causes of increased leakage current that can be addressed. Contamination of the end-windings with dust, particulates, dirt, etc. can cause an increase in leakage current. By monitoring leakage current, motor operators can determine when the stator end windings need to be cleaned. By removing these contaminants the operator can extend the insulation life and thus the life of the motor.

How important is it to know where the insulation failed? Can the stator insulation be repaired?

The Partial Discharge system has the ability (which MSIM does not) to give an approximate physical location of the insulation failure. This makes it possible for a repair shop to find and repair that location. However, this is much more important and common with large generators. Even most of the largest motors, once the insulation has failed, will simply be replaced or re-wound. This is because the failure is often in a location that is inaccessible. According to large motor OEMs, these insulation failures can be repaired less than 20% of the time. The ability to determine the exact location of the insulation failure is of limited value for medium voltage and high voltage motors used in industry.

Does insulation always degrade? What changes happen in the insulation over the life of the motor?

One might expect that the stator insulation would continually degrade over the life of the motor. This is not always the case. When a motor ships new from the factory, the insulation is only mostly cured. Over the next 1-2 years the insulation will continue to be cured as the motor is running at operating temperature and conditions. During this period it is normal for the insulation leakage current to actually decrease. After this final cure on the insulation, the leakage current will flatten out and the insulation will begin to age. So over the long life of a normal motor (one without a premature failure) the leakage current trend will look like a bathtub curve with leakage current decreasing for the first 1-2 years, flattening out for the bulk of the insulation life, and then increasing near end of life. MSIM can measure and trend these values for the first time online.

MSIM/HSCT 3500 SOFTWARE AND SYSTEM 1

Which versions of 3500 Configuration Software are Compatible with MSIM?
3500 Configuration Software v5.0 is compatible with MSIM. All previous versions are incompatible.

Which versions of System 1 is Compatible with 3500/82 MSIM?
The MSIM system is compatible with all System 1 versions 6.5+.

What MSIM data is available in System 1?
Currently static variables are available in System 1 using the "Custom Monitor" option. This is sufficient as the trended values are of most interest in this application. See the list of variables above under "New Features"

Can I set Alert and Danger Setpoints for MSIM values in the 3500 System?
Yes, all variables in the MSIM monitor are treated like any other proportional values (PPLs) in the 3500 system. Alert and Danger setpoints are configurable. Alert and Danger time delays are configurable.

Alert and Danger Latching are available. Not OK Latching is also available.

Is the MSIM System Compatible with MODBUS?
Yes, all of the Proportional values (PPLs), alarm values, and statuses that are provided with the 3500/82 MSIM monitor are available and fully configurable in the 3500/92 Communications Gateway module. Users can use the 3500 configuration software and the 3500/92 to configure a standard Modbus map or a "condensed" or "custom" Modbus map which includes all of the 3500/82 (MSIM) proportional values, status, etc.

How should I use MSIM with System 1?
All MSIM variables are available in System 1. Software alarms should be set in System 1 to alert users of changes in Leakage Current. Email notification can also be configured in System 1 to alert users of changes.

What Alert and Danger Setpoints Should be used for MSIM?
Actual alarm setpoints will vary depending on many factors. Typically these values will have to be determined by consultation with the end customer, the OEM, and input from Bently Nevada.

What new software do I need for MSIM?
MSIM uses the 3500 software for configuration and System 1 for viewing data and for diagnostics. The 3500 software is typically supplied with every 3500 system. If your plant already uses System 1 then you already have all of the software that you need. For example, if electrical engineers at the facility want to view the MSIM data, all that is needed is to install the System 1 Display client on their machine (assuming System 1 is available on their corporate network). So there is no need to invest in any additional software or training to view the MSIM data. Leakage current, C&DF, Dissipation Factor, resistance, and capacitance can all be viewed and trended in System 1.

MSIM/HSCT SYSTEM PRICE

What is the cost of the MSIM system?

The price of the MSIM system is comparable to other online motor insulation testing systems such as Partial Discharge.

How much will the services cost for MSIM installation and configuration?

There are two parts to the services for an MSIM installation. The first part is the high voltage electrical installation of the HSCT current transformers, HVS high voltage sensors inside the motor connection box, and associated instrumentation and field wiring. This part must be completed by qualified electricians. Bently Nevada site project managers can offer project management services to hire qualified electrical contractors or alternatively the site can handle the high voltage electrical part of the installation with their own plant electricians or by partnering with a local electrical contractor to perform the work. The cost of the high voltage electrical installation will vary greatly depending upon whether the installation occurs at a motor OEM shop which would be very cost-effective, or by a contractor at a customer site during a machine shutdown or outage. Reference the HSCT Installation Case Studies document which details 3 field installations and includes photos. This document can be provided to electrical sub-contractors to help with the bidding process. Consult your Bently Nevada sales representative for details.

The second part of the installation is the MSIM 3500 and System 1 configuration and must be performed by Bently Nevada services organization. If multiple motors are involved, less time per motor should be required. These services can be bundled into a complete 3500 and System 1 installation or upgrade project. Consult your Bently Nevada sales representative for details.

MSIM/HSCT INSTALLATION

What is the Maximum Distance from the Motor or Interface Modules to the 3500 Monitor?

Typical maximum field wiring lengths apply to the HSCT and HVS sensors and interface modules. The maximum distance from the motor to the 3500 rack is 330 meters (1,000 feet).

Are there any special requirements for HSCT and HVS installation inside a motor connection box (MCB)?

Unlike Partial Discharge Analysis (PDA) technology which uses RF current transformers, and PD couplers, there are no special installations or complicated routing requirements for HSCT or HVS cabling beyond standard instrumentation cable best practices, such as those employed for Proximitors, temperature sensors, etc. Installation and routing of instrumentation cable however should always follow sound practice and local codes and standards. For reference see the HSCT Installation Case Studies Document.

Partial Discharge Analysis technology requires that more stringent precautions be taken in the installation of the instrument cabling. Noise from power leads for example can be easily coupled on to the PD instrument cabling causing difficulty interpreting results. The MSIM System does not suffer from these disadvantages.

Where Can the HSCT and HVS Interface Modules be Located?

The HSCT and HVS both have Interface Modules to condition the raw signals so they can be incorporated into the 3500/82 monitor (HSCT Interface Module shown on left). These Interface modules are visually similar to our standard Bently Nevada 3300XL Proximitor. However, the HSCT and HVS Interface Modules have different connections that prevent miss-wire with a 3300XL and with each other. The interface modules use an industry standard Lemo connector that is incompatible with the 3300XL Click-Loc connection. Also the Lemo connector for the HVS interface module is a 3-pin MIL-SPEC connector and the Lemo connector for the HSCT is a 2-pin Mil-Spec connector so that they can never be miss-wired.

The HSCT and HVS interface modules have the exact same footprint and configuration as our Bently Nevada 3300XL Proximitor and can be mounted with the same DIN-rail hardware, or 4-hole (old style) Proximitor mount. As such the same junction box layout can be used for the HSCT and HVS interface modules as is used for the 3300XL junction box. Typically this interface junction box will be located on or very near the motor where the HSCT and HVS are installed.

Does The MSIM System Require an External Power Supply?

Yes, a 24-volt external power supply is required and provided for each MSIM 3500/82 monitor (photo shown below). The power supply is required to drive all of the instrumentation.

What Does the Cabling Look Like for the HSCT/HVS Sensors/ Interface Modules?

The HSCT sensor uses a standard MIL-SPEC connector on the sensor end and a Lemo connector on the Interface Module end (see photo below). The HVS cable is manufactured integral to the HVS sensor with a Lemo connector on the Interface Module end (see photo below).

The HSCT cable is 5 meters (16.4 ft.) in length.

The HVS integral cable is 4.5 meters (14.7 ft.) in length.

Why does the HSCT have a metal case vs. a plastic or insulated case like most CTs?

The HSCT sensor has gain and signal to noise ratio that is a full order of magnitude higher than a typical CT. To maintain the sensitivity and accuracy of the HSCT it is important to maintain the dimensional stability of the CT. The CT was designed into the aluminum housing to maintain that stability.

Can the HSCT sensors be installed in the Motor Control Center (MCC)?

No, the HSCT sensors must encircle both the phase and neutral lines. Those are typically only available in the motor connection box (MCB).

Does orientation of the HSCT sensor matter? Does it matter how I route the cables through the HSCT?

Yes, the power coming from supply must enter the HSCT from the label side and exit on the cover side. Neutral lines coming from the motor must pass from the cover side and exit on the label side where they are connected at the star point.

Do the conductors need to pass through the exact center of the HSCT?

No, the HSCT is not sensitive to conductor placement location as long as each phase and neutral pass through the HSCT opening. However best practice installation for all CTs including HSCT is to put the conductors as close as feasible to the center of the HSCT opening and keep them away from the edges which could abrade or dent the cable insulation.