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Rockwell Automation + Schlumberger

Lift Control Systems

INSTRUCT LIFT CONTROL SYSTEMS

ES7 Low Voltage VSD

Installation, Operation & Maintenance Manual

MODEL: INSTRUCT ES7 Intelligent VSD

Manual No. LCS-ENG-M0012 (InTouch ref # 4197006), Rev. 01

Publisher Notes

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REVISION HISTORY

REVISION	DESCRIPTION OF CHANGE	SENSIA ISSUER	DATE
01	Initial release.	Lift Control Systems	30 Mar 2022

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GENERAL

WARNING!

To avoid the risk of electric shock and fire, the following safety instructions must be observed and the guidelines followed.

The specifications must not be exceeded, and the device must only be applied as described in the following.

Prior to the installation and commissioning of the unit, the installation guide must be examined carefully.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

GENERAL

AVERTISSEMENT!

Pour éviter tout risque de choc électrique et d'incendie, les consignes de sécurité de ce manuel doivent être observées, et les instructions suivies.

Les spécifications ne doivent pas être dépassées, et l'unité ne doit être appliquée que comme décrit dans le texte suivant.

Ce manuel doit être examiné avec soin, avant l'installation et la mise en service de l'unité.

Si l'équipement est utilisé d'une manière non spécifiée par le fabricant, la protection assurée par l'équipement peut être altérée.

INSTALLATION

WARNING!

Installation may only be carried out by electrically skilled and instructed personnel in accordance with national leg-isolation, including the relevant standards.

All technical data on the instrument is to be observed.

Changes to the design and modifications to the equipment are not permitted.

The equipment shall only be operated as intended and only in undamaged and perfect condition.

Sufficient segregation must exist between different cables and wires carrying different types of signal or power and all other circuits.

All wires must be terminated, complete with crimping lugs. Unused cores should be terminated to the earth bus bar.

INSTALLATION

AVERTISSEMENT!

L’installation ne peut être effectuée que par un électricien qualifié, conformément à la législation nationale, y compris les normes pertinentes.

Toutes les données techniques sur l'instrument doivent être observées.

Modifications de l'équipement ne sont pas autorisés.

L'équipement ne doit être utilisé comme prévu par le fabriquant et uniquement si il est en parfait état.

Une séparation suffisante doit exister entre les différents câbles et les fils transportant différents types de signaux ou de puissance et tous les autres circuits.

Tous les fils doivent être terminés, avec pattes de sertissage. Les noyaux non-utilisés doivent être terminés au jeu de barres de la terre.

Section 1: **Description**

Sensia ES7 Low Voltage Variable Speed Drives (VSD) are available in several configurations. They are available with or without an integrated output sinewave filter, and in multi-pulse configurations selectable as 6-, 12- or 18-pulse drives. The 18-pulse drive has an integrated 18-pulse phase-shifting autotransformer built in. Optional features include a junction box for bottom cable entry and an input EMC filter which may be required for certain regions and countries.

The Sensia ES7 drive with updated technology replaces the Sensia S3 drive. The ES7 and S3 drives are very similar and many of the components are unchanged. The ES7 performs all of the S3 functions, but notable differences include the control board (G3 and G7), gate driver board, interface board, and keypad used for troubleshooting. Additionally, parts are constantly reviewed in the drive and updated, so there may be changes to IGBTs, circuit breakers, CPTs, and other drive components.

The 18-pulse configuration was developed to offer superior harmonic performance in the Sensia low voltage VSD line. With an emphasis on compliance with the Institute of Electrical and Electronics Engineers (IEEE) standard IEEE 519-2014 for recommended harmonic limits, the drive uses a patented integral autotransformer to achieve 18-pulse cancellation at the input.

The Sensia sine wave filter, used in other Sensia drives, is applied to mitigate harmonics and voltage spikes at the output of the Sine Wave Drive (SWD) version which is suitable for Electrical Submersible Pumping (ESP) downhole installations and is application insensitive.

Note

It is important to know the type of drive at the time of commissioning or troubleshooting since several of the drive components are not interchangeable and troubleshooting procedures are different.

It is essential to check the proper spare parts list for the drive on the engineering drawings and contact Lift Control Systems when ordering spares since some parts are not interchangeable between drive lines.

Refer to Table 1-1 for a summary of the VSD types sold through Sensia, or through Schlumberger prior to the establishment of Sensia:

Table 1-1 - Summary of VSD Types Sold through Schlumberger/Sensia

Legacy Brand Name	New Brand Name	Model	Control Board	Timeline
SpeedStar S3	-	SS2K+, SWD	G3	Before July 2009
SpeedStar S7+	INSTRUCT ES7	SS2K+, SWD	G7	After July 2009
VariStar ST7	-	SS2K+, SWD	G7	After December 2007
SpeedStar 519	INSTRUCT ES7	VSD, SWD	G7	After January 2010

Sensia VSDs provide surface control for ESP applications and horizontal pumping systems (HPS). The enclosure for the ES7 is a NEMA-rated cabinet which contains: a motor controller (refer to section 1.1 Motor Controller), the power converter (Toshiba G7, the actual variable-speed drive), and other associated power components , such as control power transformers, circuit breakers, fuses, a magnetic contactor, Surge Protection Devices (SPD), and a sine wave filter for the SWDs. Several configurations are available with components mounted on the exterior of the cabinet such as a heat exchanger, junction box, etc.

Refer to Figure 6-1 for a simplified block diagram of the Sensia ES7 VSD. Refer to Figure 1-2 and Figure 1-3 of the 18P to see the drives' internal components.

External to the Sensia ES7, optional and combinable equipment may be installed at the wellsite. Since this equipment is optional and application dependent, this manual will present only instructions for connecting it to the Sensia VSD system. Since any communications equipment, such as SCADA systems, can be used to communicate (send commands/acquire data) with the Sensia VSD, some very basic connection and communication instructions and troubleshooting procedures are included in this manual.

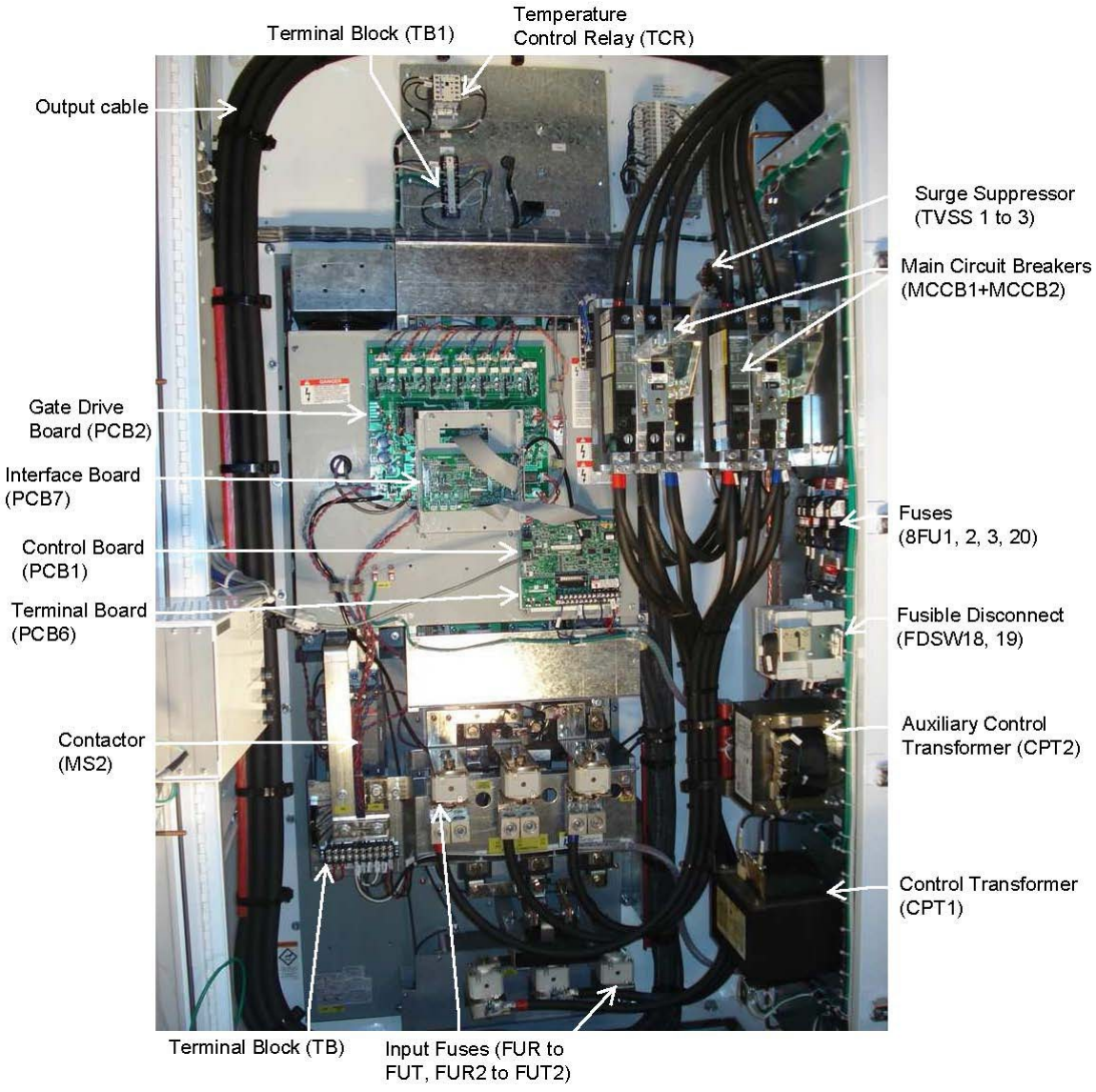

Figure 1-1 - Sensia ES7 VSD Major Components (interior of typical single-inverter 260–518 kVA shown)

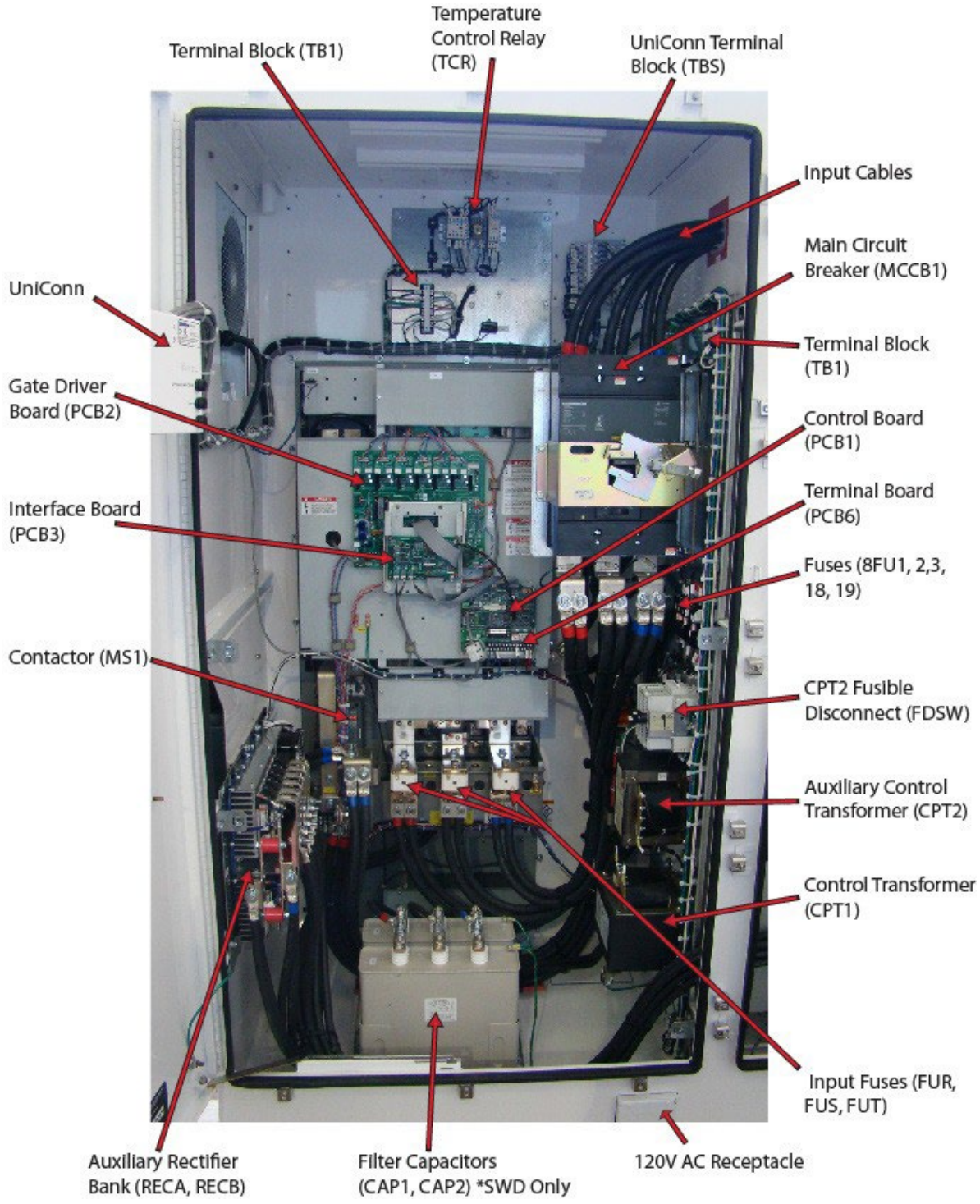

Figure 1-2: Sensia ES7 18P Series Drive Section Internal Components (454 kVA shown)

Figure 1-3: Sensia ES7, 18P Series Transformer Compartment (interior of 454 kVA shown)

1.1 MOTOR CONTROLLER

The ES7 VSD utilizes the INSTRUCT ESP Intelligent Controller, which provides motor protection, monitors motor operating parameters and performance, and interfaces with external devices and SCADA systems. Refer to the *INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576) for details.

1.2 AUTOTRANSFORMER (18P)

The integrated autotransformer in the 18-pulse configuration distributes the incoming three-phase power to the auxiliary rectifier units in the drive. The output of the autotransformer provides the sine wave voltage as the main incoming voltage to ensure balanced voltage at the auxiliary rectifier units. A thermistor monitors the temperature of the transformer. The output of the thermistor is connected to the control circuit of the drive. In the event of an overheat, the drive will trip. Figure 1-3 shows the transformer located in the NEMA 3R/ (optionally IP56) transformer compartment.

1.3 SINE WAVE FILTER (SWF)

This ES7 VSD has an output filter inside the enclosure. The result is a voltage similar to a rotating generator output that has no application concerns for any submersible pump at any cable length. Refer to Figure 1-4.

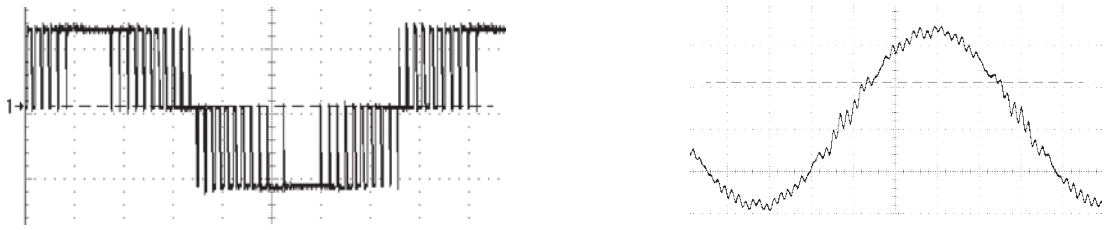

Figure 1-4: Sine Wave Drive Output Comparison

The left image shows the output of the drive before a sine wave filter.
The right image shows the result after the filter.

This improved wave form eliminates the significant voltage stress that can cause premature insulation failure. Installation of a sine wave drive will mitigate premature failure on weak or compromised insulation in an older well. It will increase the time before the well requires replacement of equipment due to electrical stress-related failures.

Section 2: **QHSE**

The following safety precautions should be followed when installing, operating, or maintaining a Sensia VSD.

2.1 OPERATING SAFETY PRECAUTIONS

1. Do not power up the VSD until this entire operation manual is reviewed.
2. The input voltage must be within ±10% of the specified input voltage. Voltages outside of this permissible tolerance range may cause internal protection devices to turn ON or can cause damage to the unit. Also, the input frequency should be within ±5% of the specified input frequency.
3. Proper coordination of the motor and VSD is required. For submersible and surface motor applications, consult with Sensia when utilizing this VSD for a new application.
4. This VSD is designed to operate both standard NEMA B and Schlumberger submersible pump motors. Consult InTouch before using the VSD for special applications such as an explosion-proof motor or one with a repetitive type piston load.
5. Do not touch any internal part with power applied to the VSD; first remove the power supply from the drive and wait until the DC bus is discharged. Charged capacitors can present a hazard even if source power is removed. Use appropriate lockout/tagout procedures (refer to SENS-HSE-S027) to ensure that the VSD power is off before proceeding with the checks and the procedures inside the drive or the junction box.

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Do not operate this VSD with its cabinet door open.

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6. Do not apply commercial power to the output terminals T1, T2, or T3 even if the VSD source power is off. This will cause damage to components within the drive. Disconnect the VSD from the motor before using a megger or applying bypass voltage to the motor.
7. Interface problems can occur when this drive is used in conjunction with some types of process controllers. Signal isolation may be required to prevent controller and/or drive malfunction. Contact Sensia or the process controller manufacturer for additional information about compatibility and signal isolation.
8. Do not open and then reclose a secondary magnetic contactor (MC) between the drive and the load unless the drive is OFF (output frequency has dropped to zero) and the motor is not rotating. Abrupt reapplication of the load while the drive is on or while the motor is rotating can cause drive damage.
9. Use caution when setting output frequency. Increasing the motor speed beyond its normal capacity can decrease its torque-developing capability and can result in damage to the motor and/or driven equipment.
10. Use caution when setting the acceleration and deceleration time. Unnecessarily short time settings can cause tripping of the drive and mechanical stress to loads.
11. Only qualified personnel should have access to the adjustments and operation of this equipment. They should be familiar with the drive operating instructions and with the machinery being driven.
12. Only properly trained and qualified personnel should be allowed to service this equipment.
13. Follow all warnings and precautions. Do not exceed equipment ratings.

Danger

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Three-phase input power to the CPT2 circuit is applied at all times. Opening the MCCB1 circuit breaker does not remove power from the CPT2 Control Power Transformer circuit. Ensure that the three-phase power to the system is off and that the system is locked out and tagged out before performing maintenance or repairs on the VSD. The relationship of MCCB1 to the rest of the system is shown in Figure 2-1.

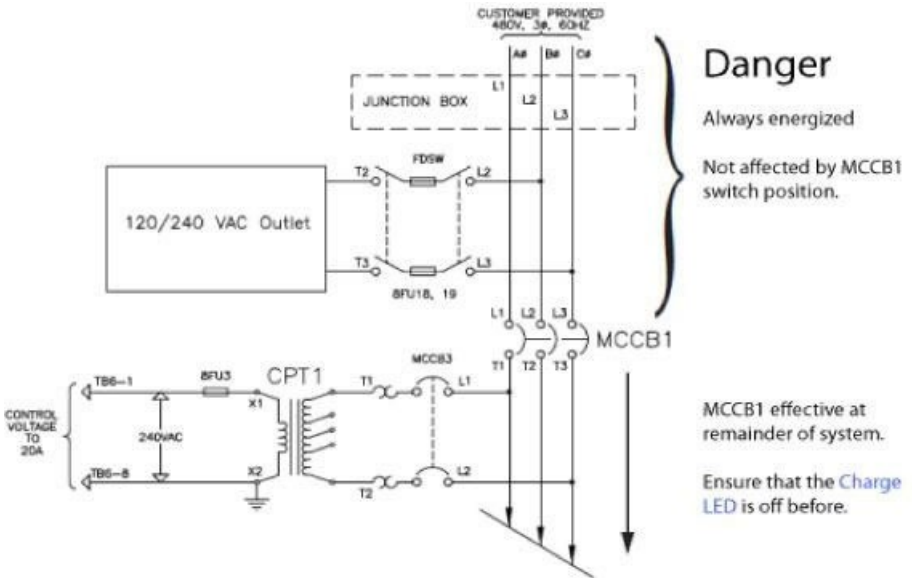


Figure 2-1: Placement of the MCCB1 Circuit Breaker in the ES7 VSD System

2.2 INSTALLATION AND MAINTENANCE SAFETY

Warning

Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Machinery equipment hand tools

Ignoring the following instructions can cause physical injury or death, or damage to the equipment

1. Never work on the drive, motor cable or motor when main power is applied.
2. After disconnecting the input power, always wait for 5 minutes to let the intermediate circuit capacitors discharge before working on the drive, motor or motor cable.
3. Verify the following voltages with a multimeter (impedance at least 1 Mohm):
   a. Voltage between drive input phases L1, L2 and L3 and the frame is close to 0 V.
   b. DC bus voltage at the -DC and +DC is close to 0 V.
4. Do not work on the control cables when power is applied to the drive or to the external control circuits. Externally supplied control circuits may cause dangerous voltages inside the drive even when the main power to the drive is switched off.

5. Do not make any insulation or voltage withstand tests on the drive.
6. Do not connect the drive to a voltage higher than what is marked on the nameplate.

Note

- The motor cable terminals on the drive are at a dangerously high voltage when the input power is on, regardless of whether the motor is running or not.
- The DC terminals (+DC, -DC) carry a dangerous DC voltage (over 500 V) when internally connected to the intermediate DC circuit.
- Depending on the external wiring, dangerous voltages (115 V, 220 V or 230 V) may be present on the terminals of relay outputs.

Section 3: **Inspection/Storage/Disposal**

This section describes how to inspect a VSD when it first arrives at the wellsite or jobsite, how to ship or store the unit if it will not be immediately connected and put in service, and how to dispose of any old or previously installed electrical/electronic drive equipment.

3.1 INSPECTION OF NEW UNITS

1. Immediately upon receipt of the drive, un-crate it and visually inspect it for damage.
2. Check the unit for loose, broken, bent, or otherwise damaged parts.
3. Verify that the rated capacity and the model number specified on the nameplate conform to the order specifications.
4. Install the circuit breaker handle, if applicable, and shut and seal the drive door before storing or shipping. Ensure there are no openings in the drive to allow moisture or dust to enter.

3.2 STORAGE AND SHIPPING

For packaging and international shipping requirements, refer to InTouch Content ID 5170246. For general storage and shipment, refer to the instructions below:

1. Store the unit and any optional equipment in a clean, dry, and well-ventilated location. The VSD must be stored and shipped upright.
2. Avoid storage in locations with high humidity and dust. It is highly recommended to store drives indoors. If the drive cannot be stored inside, it should not be left outside for more than 30 days.
3. Store spare part PCB's in anti-static packages in a dry environment.
4. Drives should be stored and shipped with all inspection plates and doors properly closed, including the C-clamps surrounding the door frame.
5. Drives that have been running or opened for inspection must have a dry interior before shipping or storing. Dry the cabinet in any appropriate fashion including using heaters. Do not heat components over 140 degF (60 degC) while drying. After the drive is dry, it is optional to add desiccants or corrosion inhibitor packages. Shut and seal the drive doors.
6. Ship and store the drives in accordance with the following environmental conditions:
   - Type 1 Indoor Drives: -58 degF (-40 degC) to 140 degF (60 degC) for indoor storage or inside protected enclosed containers.
   - Type 3R Outdoor Drives: -58 degF (-40 degC) to 140 degF (60 degC) for shipping and storing.
7. Sensia ES7 drives should be warmed to -22 degF (-30 degC) before connecting power and running a load.

3.3 DISPOSAL

Lithium batteries MUST be removed from the INSTRUCT ESP Intelligent Controller prior to disposal of the unit. The batteries MUST be disposed of separately and according to local regulations.

The circuit boards and display module of the INSTRUCT ESP Intelligent Controller used in this equipment may contain lead solder and solder paste. The boards should be disposed of according to local regulations.

Please contact your local environmental agency or Sensia HSE advisor for details on proper disposal of electrical components and packaging in your particular area.

Potential Severity: Major
Potential Loss: Personnel
Hazard Category: Electrical, Explosives, Fire flammable, Toxic corrosive hazardous substances

Never dispose of electrical components by incineration.

Section 4: **Specifications**

This section contains operating specifications for Sensia ES7 drives.

Refer to the *INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576) for the detailed information of the operator interface.

4.1 SENSIA ES7 VSD OPERATING SPECIFICATIONS

The following table lists operating specifications and ranges for the entire range of Sensia ES7.

Table 4-1: ES7 VSD Operating Specifications

Item		Standard Specifications
Principal Control Parameters	Control System	PWM or SineWave, Flux vector control
	Input Voltage Supply	380/415/480 V ±10%, 50/60 Hz ±2 Hz
	Output Voltage Regulation	0 - 480 V
	Frequency Setting	0.1 to 120 Hz output
	Carrier Frequency	2.2 kHz (default setting), adjustable between 0.5 and 3 kHz without sinewave filter
	Converter Type	Diode bridge rectifier
	DC Bus	Nominal 537 - 680 VDC constant (based on input voltage)
	Inverter Type	IGBT (Insulated Gate Bipolar Transistor)
	Overload Setting	100% continuous, 120% for 60 seconds
	Displacement Power Factor	0.96 at all loads and speeds
	Inverter Efficiency	0.98
	Starting Frequency	0 - 10 Hz
	Voltage Boost	0 - 30%
	Voltage per Hertz Characteristic	Constant V/Hz, variable torque, automatic torque boost
	Cooling Fan Control	Automatic
Operating Functions	Accel/Decel Time	Frequency over time: 0.1 - 20 Hz over 1 - 1000 seconds
	Forward and Reverse	Programmable
	Soft Stall	Automatic load reduction during overload
	Frequency Jumps	Three jump frequency settings
	Motor Controller	Direct control of VSD
	Automatic Restart	A coasting motor can be smoothly restarted
	Upper/Lower Limit	Limits frequency between minimum and maximum values
	Coast Stop, Controlled Stop, Emergency Stop	ST — CC: coast to stop Operator interface: Controlled stop S4 — CC: Emergency stop

Item		Standard Specifications
	Applications	Electrical Submersible Pumps and Horizontal Pumping
Inverter/Motor	Protective Functions	Motor overload/underload, ground fault, input or output phase low/lost, inverter overcurrent, soft stall, DC bus overvoltage/undervoltage, heatsink and drive overtemperature, output overvoltage, overtorque, emergency stop, RAM error, communication error
	Electronic Thermal Characteristics	Adjustable for motor rated amperage
Motor Controller	Power Supply	100-240 volts AC ±10%, 50/60Hz
	Display	LCD, Color GUI, backlit with heater
	Keypad	5 function keys and 3 fixed keys
	Digital Input/Output	6 digital inputs, 3 digital outputs
	Analog Input/Output	4 analog inputs, 2 analog outputs
	Mode of Operation	Hand - Auto - Off
	Communication	RS-485 (configurable for Modbus RTU)
	Expansion Slot	4 slots (3 are open)
Enclosure	Type	UL Type 3R, UL Type 1 or IP56 (18P), 12-gauge steel. Floor mount, forklift slots and lifting eyes are provided.
	Dimensions (H x W x D)	kVA size dependent. Refer to manufacturer's drawings for details.
	Junction Box	6/12P - Optional, standard on 518 kVA 40 DegC UL Type 3R only 18P - Standard on UL Type 3R and IP56
	Door Handle	Three-point latch c/w stainless steel U-type clamps for watertight seal
	Door Interlock(s)	Opening enclosure door removes the 240 VAC Control Power for all double door cabinets.
	Cooling Method	Forced air cooling, heat exchanger for electronics compartment
	Color	White for UL Type 3R, Grey for UL Type 1
	Ambient Temperature	-22 degF to 122 degF (-30 degC to 50 degC) or as marked
	Relative Humidity	20 to 95% maximum (non-condensing)
	Vibration	5.9 m/m^2 (0.6 G) maximum (10 to 57 Hz)
	Altitude	1371 m (4500 ft) for 6 & 12P 1000 m (3300 ft) for 18P
	Service Environment	Consult factory for harsh environment applications such as offshore, cold climate or desert environments. Some de-rating may be required for direct sunlight.

Item		Standard Specifications
Sinewave Filter	Type	A specially designed three-phase reactor and three-phase capacitors (LC filter) convert a PWM waveform to sinusoidal waveform
	Construction	Integral part of VSD housed inside a UL Type 3R or Type 1 enclosure
Approvals		* UL Listed (UL 508) * CE Compliance (optional) * IEC Compliance (optional) * IP56 upon request, NEMA 3R Standard
* Contact Lift Control Systems for details on compliance.		

Section 5: **CE Compliance Requirements**

In Europe, the current low-voltage directive and EMC directive, which took effect in 2007 and 2009, respectively, require that the CE mark be placed on every applicable product to prove that it complies with the directives. VSDs do not work alone but are designed to be installed in an enclosure and are used in conjunction with other machines or systems. Thus, the VSD is not considered to be subject to the EMC directive. However, the CE mark must be put on all VSDs because they are subject to the low-voltage directive.

The CE mark must be placed on all machines and systems with a built-in VSD because the machines and systems are subject to the above directives. If the VSD is the final product, it may also be subject to machine-related directives. It is the responsibility of Toshiba International Corporation to put the CE mark on each VSD. The CE Compliance section explains how to install VSDs and provides other measures required to satisfy the EMC and low-voltage directives.

Toshiba International Corporation has tested representative VSD models that were installed as described in this manual to ensure compliance with the EMC directive. However, all VSDs cannot be tested for EMC directive compliance because system compliance is a function of the installation and connectivity.

Applicable EMC standards vary, depending on the composition of the enclosure in which the VSD is installed, the relationship with other electrical devices installed in the enclosure, wiring conditions, equipment layout, etc. To that end, please ensure that your machine or system complies with the EMC standards as a whole.

Toshiba International Corporation has applied the following standards for systems deployed in the European market.

Table 5-1: European Market Standards

Category	Subcategory	Product Standards	Test Standards and Level
Emissions	Radiated	EN 61800-3	EN55011 Class A Group 1
	Conducted		EN55011 Class A Group 1
Immunity	Generic Industrial		EN 61000-6-2
	Electrostatic Discharge		EN 61000-4-2
	Radiated		EN 61000-4-3
	Electrical Fast Transient Burst		EN 61000-4-4
	Lighting Surge		EN 61000-4-5
	Conducted		EN 61000-4-6
	Voltage Dip		EN 61000-4-11
	Generic Standards		EN 61000-6-4
Adjustable Speed Electronic Power Drive Systems		EN 61800-5-1	

5.1 EMC DIRECTIVE

The CE mark must be placed on every final product that includes an VSD and a motor. The HX7+ Pack VSD complies with EMC Directive 2004/108/EC, which took effect on 20th July 2009, if an EMC filter recommended by Toshiba is connected to it and wiring is carried out correctly.

The EMC standards are broadly divided into two categories: emissions and immunity-related standards. Each category is further categorized according to the operating environment of each individual machine. Because VSDs are intended for use with industrial systems under industrial environments, they fall within the EMC categories listed in European Market Standards. The tests required for machines and systems as final products are the same as those required for VSDs.

5.2 LOW-VOLTAGE DIRECTIVE

The low-voltage directive provides for the safety of machines and systems. All Toshiba International Corporation VSDs are CE-marked in accordance with the European standard EN 50178 specified by the 2006/95/EC Low-Voltage Directive on Electrical Safety and can therefore be installed in machines or systems and imported by European countries without any issues.

The ES7 Pack also complies with the low-voltage standard EN 61800-5-1:2007. To comply with this standard, Toshiba International Corporation uses mostly Imperial hardware that is compatible with metric hardware. Below is a table for reference in choosing the correct tools to prevent unnecessary maintenance on the VSD.

Table 5-2: Tool Equivalency Table

	Imperial Hardware	Imperial Tool	Metric Tool
	1/4 Hex	7/16in Socket	11mm Socket
	3/8 Hex	9/16in Socket	15mm Socket
	3/8 Brass Standoff	3/8in Socket	10mm Socket
	1/2 Hex	3/4in Socket	19mm Socket

5.3 CE COMPLIANT INSTALLATION GUIDELINES

VSDs shall be installed in accordance with the following guidelines and Table 5-3.

1. Filtering — An input filter shall be used with the VSD. A Schaffner input filter of the appropriate rating shall be mounted next to the VSD. The filter output must be screened.
2. Mechanical — The VSD and the associated equipment shall be mounted on a flat metallic backplane. Adequate ventilation must be provided for the filter. The filter output cable to be connected from the bottom of the filter to the VSD power input should be as short as possible. Units received as an Open Chassis shall not be placed into operation until the unit is placed into an approved enclosure that will protect personnel against electrical shock. Opening and closing of enclosures or barriers shall be possible only with the use of a key or a tool.

3. Cabling — The power, filter, and motor cables shall be of the appropriate current rating. The cables shall be connected in accordance with the guidelines of the manufacturer and the applicable local and national agencies. A 4-core screened cable (such as RS 379-384) is to be used for the power and earth connections to minimize RF emissions. Units that are sent to Europe require a 5-core screened cable to be used with a neutral conductor. Control cabling must be screened using P/N RS 367-347 (360º gnd) or a similar component.
4. Grounding — The mains (input) ground shall be connected at the ground terminal provided on the filter. The filter and motor shall be grounded at the ground terminals provided in the VSD.
5. Screening — The mains (input) screen shall be connected to the metallic back-plane at the filter; remove any finish coating as required. The screen over the filter output cables, the motor cable screen, and the control wire screens must be connected to the VSD case using glands or conduit connectors. The motor cable screen shall be connected to the motor case. When using a braking resistor, the cabling between the resistor and VSD shall also be screened. This screen shall connect to both the VSD enclosure and the resistor enclosure.
6. Shielding — Shielding terminations (clips, lugs, etc.) shall be connected to both the input and output ends of the VSD.
7. Where residual-current-operated protective device (RCD) is used for protection in case of direct or indirect contact, only RCD of type B is allowed on the supply side of this Electronic Equipment (EE). Otherwise, another protective measure shall be applied, such as separation of the EE from the environment by double or reinforced insulation, or isolation of the EE and the supply system by a transformer.
8. When doing maintenance, be extremely careful not to put your fingers into the VSD through a wiring hole and touch a charged part, which may occur depending on the model and capacity of the VSD used.
9. Do not connect two or more cables to the main circuit earth terminal of the VSD. If necessary, install an additional earth terminal on the noise cut plate on which the VSD is installed and connect another cable to it.

Table 5-3: Filter Selection

Filter Selection Table for ES7 Pack			
kVA	**FILTER MODEL**	**kVA**	**FILTER MODEL**
66	FN 258-100-35	600	FN 3359-1000-99
86	FN 258-130-35	700	FN 3359-1000-99
110	FN 258-180-40	815	FN 3359-1600-99
163	FN 258-250-40	932	FN 3359-1600-99
200	FN 3359-320-99	1000	FN 3359-1600-99
260	FN 3359-400-99	1200	FN 3359-1600-99
390	FN 3359-600-99	*1400	FN 3359-2500-99
454	FN 3359-600-99	*1500	FN 3359-2500-99
*518	FN 3359-1000-99	*Note: 40 degC device.	

EU DECLARATION OF CONFORMITY WITH COUNCIL DIRECTIVE 2014/30/EU and 2014/35/EU	
Date of Issue:	8/17/17
Directive(s):	2014/30/EU Directive on Electromagnetic Compatibiilty 2014/35/EU Low Voltage Directive on Electrical Safety
Conforming Apparatus:	G7, H7, Q7 & Plus Pack Low Voltage Adjustable Speed Drives operating @ 380-460Vac, 3-phase as detailed in Technical File Numbers IG7F000 Issue 3 & IG7F002 Issue 4
Manufacturer:	Toshiba International Corporation 13131 West Littler York Road Houston, TX 77041 USA
Authorised Representative:	Mr. Kevin McDermot Park Electrical Services 3 Hertford House Farm Close, Shenley Hertfordshire WD7 9AB United Kingdom Tel: + 44 01923 853434
Harmonised LVD Standards: *Harmonised EMC Standards:* *Referenced or Applied*	EN 62477-1:2012+A11:2014, EN 61010-1:2010, EN 60204-1:2006+A1:2009, EN 61800-5-1:2007 EN 61800-3 2004 +A1 2012
EMC Notified Body:	Technology International (Europe) Ltd NB number 0673
EU-Type Examination Certificate:	NB12875TOS3.CPS
Specifications with which Conformity is Declared:	*Restrictive use: For industrial environment only* *Safety Objectives of Annex 1 of the Low Voltage Directive*
This declaration of conformity is issued under the sole responsibility of the manufacturer. We hereby certify that the apparatus described above conforms with the protection requirements of Council Directive(s) 2014/30/EU and 2014/35/EU on the approximation of the laws of the Member States relating to electromagnetic compatibility and electrical equipment designed for use within certain voltage limits.	
Signed:.....	
Signatory:	Mark Rayner Manager of R&D and Quality Control Toshiba International Corporation

Figure 5-1: EU Declaration of Conformity with Council Directive 2014/30/EU & 2014/35/EU

Toshiba International Corporation has applied the following additional standards for systems deployed in the European market.

Table 5-4: Additional Standards Toshiba has Applied

Subcategory	Test Standard and Level
Basic and Safety Principles for Man-Machine Interface, Marking and Identification	EN 60445
Machine Safety	EN 60204-1
Power Transformers	EN 60076
Low-Voltage Fuses (must be met by fuse manufacturer)	EN 60289-1
Power Transformers and Reactors	EN 60050
Electrical Equipment for Measurement, Control, and Laboratory Use	EN 61326
Functional Safety of Electrical/Electronic/Programmable Electric Safety-Related Systems	EN 61508
Electronic Equipment for Use in Power Installations	EN 50178
Enclosure Protection	EN 60529
Environmental Conditions	EN 60721-3-3
Environmental Testing (temperature, humidity, shock, vibration)	EN 60068-2-6
Graphic Symbols for Use on Equipment	EN 60417

Section 6: **Wiring**

This section contains intra- and inter- VSD connections:

- to incoming (customer-supplied) power
- from the main power bus through the VSD and other components inside the drive enclosures
- between the drives' major components (between the motor controller/operator interface and the VSD) and optional equipment (site communications equipment)
- from the outgoing power to output transformer (when used) and on to the motor(s)

6.1 IMPORTANT NOTES ON DRIVE WIRING

1. Properly ground the drive cabinet with a copper conductor to meet local electrical codes. For VSD applications, metal conduit is not an acceptable ground. Cabinet ground connection must also comply with NEC-Article 250 and CEC-Section 10.
2. The motor should be grounded to the same point in the drive cabinet as the copper wire. Do not mix input and output conductors in the same conduit. Ground connection must also comply with NEC-Article 250 and CEC-Section 10.
3. An optional junction box is available to simplify the installation of input and output cables. Terminals are marked identically to the drive and accessible from a separate box outside the enclosure.
4. Output transformers have numerous taps for different motors and cable lengths.
5. Contact InTouch Support before starting a new application to ensure correct sizing and wiring.
6. Twelve-pulse input requires a phase-shifting input transformer. This type of input reduces harmonics reflected to the power line.

6.2 SELECTION OF WIRING EQUIPMENT AND STANDARD CABLE SIZES

Table 6-1 lists the sizes of main termination lugs that are available for the drives for 6- and 12-pulse variants.

Table 6-2 provides similar information for drives for 18-pulse variants.

Note
For cables size values, the initial dash-number indicates the quantity of cables of the parenthesized suggested size range to be used.
The following ratings are guidelines and shall not be the sole determining factor of the lug or wire size used with the VSD. Application-specific, wire insulation type, conductor material, and local and regional regulations are but a few of the considerations when selecting the actual lug and wire type to be used with the VSD.
Cables and terminals specifications are based on the rated current of the VSD. They DO NOT include a 10% Service Factor.

Table 6-1: Selection of Main Circuit Wiring Equipment for ES7, 6/12P VSDs (Standard Cables Shown)

	*Molded case circuit breaker (MCCB)		Amp Capacity (USA, FLA x 1.25)	**Termination Lug Sizes				Suggested Cable Size (AWG or Kcmil)				
kVA	Amp Rating (A) 6 Pulse	Amp Rating (A) 12 Pulse	Amps (A)	Digital Control Inputs (AWG)	***Input Lug Wire Capacity 6 Pulse (Per Phase)	***Input Lug Wire Capacity 12 Pulse (Per Phase)	***Output Lug Wire Capacity	****Ground Lug	Input Power Cable Size 6-Pulse (Per Phase)	Input Power Cable Size 12-Pulse (Per Phase)	Output Power Cable Size (Per Phase)	NEC Ground Cable Size	IEC Ground Cable Size
66	100	2 - 100	99	# 14	1x (#2 - 3/0)	1x (#2 - 3/0)	1x (#2 - 500MCM)	#2 - 4/0	1 - (#4 - 3/0)	1 - (#2 - 3/0)	1 - (#2 - 500MCM)	1 - (#2 - 4/0)	1 - (#2 – 4/0)
83	150	2 - 150	125	# 14									
110	250	2 - 250	166	# 14	1x (1/0 - 300MCM)	1x (1/0- 300MCM)			1 - (3/0 - 350MCM)	1 - (3/0 - 350MCM)			
130	250	2 - 250	195	# 14			1x (3/0 - 500MCM)		1 - (3/0 - 350MCM)	1 - (300 - 350MCM)	1 - (3/0 - 500MCM)		2- (#2 – 4/0)
163	250	2 - 250	245	# 14									
200	400	2 - 250	301	# 14	1x (300- 600MCM)				1 - (3/0 - 600MCM)				2- (#1 – 4/0)
260	400	2 - 200	391	# 14	1x (500- 600MCM) or 2x (3/0 - 250MCM)	1x (2/0- 300MCM)	2x (1/0 - 350MCM)	#2 - 4/0MCM	1 - (4/0 - 500MCM)	1 - (1/0 - 300MCM)	2 - (1/0 - 350MCM)		2 - (2/0 - 4/0)
390	600	2 - 400	586	# 14	3x (3/0 - 500MCM)	2x (3/0 - 250MCM)	2x (4/0 - 500MCM)		3 - (3/0 - 500MCM)	2 - (3/0 - 250MCM)	2 - (4/0 - 500MCM)	2 - (#2 - 4/0)	
454	600	2 - 400	683	# 14								2 - (1/0 - 4/0)	2 - (3/0 - 4/0)
518, 40 degC	800	2 - 400	779	# 14									
518	800	2 - 400	779	# 14	3x (3/0 - 500MCM)	2x (250 - 600MCM)	4x (2/0 - 750MCM)	#1 - 350MCM	3 - (4/0 - 350MCM)	1 - (250 - 600MCM)	4 - (2/0 - 750MCM)	2 - (1/0 - 350MCM)	2 - (3/0 - 350MCM)
600	800	2 - 400	903	# 14									2 - (250 - 350MCM)
700	1000	2 - 600	1053	# 14	4x (250- 500MCM)		4x (250 - 750MCM)		4 - (250 - 500MCM)	2 - (250 - 600MCM)	4 - (250 - 750MCM)	2 - (4/0 - 350MCM)	2 - (300 - 350MCM)
815	1000	2 - 600	1225	# 14									
932, 40 degC	1200	2 - 600	1401	# 14								3 - (3/0 - 350MCM)	3 - (300 - 350MCM)
1000, 40 degC	1200	2 - 600	1504	# 14									
932	1200	2 - 600	1401	# 14	4x (400- 500MCM)	3x (4/0- 750MCM)	4x (400 - 750MCM)		4 - (400 - 500MCM)	3 - (4/0 - 750MCM)	4 - (400 - 750MCM)	4- (1/0 - 350MCM)	4 - (4/0 - 350MCM)
1000	1200	2 – 600	1504	# 14									
1200	1600	2 - 800	1804	# 14	4x (600 - 750MCM)	3x (300 - 750MCM)	4x (600 - 750MCM)		4 - (600 - 750MCM)	3 - (300 – 750MCM)	4 - (600 - 750MCM)	4 - (2/0 - 350MCM)	4 - (300 - 350MCM)
1400, 40 degC	1800	2 - 1000	2105	# 14	6x (400 - 750MCM)	4x (250 - 750MCM)	6x (400 - 750MCM)		6 - (400 - 750MCM)	4 - (250 - 750MCM)	6 - (400 - 750MCM)	4 - (3/0 - 350MCM)	
1500, 40 degC	1800	2 - 1000	2255	# 14									

*Any customer-supplied Molded Case Circuit Breaker (MCCB), Magnetic Circuit Protector (MCP), or fuses between the three-phase power source and the VSD should be in accordance to the short circuit current setting of the VSD and NEC Article 430.

** Wire sizing should be based upon NEC Table 310.16 or CEC Table 2 using 75 degC cable, an ambient of 30 degC, cable runs for less than 300 ft, and copper wiring for no more than three conductors in the raceway, cable or earth (directly buried). A de-rating factor should be taken into account for 50 degC as per NEC, CEC code, or applicable local area code. The customer should consult the NEC, CEC, or applicable local area codes standard wire tables for their own particular application, wire sizing and ambient de-rating factors.

*** Use parallel conductors instead of a single conductor (this will allow for the proper wire bending radius within the cabinet). Use separate conduits for routing parallel conductors. This prevents the need for conductor de-rating (see Note 2).

**** Lug sizes are based on using copper/aluminium bonding conductor. Refer to CEC Table 16 for copper wire and NEC Table 250.122, based on copper.

Note
For cables size values, the initial dash-number indicates the quantity of cables of the parenthesized suggested size range to be used.
The following ratings are guidelines and shall not be the sole determining factor of the lug or wire size used with the VSD. Application-specific, wire insulation type, conductor material, and local and regional regulations are but a few of the considerations when selecting the actual lug and wire type to be used with the VSD.
Cables and terminals specifications are based on the rated current of the VSD. They DO NOT include a 10% Service Factor.

Table 6-2: Selection of Main Circuit Wiring Equipment for ES7, 18P VSD (Standard Cables Shown)

	Molded Case Circuit Breaker (MCCB1)	Amp Capacity (USA, FLA x 1.25)	Termination Lug Sizes						
kVA	Amp Rating (A)	Amps (A)	Digital Control Inputs (AWG)	Input Lug Wire Capacity		Output Lug Wire Capacity		Ground Lug	
				UL Type 1	UL Type 3R or IP56	UL Type 1	UL Type 3R or IP56	UL Type 1	UL Type 3R or IP56
110	250	166	#14	1 x (4AWG-350MCM)	Lug provided by customer	1 x (4AWG-500MCM) per phase	Lug provided by customer	2AWG-4/0	4AWG-3/0
130	250	195	#14	1 x (4AWG-350MCM)	Lug provided by customer	1 x (4AWG-500MCM) per phase	Lug provided by customer	2AWG-4/0	4AWG-3/0
200	400	301	#14	1 x (1AWG-600MCM) or 2 x (1AWG-250MCM) per phase	Lug provided by customer	1 x (4AWG-500MCM) per phase	Lug provided by customer	2AWG-4/0	4AWG-3/0
260	400	391	#14	1 x (1AWG-600MCM) or 2 x (1AWG-250MCM) per phase	4 x (3/0 AGW-500MCM)	2 x (6AWG-350MCM)	4 x (3/0 AGW-500MCM)	2AWG-4/0	2AWG-4/0
390	600	586	#14	3 x (3/0AWG-500MCM) per phase	4 x (3/0 AGW-500MCM) per phase	4 x (4AWG-500MCM) per phase	4 x (3/0 AGW-500MCM) per phase	2AWG-4/0	2AWG-4/0
454	600	683	#14	3 x (3/0AWG-500MCM) per phase	4 x (3/0 AGW-500MCM) per phase	4 x (4AWG-500MCM) per phase	4 x (3/0 AGW-500MCM) per phase	2AWG-4/0	2AWG-4/0
518, 40 degC	800	779	#14	3 x (3/0AWG-500MCM) per phase	4 x (3/0 AGW-500MCM per phase	4 x(4AWG-500MCM) per phase	4 x (3/0 AGW-500MCM) per phase	2AWG-4/0	2AWG-4/0
518	800	779	#14	3 x (3/0AWG-500MCM) per phase	4 x (1/0 AGW-750MCM) per phase	4 x (4/0 AGW-750MCM) per phase	4 x (1/0 AGW-750MCM) per phase	1/0-350MCM	2 x (2AGW-4/0)
600	800	903	#14	3 x (3/0AWG-500MCM) per phase	4 x (1/0 AGW-750MCM) per phase	4 x (4/0 AGW-750MCM) per phase	4 x (1/0 AGW-750MCM) per phase	1/0-350MCM	2 x (2AGW-4/0)
700	1000	1053	#14	4 x (3/0AWG-500MCM) per phase	4 x (1/0 AGW-750MCM per phase	5 x (4/0 AGW-750MCM) per phase	4 x (1/0 AGW-750MCM) per phase	1/0-350MCM	2 x (2AGW-4/0)
815	1000	1225	#14	NA	4 x (1/0 AGW-750MCM) per phase	NA	4 x (1/0 AGW-750MCM) per phase	NA	2 x (2AGW-4/0)
1000	1200	1504	#14	NA	4 x(3/0 AGW-500MCM) per phase	NA	4 x (1/0 AGW-750MCM) per phase	NA	2 x (2AGW-4/0)
1200	1600	1804	#14	NA	4 x (1/0 AGW-750MCM) per phase	NA	4 x (1/0 AGW-750MCM) per phase	NA	2 x (2AGW-4/0)

*Any customer-supplied Molded Case Circuit Breaker (MCCB), Magnetic Circuit Protector (MCP), or fuses between the three-phase power source and the VSD should be in accordance with the short circuit current setting of the VSD and NEC Article 430.

** Wire sizing should be based upon NEC Table 310.16 or CEC Table 2 using 75 degC cable, an ambient of 30 degC, cable runs for less than 300 ft, and copper wiring for no more than three conductors in the raceway, cable or earth (directly buried). A de-rating factor should be taken into account for 50 degC as per NEC, CEC code, or applicable local area code. The customer should consult the NEC, CEC, or applicable local area codes standard wire tables for their own particular application, wire sizing and ambient de-rating factors.

*** Use parallel conductors instead of a single conductor (this will allow for the proper wire bending radius within the cabinet). Use separate conduits for routing parallel conductors. This prevents the need for conductor de-rating (see Note 2).

**** Lug sizes are based on using copper/aluminium bonding conductor. Refer to CEC Table 16 for copper wire and NEC Table 250.122, based on copper.

Note
Contactors used to connect drive terminals should be capable of switching low-current signals (i.e., 5 mA).
When wiring with parallel conductors, the conductors should be kept together in phase sets with U1, V1, W1 in one conduit and parallel conductors U2, V2, W2 in another conduit. The ground conductor should be in one of these conduits.
Twisted-pair wiring should be used for pressure feedback signal wiring terminals.
Pressure feedback input: 4 to 20 mA or 1 to 5-V signal two-wire twisted pair, #20 AWG; other signal circuits, use #18 AWG.

Warning
Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical

Turn off power and lockout/tagout (refer to SENS-HSE-S027) the drive before making any wiring changes.

Caution
Potential Severity: Light
Potential Loss: Assets
Hazard Category: Electrical

Use separate conduits for routing incoming power, power to motor, and control conductors. Use no more than three power conductors and one ground conductor per conduit.

6.3 GROUNDING

The VSD should be grounded in accordance with Article 250 of the National Electrical Code (NEC) or Section 10 of the Canadian Electrical Code (CEC), Part I and the grounding conductor should be sized in accordance with NEC Table 250.122 or CEC, Part I Table 16. Refer to Table 6-1. Local grounding codes may apply. A ground lug is provided inside the VSD on the ground bus.

Caution
Potential Severity: Light
Potential Loss: Assets
Hazard Category: Electrical

Conduit is not a suitable ground for the inverter.

6.4 WIRING CONSIDERATIONS FOR MECHANICAL EQUIPMENT

The following cautions and warnings should be considered for mechanical equipment and components such as motors, shafts and bearings when this equipment will be driven and controlled by a VSD.

Caution
Potential Severity: Light
Potential Loss: Assets
Hazard Category: Machinery equipment hand tools, Temperature

Surface motors operating from adjustable-speed drive power sources tend to operate at higher temperatures which may increase the need for more frequent lubrication cycles. Failure to lubricate motors driven by adjustable-speed drives could cause premature failure of the motor.

Warning

Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Operating motors at carrier frequencies higher than 5 kHz may require the motor shaft to be grounded or motor bearings to be insulated to prevent current from being passed down the shaft by capacitive coupling to ground.

Warning

Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical

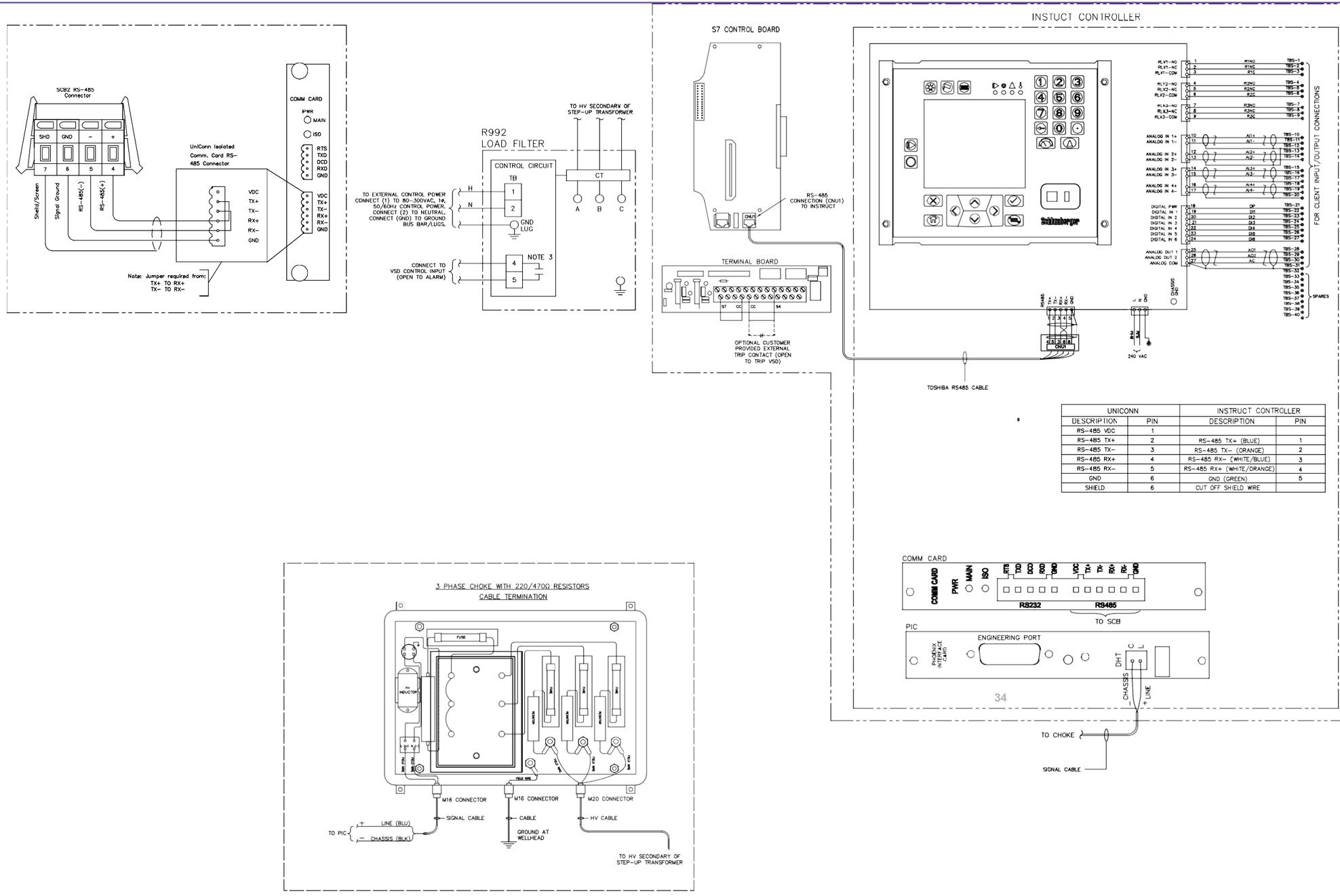
Submersible motors powered by VSD output transformers require special application concerns. Contact InTouch or LCS Engineering before starting a new VSD application.

6.5 INTERCONNECTION WIRING

The following subsections describe how the PC boards of the motor controller and the VSD are interconnected for power and communication both within the drive and to external or optional equipment. Refer to Figure 6-1 for a simplified diagram of how the controller, VSD, site communications equipment (if required), and external devices (if required) are connected. Detailed interconnection diagrams are presented in the respective subsystem manuals.

Note

Do not use this interconnection wiring for construction purposes



UNICONN		INSTRUCT CONTROLLER	
DESCRIPTION	PIN	DESCRIPTION	PIN
RS-485 VDC	1		
RS-485 TX+	2	RS-485 TX+ (BLUE)	1
RS-485 TX-	3	RS-485 TX- (ORANGE)	2
RS-485 RX+	4	RS-485 RX- (WHITE/BLUE)	3
RS-485 RX-	5	RS-485 RX+ (WHITE/ORANGE)	4
GND	6	GND (GREEN)	5
SHIELD	6	CUT OFF SHIELD WIRE	

Figure 6-1: ES7 VSD Power and Communications System Overview Block Diagram – INSTRUCT ESP Controller

6.5.1 MOTOR CONTROLLER WIRING

Refer to *the INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576) for detailed wiring and connection information.

6.5.2 VSD WIRING

For purposes of discussion in this manual, VSD wiring is confined to interconnection or communication wiring to or from the drive, or to the motor controller or other external devices in the Sensia VSD systems. Wiring internal to the Toshiba G3 or G7 is not within the scope of this manual.

6.5.2.1 VSD Terminal Board Connections

The following figures describe all control wiring connections to the VSD Terminal Board. Refer to Table 6-3 for terminal descriptions.

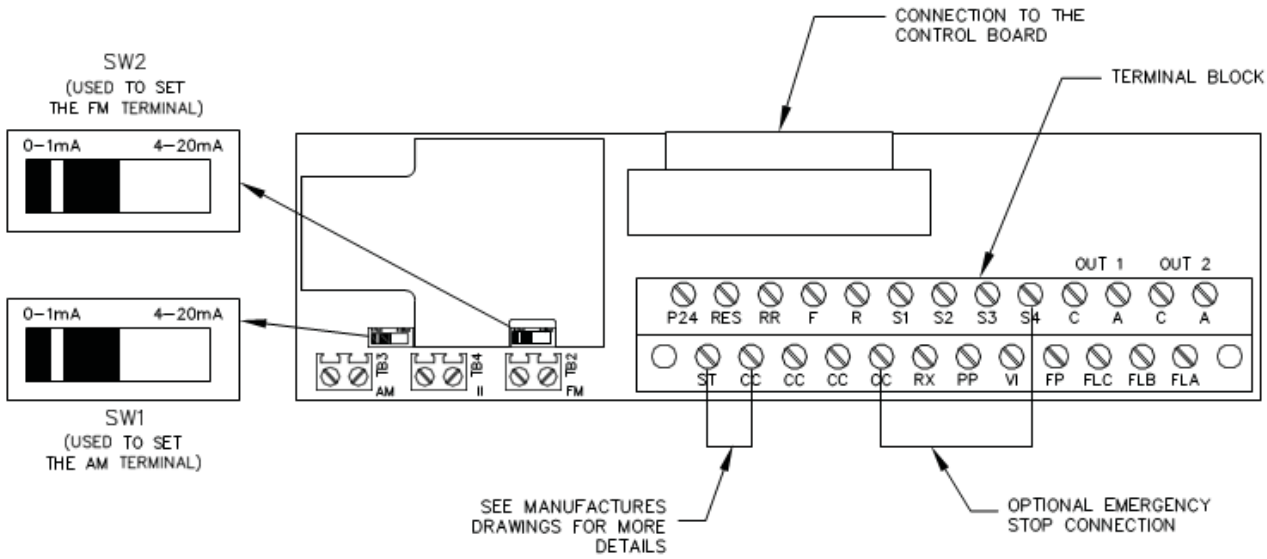


Figure 6-2: ES7 VSD Terminal Board Interconnect Diagram

The VSD Terminal Board contains two interlocks which enable and disable certain functions of the drive. See the following list for interlock descriptions.

Term	Definition
ST to CC	Opening this interlock enables the coast stop function of the VSD. Reconnecting this interlock restarts the drive if it was running before it stopped. **If the ST to CC connection is not made, the drive will not start.** **Please see** InTouch 4027175 **or I808**18 of the drawings for proper configuration of the ST-CC connection.** **Note** This interlock should not be used in the field. This interlock may cause inverter overload messages when the drive restarts.
S4 to CC	Opening this interlock causes an E-stop trip in the VSD. This must be reset before the drive can be restarted.

Table 6-3: VSD Terminal Locations

Terminal Name	Terminal Functions	Terminal Location
L1(R), L2(S), L3(T)	Line input terminals for 6- or 18-pulse models: connect to either 3-phase 50-Hz 380 to 400 volts AC or 3-phase 60-Hz 415 to 480 volts AC	VSD terminal block or bus bar
L1(R), L2(S), L3(T), 12(R2), L22(S2), L32(T2)	Line input terminals for 12-pulse models: connect to either 6-phase 50-Hz 380 to 400 volts AC or 6-phase 60-Hz 415 to 480 volts AC	
T1(U), T2(V), T3(W)	Motor output terminals. Connect these terminals to a 3-phase induction motor of the proper voltage, current, and horsepower or input to a step-up transformer.	

6.5.2.2 VSD Control Board Connections

The Sensia ES7 VSD Control Board is located directly above the Terminal Board and is in the direct center of the VSD when viewing the drive with the enclosure door open. Refer to Figure 6-3.

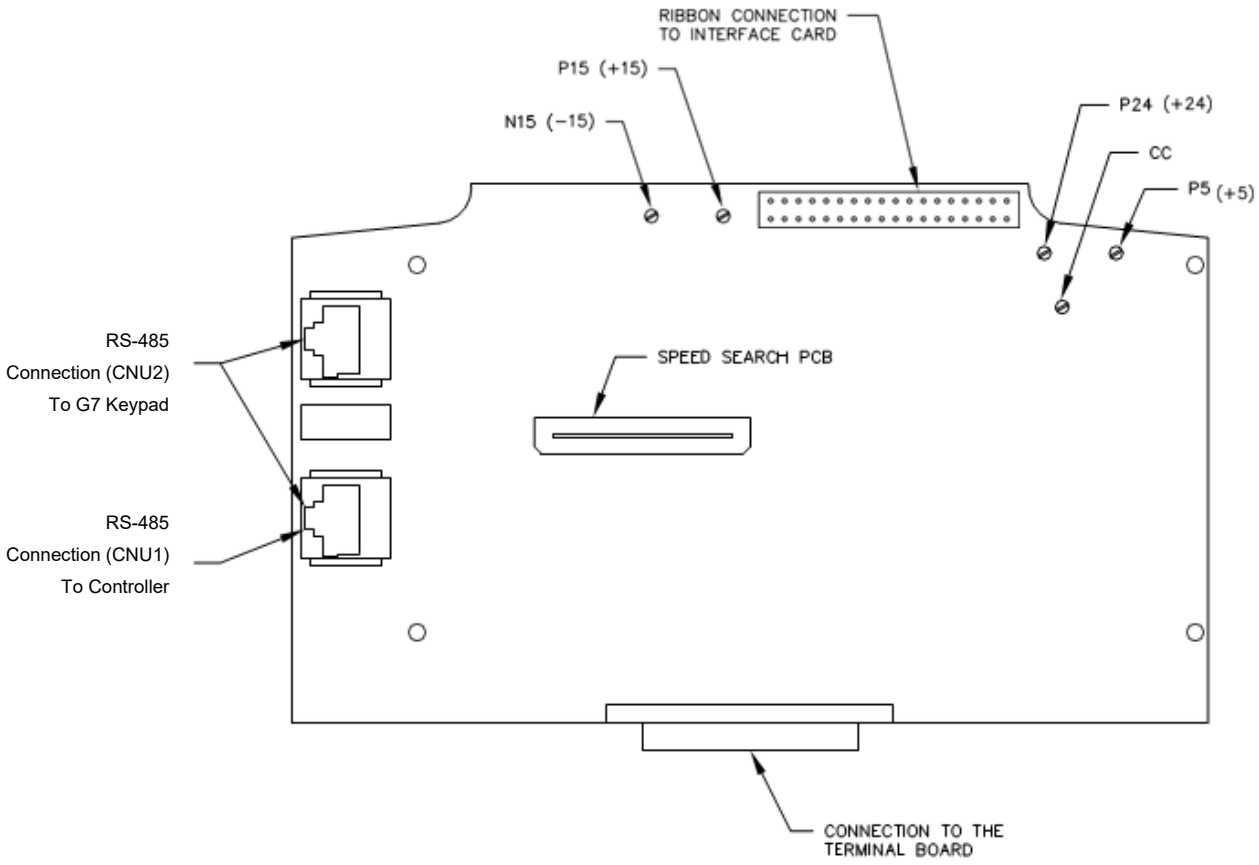


Figure 6-3: ES7 Control Board Diagram

6.5.2.3 Controller RS-485 Wiring

The controller connects to ES7 VSD via 4-wire RS-485, from the operator's choice of one of the four expansion slots or the native RS-485 port. The VSD will use the CNU1 from the control board. The default communication setting for both devices is 9600-8-1-E, and it is recommended to leave this unchanged.

Table 6-4: RS-485 Wiring Cross Reference

Description	Cable Color Code		
	CAT 5	CAT 6	Pin
RS-485 TX	Blue	Blue	1
RS-485 TX-	Orange	Blue/White	2
RS-485 RX-	White/Orange	Green	3
RS-485 RX+	White/Blue	Green/White	4
GND	Green	Brown	5
Shield Wire			5

Figure 6-4: INSTRUCT ESP Intelligent Controller Control Card RS-485

Note:

The RX+ and RX- terminals are reversed as compared with the Communication Card (101120028).

Note:

For RS-485 connections, ensure that the shield wire is connected to the RS-485 GND pin (pin 5) of the INSTRUCT Control Card. Do not connect the shield to Chassis GND.

Section 7: **Operator Interface**

For the operator interface of the motor controller, refer to the *INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576)

Section 8: **Installation**

This section describes how to install the VSD on location. Installation procedures for optional and combinable equipment for the drive (site communications, external inputs or output devices such as transducers) are discussed in Section 10: Optional and Combinable Equipment.

Potential Severity: Major
Potential Loss: Assets, Personnel, Reputation
Hazard Category: Electrical, Explosives, Machinery equipment hand tools

Troubleshooting or servicing a VSD must be performed by qualified personnel. “Qualified personnel” is defined as personnel who have attended and successfully completed the required trainings. Only then should qualified personnel contact InTouch for additional support and troubleshooting/repair instructions.

8.1 INSTALLATION SAFETY PRECAUTIONS

1. Install the drive in a secure and upright position in a well-ventilated location. NEMA 3R/ IP56 enclosures are used in outdoor applications. A sun-shaded roof is recommended if the drive is installed in the direct sunlight, a temperature derating factor may be required. Temperature should range from -40 degF (-40 degC) to 122 degF (50 degC).
2. For NEMA 3R/ IP56 units, allow a clearance space of 8 in (20 cm) for the top and 6 in (10 cm) on both sides. Do not obstruct any of the ventilation openings. Rear ventilation requires free air flow for proper cooling. NEMA 1 units need 6 in (15 cm) for ventilation in the back; no side clearance is required.
3. Avoid installation in areas where extreme vibration, extreme heat, or sources of electrical noise are present.
4. Adequate working space should be provided for adjustment, inspection, and maintenance of the drive.
5. Adequate lighting should be available for troubleshooting and maintenance.
6. A non-combustible insulating floor or mat should be provided in the area immediately surrounding the electrical system where maintenance is required.
7. Always ground the unit properly to prevent electrical shock and to help reduce electrical noise.

Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

A separate ground cable should be run inside the conduit with the input, output, and control power cables (Refer to section 6.3 Grounding in the Wiring section of this manual). The metal of conduit is not an acceptable ground.

8. Use lockout/tagout procedures before connecting three-phase power of the correct voltage to input terminals (L1, L2, L3 [R, S, T] for a 6- or 18-pulse drive; L1, L2, L3 [R, S, T] and L4, L5, L6 [R2, S2, T2] for a 12-pulse drive) and connect three-phase power from output terminals T1, T2, T3 (U, V, W) to a motor of the correct voltage and type for the application. Size the conductors in accordance with section 6.2 Selection of Wiring Equipment and Standard Cable Sizes.
9. If conductors of a smaller than recommended size are used in parallel to share current, then the conductors should be kept together in sets i.e., U1, V1, W1 in one conduit and U2, V2, W2 in another. National and local electrical codes should be checked for possible cable derating factors if more than three power conductors are run in the same conduit, through the same hole in the cabinet or through a non-metallic flange or bulkhead. Temperatures can become excessive if phase U1, U2, and/or U3 cables are in proximity to each other (eddy current field effect).

10. Use separate metal conduits for routing the input power, output power, and control circuits.
11. Installation of drive systems should conform to the National Electrical Code, regulations of the Occupational Safety and Health Administration, and all national, regional, or industry codes and standards when installed in the United States. Other codes may apply if installed outside of the US.
12. Do not connect control circuit terminal block return connections marked CC to VSD earth ground terminals marked GND(E). Refer to section 6.5.2.2 VSD Control Board Connections and section 6.5.2.1 VSD Terminal Board Connections.

Warning
Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

If a secondary Magnetic Contactor (MC) is used between the VSD output and the load, it should be interlocked so that the ST-CC terminals on the VSD terminal board are disconnected before the output contactor is opened. If the output contactor is used for bypass operation, it must also be interlocked so that supply power is never applied to the drive output terminals (U,V,W).

Warning
Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Power factor improvement capacitors or surge absorbers must not be installed on the VSDs output.

13. Never install any type of starter(s) or contactor(s) on the drive output to switch motor loads instantaneously.
14. Only qualified personnel should install this equipment.

8.2 CONTROLLER MOUNTING

The following tools are required to mount the controller.

1.	7/64” Hex Key	
2.	5/16-in Slotted Screwdriver	
3.	Torque Screwdriver Set	
4.	3/8” Nut Driver	

5.	Adjustable Wrench	
6.	USB Flash Drive (with FAT 32 file system)	
7.	USB Type-B Cable (quantity 2)	
8.	USB Isolator (PN 102837305, MFG PN B&B UH401)	
9.	StarView V5+ Software application	

1. Make sure that the connectors and cables for RS-485, ferrite bead, power and I/O are not damaged.
2. Remove the screws from the controller's bezel with a 7/64-in hex key.

Figure 8-1 - Controller Bezel Removal

3. Install the controller into the opening provided on the VSD door and hold it in place from the inside of the VSD door.

Note
A minimum of two qualified personnel is necessary. One person holds the nuts and the controller from inside of the drive, while the other person installs the screws on the outside of the drive.

Figure 8-2- Controller Mounting Tabs

4. Install the screws into the four pre-drilled holes located on the outside of the VSD door. Install these screws with a 5/16-in slotted screwdriver.

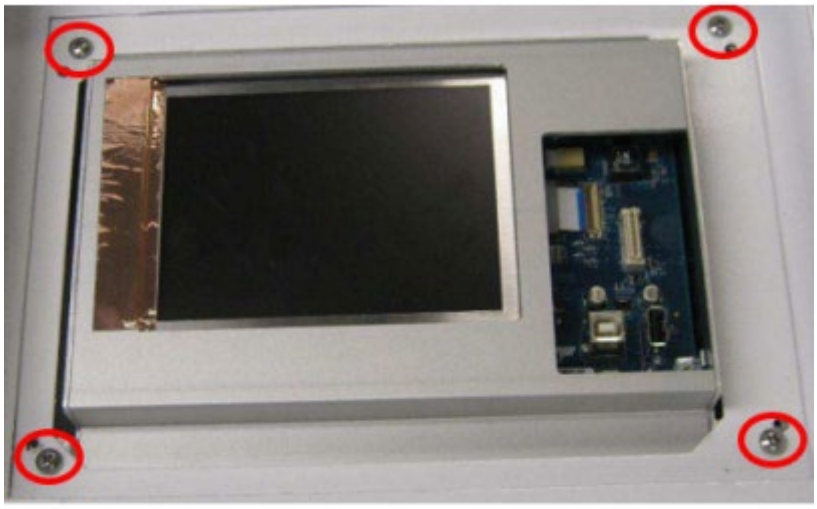


Figure 8-3 - Controller Bezel Removed

Note:

A 3/8-in nut driver or an adjustable wrench is necessary to hold the nuts from inside of the VSD door, while the screws are installed from the outside of the VSD door (torque to 16 lbf-in). The recommended screw size is MS Binding 10-32 x 1/2-in Slot Drive, and the recommended nut size is Locknut Hex 10-32 Steel Zinc KEPS.

5. Make sure that the controller is correctly secured on the drive's cabinet.

Figure 8-4 - Controller Mounted from the Inside

Caution

Potential Severity: Light
Potential Loss: Assets
Hazard Category: Machinery equipment hand tools, Temperature

Before you plug in the power connector for AC power supply, verify that L, N, and Ground wires are not interchanged and are as per the input label on the controller. For a DC power supply, make sure that DC ± are not interchanged.

6. Connect the Power connector to the controller.

Figure 8-5 - Power to the Controller

7. Verify that the RS-485 wiring connection is correct per section **6.5.2.3 Controller RS-485 Wiring**.

8. Connect the RS-485 connector to the controller.
9. Connect the I/O connectors on the I/O card of the controller. Refer to the rear label of the controller for more information on the I/O card pin out.
10. Align the Display connector with the bezel of the controller.

Figure 8-6 - Installing the Bezel

11. Reinstall the screws on the bezel/keypad. Torque the screws to 3 lbf-in.

Figure 8-7 - Bezel Installation

8.3 INPUT AND OUTPUT POWER WIRING (18P ONLY)

The terminals for the input and output connections to the drive are housed in a junction box at the rear of the drive. Figure 8-8 shows the junction box with the access cover removed to show the terminals.

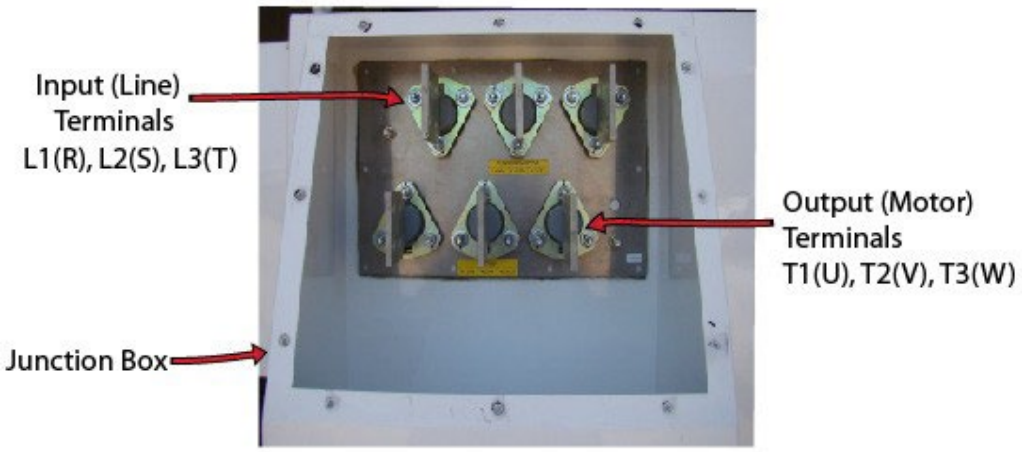


Figure 8-8: Input and Output Terminals for 18P

Note
Each input/output terminal can accommodate up to a four-phase conductor, subject to the size of the cable lugs.

Complete the following procedures to connect to the input and output of the drive. Refer to 6.2 Selection of Wiring Equipment and Standard Cable Sizes and 6.3 Grounding.

1. Connect the incoming cables to input terminals L1(R), L2(S), and L3(T).
2. Connect the outgoing cables to the output terminals T1(U), T2(V), and T3(W).

8.4 CONFIRMATION OF WIRING

Make the following final checks before applying power to the unit:

1. Confirm that source power is connected to terminals L1(R), L2(S), and L3(T) for a 6-pulse or 18-pulse Sensia ES7; L1(R), L2(S), L3(T) and L12(R2), L22(S2), L32(T2) for a 12-pulse. Connection of incoming source power to any other terminals will damage the drive.
2. The three-phase source power should be within the correct voltage and frequency tolerances.
3. The output leads must be connected to terminals T1(U), T2(V), and T3(W).
4. Make sure there are no short circuits or inadvertent grounds and tighten any loose connector terminal screws.

8.5 START-UP TEST

Caution
Potential Severity: Light
Potential Loss: Assets
Hazard Category: Machinery equipment hand tools, Temperature

Prior to releasing an electrical drive system for regular operation after installation, a start-up system test should be performed by qualified personnel. This start-up test assures correct operation of the equipment, system reliability, and safe performance. It is important to schedule time for a start-up test, to conduct it, and document it. Perform start-up testing as described in Section 9: Start-up and Commissioning.

When power is applied for the first time, the drive's parameters are set to default values that may or may not be appropriate for the application. If these settings are not optimal for the application, the desired settings must be programmed before initiating a run. The drive can be operated with no motor connected.

Note

Operation with no motor connected or use with a small trial motor is recommended for initial adjustment or for learning to adjust and operate the drive.

Section 9: **Start-up and Commissioning**

This section describes step-by-step procedures for starting up and commissioning new VSD installations. Some steps are included for equipment that is optional and combinable with the drives, where practical. If this manual does not include information for the optional equipment attached to your drive application, refer to the appendices of this manual (specifically reference material and third-party information) for additional information.

If at any point during the start-up and commissioning process it is found that there are damaged components or unexpected results, please refer to the troubleshooting procedures in Section 12: Troubleshooting.

Potential Severity: Major
Potential Loss: Assets, Personnel, Reputation
Hazard Category: Electrical, Explosives, Machinery equipment hand tools

Troubleshooting or servicing a VSD must be performed by qualified personnel. Qualified personnel is defined as personnel who have attended and successfully completed the required trainings. Only then should qualified personnel contact InTouch for additional support and troubleshooting/repair instructions.

9.1 REQUIRED STARTUP EQUIPMENT AND TOOLS

Before attempting any start-up procedures, ensure that the personnel assigned to the job have the required equipment and tools listed in the VSD Tools Kit (part number 100072064). The list may also be obtained and items ordered from Lift Control Systems.

9.2 PRE-POWER UP CHECKS FOR INITIAL STARTUP

9.2.1 INSTALLATION CHECKLIST

Perform the following pre-power up checks:

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Use appropriate lockout/tagout procedures (refer to SEN-HSE-S027) to ensure that VSD power is OFF before proceeding with the following checks and procedures.

Use a Volt Ohm Meter (VOM) to verify that ALL power is OFF on the VSD, including

- Incoming line at the bottom of the circuit breaker
- Motor terminals
- DC bus

1. Verify that the board numbers, switch settings, and jumper settings are correct for the application and that connections to the proper taps of the CPT(s) are made. Use the drawings as reference.

Note
Pay special attention to the setting for the ST-CC jumper. See InTouch Content ID 4027175 for more details.

2. Verify all connectors are properly plugged in.

3. Perform a thorough visual check of all drive components. Ensure that resistors are not bent and circuit board components are not broken. If capacitors are visible, ensure they are connected with correct polarity.
4. Ensure that the drive is clean and free of debris, dust, cobwebs, etc.
5. Verify that the installation is properly grounded.
6. Verify that the input and output cables for the installation are appropriately sized and properly terminated.
7. Verify that the customer interface wiring is properly installed and ready to be connected to the application.
8. Verify that the wiring is properly installed and connected in the motor terminal box.
9. Disconnect the motor leads at the drive output terminals and perform a spot insulation resistance check ("megger") on the motor and cables. Do not reconnect motor leads.
10. Check the tightness on all cable and bus connections.
11. Check all fuses before power-up. A blown fuse indicates that power has been applied to the drive prior to arrival. Do not simply replace the fuse. Check fuses and main wiring connections for loose components and connections and tighten as necessary.
12. Use a VOM to check the soft-start resistor (refer to the appropriate schematic for resistor value specified on the drawing).
13. Ensure Category-6 (CAT6) communication cable for the ES7 has been installed from the controller to the VSD.

9.2.2 COMMUNICATION SETTINGS

Refer to *LCS-ENG-M00013 INSTRUCT ESP Controller-ES7 Configuration Manual*.

9.2.3 BASIC VSD CONFIGURATION

Refer to *LCS-ENG-M00013 INSTRUCT ESP Controller-ES7 Configuration Manual*.

9.3 MAIN POWER CIRCUIT CHECKS FOR INITIAL STARTUP

Perform the following procedures to check all components in the main power circuit for proper function:

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Turn all power OFF and use lockout/tagout procedure (refer to SEN-HSE-S027) before making changes to transformer taps or connecting wires to components.

1. Use a VOM to ensure that the DC bus capacitors have been completely discharged.

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Do not trust the LED inside the VSD cabinet to indicate discharge state of the DC bus capacitors.

2. Use a VOM to test the following main circuit components:
   - control power fuses including the fuses for the 120V power receptacle
   - DC bus fuse(s)

- sinewave filter fuses and fuse switches (SWD only)
- softstart resistor — Refer to the appropriate drawing for resistor value.
- DC bus capacitors — Check the charge and discharge rate of the capacitors and ensure that the charge rate is faster than discharge. Use the diode mode of the VOM to charge the capacitors and DC volts mode to discharge.
- discharge resistor R22 - Manually push in MS2 to take reading (if applicable).
- thermistor (should read 18 to 24 kohms at room temperature)

Danger

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Be aware of voltage located at the line side of the input circuit breakers and at the 120V receptacle located on the front of the drive, where applicable. This is convenient for the use of tools and laptop, but use caution when checking components near the circuit for the receptacle, including CPT2. See manufacturer drawing I808xx08 for details on the circuit components. The fused disconnect switch, FDSW, can be opened for safety, however there will still be 480 VAC located at the line side of the circuit breaker and the disconnect switch.

3. Verify the DIP switch settings on the Interface Board for double and triple inverter drives. Refer to the manufacturer's drawing 1808xx29 for details, or InTouch ID 4898039.

9.3.1 CHECKING INPUT DIODES (IN CIRCUIT)

This section describes how to test the input diodes (rectifiers) with the diodes installed in their operating circuit. If VOM readings do not display as shown, refer to section 12.4.1.2 for checking input diodes when isolated from the circuit.

Refer to the table below for values that should be read on the VOM with the diodes in circuit. Use the diode tester function of the VOM.

Note

A charging indication on the VOM is caused by the charging action of the DC bus filter capacitors through the forward-biased diode.

Table 9-1: Input Diode Test Reading (Diode in Circuit) for 6 &12 Pulse

Meter (+)	Meter (-)	Reading
DC Bus +	Input R	Charging
DC Bus +	Input S	Charging
DC Bus +	Input T	Charging
Input R	DC Bus +	0.2 to 0.6 volts DC
Input S	DC Bus +	0.2 to 0.6 volts DC
Input T	DC Bus +	0.2 to 0.6 volts DC
DC Bus -	Input R	0.2 to 0.6 volts DC
DC Bus -	Input S	0.2 to 0.6 volts DC
DC Bus -	Input T	0.2 to 0.6 volts DC
Input R	DC Bus -	Charging
Input S	DC Bus -	Charging
Input T	DC Bus -	Charging

Table 9-2: Input Diode Test Reading (Diode in Circuit) for 18 Pulse

Meter (+)	Meter (-)	Reading
DC Bus +	Input R	Charging
DC Bus +	Input S	Charging
DC Bus +	Input T	Charging
Input R	DC Bus +	0.2 to 0.6 VDC
Input S	DC Bus +	0.2 to 0.6 VDC
Input T	DC Bus +	0.2 to 0.6 VDC
DC Bus -	Input R	0.2 to 0.6 VDC
DC Bus -	Input S	0.2 to 0.6 VDC
DC Bus -	Input T	0.2 to 0.6 VDC
Input R	DC Bus -	Charging
Input S	DC Bus -	Charging
Input T	DC Bus -	Charging
DC Bus +	L9	Charging
DC Bus +	L6	Charging
DC Bus +	L8	Charging
DC Bus +	L4	Charging
DC Bus +	L7	Charging
DC Bus +	L5	Charging
L9	DC Bus +	0.2 to 0.6 VDC
L6	DC Bus +	0.2 to 0.6 VDC
L8	DC Bus +	0.2 to 0.6 VDC
L4	DC Bus +	0.2 to 0.6 VDC
L7	DC Bus +	0.2 to 0.6 VDC
L5	DC Bus +	0.2 to 0.6 VDC
DC Bus -	L9	0.2 to 0.6 VDC
DC Bus -	L6	0.2 to 0.6 VDC
DC Bus -	L8	0.2 to 0.6 VDC
DC Bus -	L4	0.2 to 0.6 VDC
DC Bus -	L7	0.2 to 0.6 VDC
DC Bus -	L5	0.2 to 0.6 VDC
L9	DC Bus -	Charging
L6	DC Bus -	Charging
L8	DC Bus -	Charging

9.3.2 CHECKING IGBTS (IN CIRCUIT)

This section gives step-by-step procedures for testing the IGBTs while they are installed in their operating circuit.

Note

Charging indication is due to the charging action of the DC Bus filter capacitors through the forward-biased freewheeling diode across the opposite IGBT.

1. Attach the VOM leads as shown in Table 9-3.

Table 9-3: VOM Connection Points and Readings

Meter +	Meter -	Reading
DC Bus +	Output U	Charging
DC Bus +	Output V	Charging
DC Bus +	Output W	Charging
Output U	DC Bus +	0.2 - 0.6 volts DC
Output V	DC Bus +	0.2 - 0.6 volts DC
Output W	DC Bus +	0.2 - 0.6 volts DC
DC Bus -	Output U	0.2 - 0.6 volts DC
DC Bus -	Output V	0.2 - 0.6 volts DC
DC Bus -	Output W	0.2 - 0.6 volts DC
Output U	DC Bus -	Charging
Output V	DC Bus -	Charging
Output W	DC Bus -	Charging

2. Ensure that the VOM readings match or approximate those shown in Table 9-3.

Caution

If an IGBT is found damaged or failed, all IGBTs in the phase must be replaced. The gain codes on the IGBTs in parallel must match and can only be off by one if in series.

The associated gate protect board, snubber boards (two-part numbers per phase) and gate driver board in the phase must also be replaced.

9.3.3 MAIN POWER TEST

Perform the following test to make sure the drive's power supplies are functioning properly.

1. Turn the main breaker(s) ON to apply power to the drive.
2. Refer to Figure 9-2 and Table 9-4. Ensure that all power supplies are working properly using a VOM for measurements (+5 V, +15 V, –15 V, +24 V).

Warning

Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

DO NOT touch pins on the VSD Terminal Board or Control Board together as this will produce a short that will damage the circuit board.

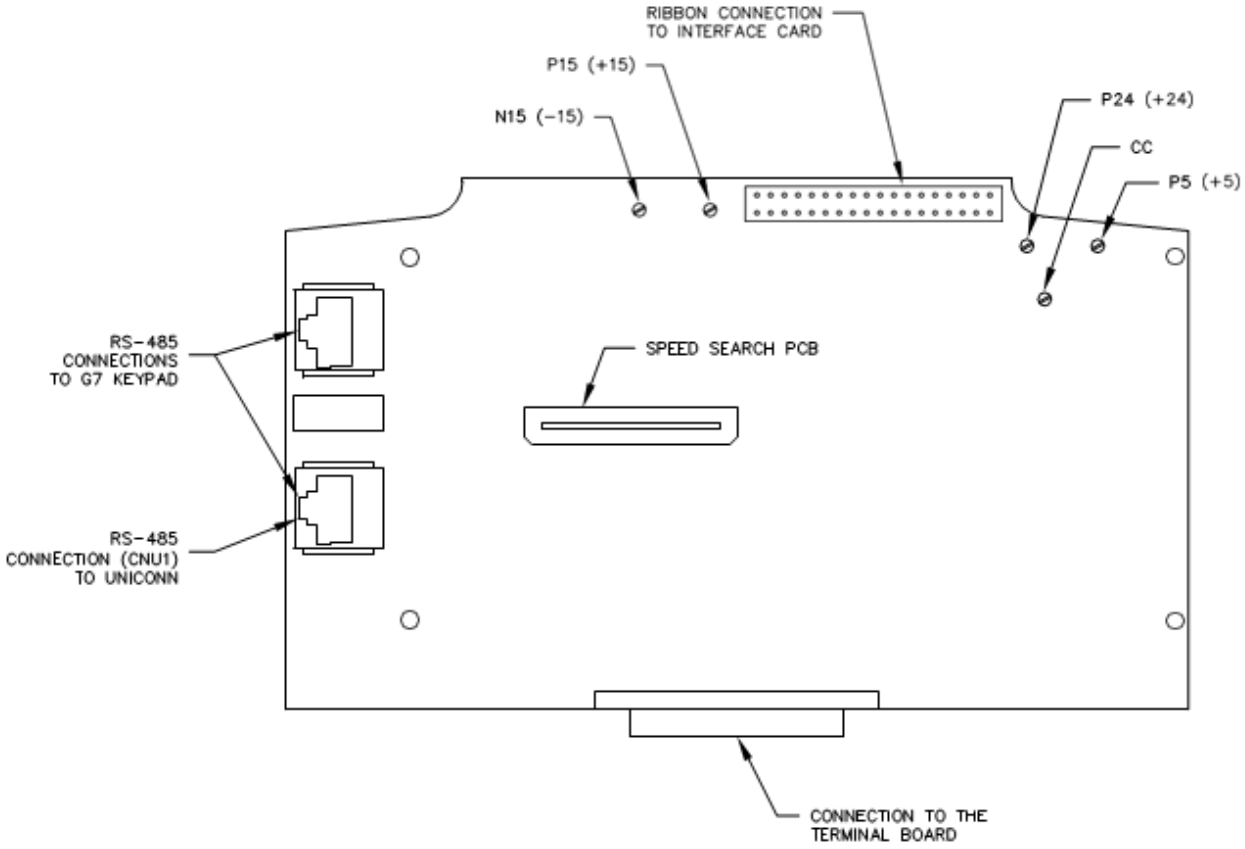


Figure 9-1: ES7 VSD Control Board (Control Power Test Points)

Table 9-4: ES7 Control Power Supplies Test Points and Readings

Power Supply (nominal volts)	Permissible Voltage Range (volts DC)	Test Point Probe	Test Point Common
+15	14.4 to 15.6	P15 see Figure 9-2	Terminal CC
-15	-14.4 to -15.6	N15 see Figure 9-2	Terminal CC
+5	4.8 to 5.2	P5 see Figure 9-2	Terminal CC
+24	21 to 27	P24 see Figure 9-2	Terminal CC

Figure 9-2: ES7 VSD Control Test Points

3. If the readings shown in Table 9-4 are good, go to the next section in this procedure. Otherwise, turn the main breaker(s) OFF to remove power to the drive and begin troubleshooting procedures as outlined in Section 12: Troubleshooting.

9.3.4 SEQUENCE TESTS

The following tests are performed to ensure that the drive's timed and monitored sequences occur according to specification.

1. Refer to the *INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576) for the appropriate commissioning procedures for the controller. See specifically the Variable Speed Drive section in the controller manual.
2. Perform a basic setup of the HMI or controller so that the drive can be started in the following procedure.
3. If the drive is equipped with an MST timer, set it to minimum and apply power. The input circuit breaker should trip. Reset the circuit breaker and set the MST between 0.3 and 3 seconds.
4. Apply power and ensure that MS2 picks up. Approximately one (1) second later, MS1 should close.
5. If applicable, test the blown fuse indicator circuit by pulling the tab on one of the indicators. The input circuit breaker should trip. Reset the blown fuse indicator.
6. Reset the input circuit breaker and, if applicable, remove the device defeating the door switch interlock. Turn the main power ON. Test the door switch interlock circuit by opening the drive enclosure door. The input circuit breaker should trip.
7. Reset the input circuit breaker. Apply power and test the fan circuit by running the drive.
8. For an 18-pulse configuration, verify that the fans have the correct phase sequence and that airflow comes from the bottom. The cooling fans in the transformer section are 3-phase, therefore, they are phase sensitive.

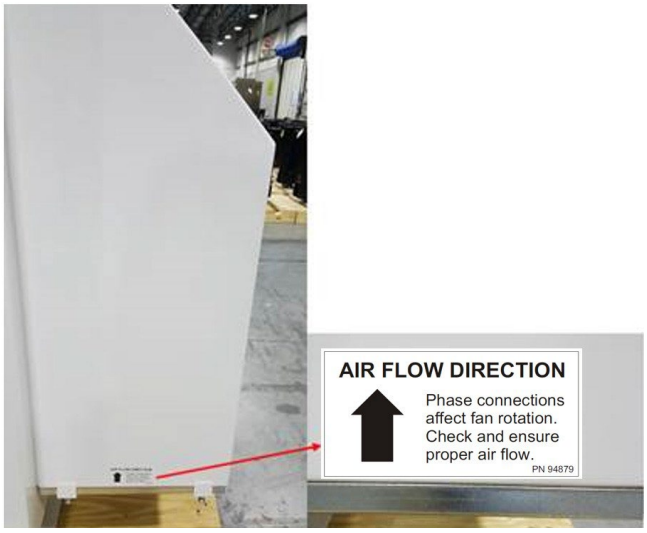


Figure 9-3: Air Flow Label (shown on an 18P VSD)

9. Test all remaining sequences (differs by application/jobsite).

9.3.5 FULL OUTPUT VOLTAGE TEST (NO LOAD)

This test checks the VSD for proper operation without a load (motor) attached. Perform the following steps:

1. Run the drive at 20 Hz. With a VOM set to AC voltage mode, check to see that the voltages between the three outputs (U-V, V-W, and U-W) are balanced. For the SWD, take a reading before the filter. Because the drive signal is PWM instead of sinusoidal, a VOM set to AC volts may not read accurately, but all three outputs should give the same reading.
2. For the SWD, check voltage at the output of the drive to make sure the sine wave filter is working correctly.
3. Run the drive up to 60 Hz. With a VOM set to AC voltage mode, verify that the voltages between the three outputs (U-V, V-W, and U-W) are balanced. For the SWD, take a reading before the filter. Because the drive signal is PWM instead of sinusoidal, a VOM set to AC volts may not read accurately, but all three outputs should give the same reading.
4. For the SWD, check voltage at the output of the drive to make sure the sine wave filter is working correctly.
5. Turn the power OFF.

9.3.6 FULL VOLTAGE OUTPUT (WITH LOAD)

This test checks the VSD for proper operation with a load (motor) connected.

1. Ensure all power is OFF. Connect the load leads to the drive output lugs.
2. Apply power and run the drive at 20 Hz. Monitor load current on the controller display.
3. Ramp the drive up to 60 Hz.
4. Use a clamp-on ammeter to check for balanced current between the power units if you have a double or triple inverter drive (518 to 1500 kVA).
5. Use clamp-on ammeter to check for balanced current between U, V, and W outputs to the load windings. Monitor the drive performance for a reasonable period of time to ensure proper operation.
6. Turn the power OFF.
7. Remove the load leads from the drive output lugs.

9.4 COMMISSIONING PROCEDURES

9.4.1 STEP-UP TRANSFORMER STARTUP AND CHECKS

Perform the following steps to verify that the output transformer is functioning properly.

1. Set the output transformer for the correct output voltage for the application.
2. Connect transformer input terminals to the drive output terminals.
3. Turn the main circuit breaker ON (MCCB1 for 6-pulse & 18-pulse, MCCB1 + MCCB2 for 12-pulse).
4. Start the VSD and ramp the drive up to 60 Hz. Check for proper operation of the VSD and transformer.
   a. Check voltage at the transformer output.
   b. The output voltages measured at the transformer should be balanced at ±2%.

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical

Only designated personnel qualified to operate high voltage equipment shall be permitted to take measurement. Use appropriate PPE when taking these measurements.

Note

Incorrect voltages may appear if the VSD is in any mode other than Constant Torque Volts/Hz pattern (Advanced/Expert settings).

5. Stop the VSD after confirming correct output voltages at the output transformer.
6. Turn the main circuit breaker OFF (MCCB1 for 6 & 18-pulse, MCCB1 + MCCB2 for 12-pulse).

9.4.2 CONNECTING THE VSD TO DOWNHOLE EQUIPMENT

Once the controller, the VSD, and the output transformer are verified, perform the following steps to connect the drive to downhole equipment, start it up, and check for proper operation.

1. Verify that all downhole equipment has been checked out before and after being run in the hole. Verify motor resistances (phase-to-phase and phase-to-ground) are correct.
2. Connect the VSD output cables to the downhole equipment at the wellhead.
3. Turn ON the main circuit breaker (MCCB1 for 6 & 18-pulse, MCCB1 + MCCB2 for 12-pulse).
4. Start the VSD.
5. Perform a calibration on the current monitoring components of the VSD from the ADJ key on the Load Monitoring Screen (Menu, Motor, Load) if applicable.
6. Reset the UNDERLOAD, TARGET, and OVERLOAD CURRENT settings of the VSD.
7. If the artificial lift system is equipped with pressure monitoring equipment, the VSD must be calibrated to the pressure transducers providing the output signal.
8. Once all external signals and subsystems have been connected to the drive, run the drive for a reasonable period of time to confirm proper operation and that no faults or shutdowns occur.
9. Download configuration/history/data for future reference by saving the site file (“.site”) in StarView Wellsite Display Software.

Potential Severity: Light
Potential Loss: Assets
Hazard Category: Machinery equipment hand tools, Temperature

Depending on the type of external devices connected to the VSD and their functions, it may be best to test drive shutdowns and other conditions with only the transformer connected to minimize wear and tear on the downhole equipment.

Section 10: **Optional and Combinable Equipment**

Data acquisition and remote access equipment, such as SCADA (Supervisory Control and Data Acquisition) systems, are optional for VSDs and must be specified and ordered for the individual application. If the drive is equipped with a controller, an expansion card for SCADA applications is shipped with the controller and appropriate documentation is included with it when ordered.

Detailed theory and complex troubleshooting techniques for optional equipment are beyond the scope of this manual. Where applicable, a reference or link to additional reference material for optional equipment is included.

10.1 SCADA EQUIPMENT

If the VSD you are installing or servicing is configured for remote data acquisition or control, SCADA equipment must be connected to the drive. This section describes how the equipment is physically and logically connected to the VSD.

10.1.1 PHYSICAL CONNECTION

Refer to *INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576) for the physical connection to SCADA system.

10.1.2 TEMPORARY SCADA CONNECTION

For installations that require temporary connection or are point-to-point in nature, a DB-9F connector can be used to mate with the DB-9M connector provided. Additional handshaking signals are available on the DB-9M connector. These signals include CTS/RTS and DSR/DTR. At the present time, the Modbus Driver software does not support or require the use of these signals. Should your application require the use of one or more of these handshake signalling lines, please contact Artificial Lift InTouch. The port can be configured for RS-485 4–wire or RS-232. Please contact InTouch Support for detailed instructions.

10.1.3 MODBUS ADDRESS MAP

Refer to the Controller Telemetry Tables (InTouch ID 6145281) for Modbus Addresses if your drive is equipped with the INSTRUCT ESP controller.

10.2 COMMUNICATION EQUIPMENT INSTALLATION, COMMISSIONING, MAINTENANCE AND TROUBLESHOOTING

SCADA equipment or site communication equipment is optional for Sensia ES7 VSD systems. The standard site communication solution for Sensia ES7 drives is the INSTRUCT SCB3.

However, equipment other than the SCB may be specified. For installing site communication equipment other than the SCB, refer to the manufacturer's recommendations and documentation.

Training is required before installing, commissioning, and operating Sensia site communication equipment.

Note

Only qualified personnel should perform SCB installations. Installation requires knowledge of the PAC, satellite modem, satellite network, end devices, and industrial electrical and communication wiring. The installer is responsible for installing the equipment according to local electrical and hazardous location regulations. The Sensia training center offers a training course on the installation of SCB.

For detailed installation instructions for the SCB, refer to InTouch ID 4458031- espWatcher Installation Reference Page. Installation topics include SCB mounting location, antenna installation, antenna aiming, satellite modem installation, PAC setup, power and communication cabling, and appendices which contain field wiring instructions for external devices to the SCB. Also included is information on operation, maintenance and troubleshooting of the SCB.

Section 11: **Maintenance**

Danger

This section discusses preventive maintenance required for ES7 drives. Recommended service intervals for maintenance procedures (especially life-limited parts and components) are included.
Potential Severity: Major
Potential Loss: Assets, Personnel, Reputation
Hazard Category: Electrical, Explosives, Machinery equipment hand tools

Troubleshooting or servicing a VSD must be performed by qualified personnel. “Qualified personnel” is defined as personnel who have attended and successfully completed the required trainings. Only then should qualified personnel contact InTouch for additional support and troubleshooting/repair instructions.

11.1 PERIODIC INSPECTION

Maintenance for variable speed drives includes periodic inspections for drives that seemingly are functioning properly but have been in service for a reasonable amount of time. Often, visual inspection can identify a problem or malfunction before it gets serious enough to require the drive to be shut down for maintenance or repair, or the drive registers a fault and shuts down by itself. Table 11-1 lists the major visual inspection objectives that should be checked on a periodic basis:

Danger

Potential Severity: Major
Potential Loss: Assets, Personnel, Reputation
Hazard Category: Electrical, Explosives, Machinery equipment hand tools

Use lockout/tagout procedures in accordance with local electrical codes before performing any drive maintenance.

Do not use liquid cleaning agents.

Table 11-1: Periodic Visual Inspection Checklist

Inspection Item	Recommended Inspection Interval	Recommended Action
Drive cleanliness	Each time drive is checked	• Carefully inspect doors, handle, door interlock, and enclosure for damage. • Check for moisture or any signs of dripping inside the cabinet. Eliminate any source of moisture, grease, dust, insects, etc. Seal off cable glands, hubs, cracks or openings that have allowed foreign objects to enter the drive. • Remove accumulated dust, sand, and dirt by vacuuming. Do not use compressed air, as it may contain moisture and blow debris elsewhere within the enclosure.

Inspection Item	Recommended Inspection Interval	Recommended Action
Check electrical components and connections for tightness	6 - 12 months or as required	• Check devices such as contactors, breakers, PTs, CTs, controller, etc. for wetness, corrosion, or contamination. Replace damaged parts if necessary. • Check loose connections on power and control terminals. Tighten with proper tools as required. • Inspect current carrying parts such as fuse clips and line/load terminals for corrosion or other abnormalities. Replace damaged parts if necessary.
Soft charge resistor	3 - 6 months	Check for discoloration or cracks.
Main capacitors	Each time drive is opened for inspection	Check for evidence of leakage, rupturing, breakage, or expansion. Replace damaged capacitors if necessary. Capacitors should be replaced in pairs at a minimum.
Heat sinks	• Each time drive is checked or every 3 months at minimum • Depending upon prevailing conditions. Frequent inspection is required in areas of excess dust, sand, insects, or high humidity.	• Keep the exposed heatsinks free of dust, debris, insects, moisture, etc. • Check for any abnormal noise or vibration on the heatsink fan/motor. Replace damaged parts if necessary. • Remove housing and clean between fins of heatsink if lacking adequate air flow. • Replace the heatsink fan/motor if the total operating time is approaching or exceeding the service life. Refer to Table 11-2.
Heat exchanger	• Each time drive is checked or every 3 months at minimum • Dependent upon prevailing conditions. Frequent inspection is required in areas of excess dust, sand, insects, or high humidity.	• Check for proper air flow through VSD enclosure from outside and inside the enclosure. • Keep the heat exchanger free of dust, debris, insects, moisture etc. • Check for abnormal noise or vibration on the fan/motor. Replace damaged parts if necessary. • Replace the heat exchanger fan/motor if the total operating time is approaching or exceeding the service life. Refer to Table 11-2.

Inspection Item	Recommended Inspection Interval	Recommended Action
Internal cooling fans including capacitor fans (muffin fans)	Each time drive is checked or every 3 months at minimum	• Check for proper air flow with a piece of paper. • Check for any abnormal noise or vibration on fan. Replace the damaged fan if necessary. • Remove accumulated dust, sand, and dirt by vacuuming. • Replace the fan if the total operating time is approaching or exceeding the service life. Refer to Table 11-2.
Autotransformer Compartment (for 18P)	Every time drive is checked or every 3 months at minimum	• Check the cooling fans on the right side of the cabinet • Ensure that the air filter is clean
Sinewave Filter (Fuse switches, Fuses, Reactor, Capacitor)	6 - 12 months or as required	• Check fuse switches and fuses for proper operation (open & close) and continuity. • Check capacitors and reactors for evidence of leakage, rupturing, breakage, noise, or discoloration
More frequent inspections are required if the drive is installed under the following conditions: • High ambient temperature and humidity • Poor environmental factors including dust, salt, H_2S, insects etc. • Fluctuation of power supply or load • Excessive vibration and/or shock loading • Frequent starting and stopping Failure to do so will result in reduced component service life.		

11.2 MOTOR CONTROLLER MAINTENANCE

Refer to the *INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576) for maintenance routines that should be performed periodically or as required.

11.3 REQUESTING MAINTENANCE SUPPORT

Refer to InTouch ID 4202020 for an example of an Application Data/Problem Information Sheet. The Application Data/Problem Information Sheet is created to correspond to information flow on InTouchSupport.com so that the field user can complete a hardcopy version on site and enter the information on the InTouchsupport.com database upon returning to the Sensia service center or shop.

Refer to Figure B-2 for the necessary information required to request assistance from LCS engineers. This data will ensure assistance is given in the most complete and timely manner possible.

Contact Lift Control Systems for warranty claim request.

11.4 TOSHIBA WARRANTY CLAIM PROCEDURE

This procedure outlines the steps required to claim warranties through Toshiba.

Sensia ES7 VSDs, 6-, 12- & 18-pulse, have a 5-year warranty period which starts from the purchase/delivery date.

Note

Normal wear and tear, extreme environment (high H2S, weather, etc.) and physical damage are not covered under warranty.

11.4.1 REQUIRED INFORMATION

All warranty claims require the following information:

- Schlumberger Quest SQ Report number and/or the InTouch number (if applicable)
- Billing Address:
- Return Shipment Address:
- Model number:
- Serial number:
- Application:
- Job or Project number (If applicable):
- Date installed:
- Date Problem Occurred:
- Description (if parts only), P/N, Qty:
- Description of Problem or Work Requested (Be Specific):
- Has the Unit / Part been replaced:

11.4.2 CLAIM PROCESS

1. Go to the Toshiba industrial Division website:

http://www.toshiba.com/ind/fieldservice_main.jsp?category=7

2. Select “Return Authorization (RA) Form.”

Figure 11-1:Select Return Authorization (RA) Form

3. The PowerForm Signer Information page will open. Enter your name and email address, and then select “Begin Signing.”

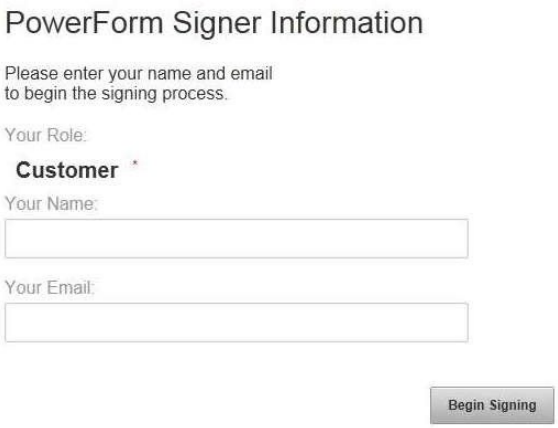


Figure 11-2: PowerForm Signer Information

4. A Request for Signature screen will open. Read the consumer disclosure.
5. Select the box next to “I agree to do business electronically with TOSHIBA INTERNATIONAL CORPORATION”. Proceed by selecting “Sign on Paper.”

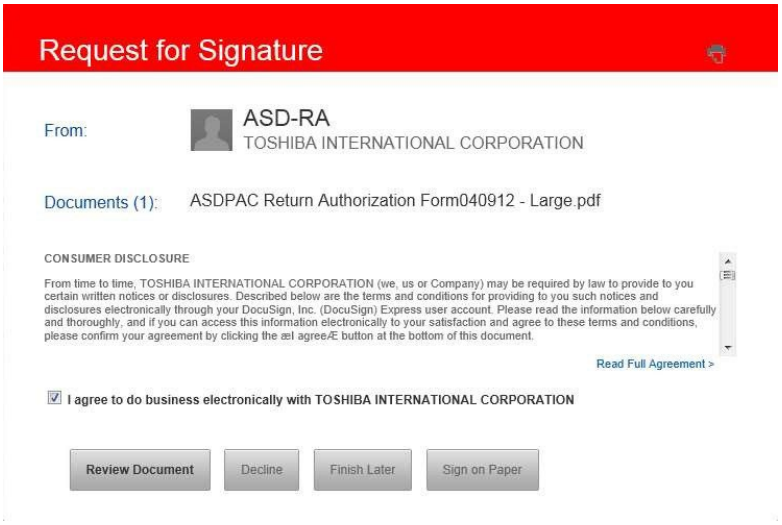


Figure 11-3: Select Sign on Paper

6. The Sign on Paper screen will open. Select “Print and Fax” to print the document.

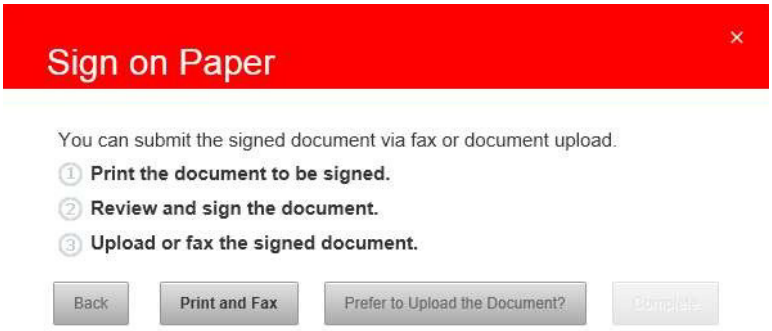


Figure 11-4: Select Print and Fax

7. The Complete button will become active. Download and fill out the document.

Figure 11-5: Select Complete

Note
There are three options to submit the signed form:
1. Fax to 713-896-5263.
2. Upload the completed document on DocuSign.
3. Email documents to www.asd-ra@tic.toshiba.com.

Note
Each document is serialized; therefore, a Return Authorization Form CAN ONLY BE USED ONCE.

8. Once the RA form is submitted the following will happen and MUST be followed to ensure there are no issues:
   - Toshiba will provide a return authorization (RA) number.
   - All returns must bear a valid RA number.
   - RA numbers are valid for 30 days from the date of issue.
   - RA numbers can be cancelled after 30 days if part is not received.
   - Any returns received without a valid number will be returned freight collect.
   - Shipping information will be available on RA form.

11.5 COMPONENT SERVICE LIFE

Some VSD components have a known optimum service life and must be replaced when their service life expires. The service lives of life-limited VSD components are shown in Table 11-2.

Note
Regular maintenance is still required per Table 11-1.

Table 11-2: Service Life Replacement Chart

Part Name	Service Life	Remarks
Large-capacity electrolytic capacitor	5 years	Apply power semiannually during long periods of inactivity.
Internal cooling fan	26,000 hours	
External cooling fan	26,000 hours	
Contact relays	500,000 operations	
Connectors	100 operations	Replace pin in case of failure.

Section 12: **Troubleshooting**

This section provides troubleshooting procedures for the VSDs that are in service and must be tested or are malfunctioning. These procedures are intended to help the field user identify which part of the drive is malfunctioning. Any attempted repairs to a VSD should be performed in conjunction with InTouch Support when necessary and should be performed by qualified personnel only as defined in the following note.

Danger

Potential Severity: Major
Potential Loss: Assets, Personnel, Reputation
Hazard Category: Electrical, Explosives, Machinery equipment hand tools

Troubleshooting or servicing a VSD must be performed by qualified personnel. “Qualified personnel” is defined as personnel who have attended and successfully completed the required trainings. Only then should qualified personnel contact InTouch for additional support and troubleshooting/repair instructions.

12.1 REQUIRED TROUBLESHOOTING EQUIPMENT AND TOOLS

Before attempting any start-up procedures, ensure that the personnel assigned to the job have the required equipment and tools listed in the VSD Tools Kit (100072064). The list may also be found, and items ordered from Lift Control Systems.

12.2 CAPTURING DRIVE DATA

The first steps in starting up or troubleshooting a VSD system are to capture all equipment and personnel contact data from the drive system.

1. Save the controller site (.site) file.
2. Export the logs & trend (.H5) file.
3. Refer to Figure B-2 for the required information to be saved about the VSD and system.

These are essential tools in troubleshooting the drive and are necessary for the problem identification. Refer to this data when contacting LCS Engineering or InTouch Support for further assistance.

Note

If the drive that is being troubleshooted fails or does not perform as expected, complete the questions found on In Touch 4202020 and contact InTouch Support for assistance.

12.3 PRE-POWER UP CHECKS

Perform the following checks before applying any power to the drive.

Potential Severity: Major
Potential Loss: Personnel, Reputation
Hazard Category: Electrical, Explosives

Use appropriate lockout/tag out procedures (refer to SEN-HSE-S027) to ensure that VSD power is OFF before proceeding with the following checks and procedures.
Use a VOM to verify that ALL power is OFF on the drive, including

- Incoming lines at the bottom of the circuit breaker
- Motor terminals
- DC bus

1. Verify that the board numbers, switch settings, and jumper settings are correct for the application and that CPT(s) have connections made to the proper taps for the application. Use the drawings as reference.
2. Verify that the MST (initial charge timer) is set to 0.3 to 1.0 seconds (if applicable).
3. Verify all connectors are properly plugged in.
4. Inspect the DC bus capacitors. Make sure they are not leaking oil, they do not show bulges, and the vent plug is opened.
5. Inspect MS1 (initial charge contactor) contacts (if possible) by checking under the cover.
6. Check the tightness on all cable and bus connections.
7. Perform a thorough visual check of all drive components. Ensure that the installer did not bend resistors or break any components on the circuit boards.
8. Ensure that the drive is clean and free of debris, dust, cobwebs, etc.
9. Check all fuses before power-up. A blown fuse indicates a possible problem in this circuit. Do not just replace the fuse. Check fuses and main wiring connections for loose components and connections. Tighten if necessary.
10. Confirm proper grounding of all appropriate items.
11. Ensure that a Category-6 (CAT6) communication cable for the ES7 has been installed from the controller to the VSD.
12. If analog signals are used in the application, ensure that there are no grounds present to interrupt the signals. No resistance to ground should be detected. The analog signals are found on the controller.
13. Confirm that step-up transformer taps are consistent with motor data and cable data. Record data in Table 12-1.

Table 12-1: Step-Up Transformer/Motor/ Cable Confirmation

Item	Data (write in)	Comments
Tap Setting		
Output Voltage		
Cable Size (AWG)		

14. Confirm that no grounds exist on the step-up transformer primary and secondary. Also ensure that no cable resistance to ground exists. Record data in Table 12-2.

Table 12-2: Step-Up Transformer and Cable Resistances

Item	Data (write in)	Comments
Resistance at Primary (ohms)		
Resistance at Secondary (ohms)		
Cable Resistance (ohms)		

15. Check the resistance of the motor with the cable for balance. To do this, the cable must be disconnected from the transformer.

12.4 MAIN POWER CIRCUIT COMPONENT CHECKS

Perform the following checks to ensure proper function of the main power circuit components.

Potential Severity: Major
Potential Loss: Personnel, Reputation
Hazard Category: Electrical, Explosives

Use appropriate lockout/tagout procedures (refer to SEN-HSE-S027) to ensure that VSD power is OFF before making changes to the transformer taps or connecting wires to components.

12.4.1 MAIN POWER CIRCUIT CHECKS

1. Use a VOM to ensure that the DC bus capacitors have been completely discharged.
2. Remove the input power fuses and test them.
3. Carefully disassemble the drive to the level of exposing the main power circuit components.
4. Give all drive components a thorough visual inspection and ensure that no parts are broken or damaged.

Potential Severity: Major
Potential Loss: Personnel, Reputation
Hazard Category: Electrical, Explosives

Be aware that not only is there still voltage located at the line side of the input circuit breakers, but that there is also voltage at the 120V receptacle located on the front of the drive, where applicable. This is convenient for the use of tools and laptop, but caution must be exercised when checking components near the circuit for the receptacle, including CPT2. Please see manufacturer drawing I808xx08 for details on the circuit components. The fused disconnect switch, FDSW, can be opened for safety, however there will still be 480 VAC located at the line side of the circuit breaker and the disconnect switch.

Be aware of voltage located at the line side of the input circuit breakers and at the 120 V receptacle located on the front of the drive. This is convenient for the use of tools and laptop but use caution when checking components near the circuit for the receptacle, including CPT2. See manufacturer drawing I808xx08 for details on the circuit components. The fused disconnect switch, FDSW, can be opened for safety, however there will still be 480 VAC located at the line side of the circuit breaker and the disconnect switch.

5. Use a VOM to test the following main circuit components:
   - control power fuses including the fuses for the 120 V power receptacle
   - DC bus fuse(s)
   - sinewave filter fuses and fuse switches (if applicable)
   - soft-start resistor. Refer to the appropriate drawing for resistor value.
   - discharge resistor R22. Manually push in MS2 to take reading (if applicable).

- thermistor (should read 18 to 24 kohms at room temperature)
- DC bus capacitors. Check the charge and discharge rate of the capacitors and ensure that the charge rate is faster than discharge. Use the diode mode of the VOM to charge the capacitors and DC volts to discharge.

6. Verify the DIP switch settings on the Interface Board for double and triple inverter drives. Refer to the manufacturer's drawing 1808xx29 for details, or InTouch ID 4898039.

12.4.1.1 Checking Input Diodes (In Circuit)

This section describes how to test the input diodes while they are still included in the drive's circuits.

Note
The charging indication displayed on the VOM is caused by the charging action of the DC bus filter capacitors through the forward-biased diode.

1. Set the VOM to the diode function. Refer to Table 12-3 and Table 12-4 for VOM connection points and readings while the diodes are still in the circuit.

Table 12-3: Input Diode Test Reading (Diode in Circuit) for 6P & 12P

Meter (+)	Meter (-)	Reading
DC Bus +	Input R	Charging
DC Bus +	Input S	Charging
DC Bus +	Input T	Charging
Input R	DC Bus +	0.2 to 0.6 volts DC
Input S	DC Bus +	0.2 to 0.6 volts DC
Input T	DC Bus +	0.2 to 0.6 volts DC
DC Bus -	Input R	0.2 to 0.6 volts DC
DC Bus -	Input S	0.2 to 0.6 volts DC
DC Bus -	Input T	0.2 to 0.6 volts DC
Input R	DC Bus -	Charging
Input S	DC Bus -	Charging
Input T	DC Bus -	Charging

Table 12-4: Input Diode Test Reading (Diode in Circuit) for 18P

Meter (+)	Meter (-)	Reading
DC Bus +	Input R	Charging
DC Bus +	Input S	Charging
DC Bus +	Input T	Charging
Input R	DC Bus +	0.2 to 0.6 VDC
Input S	DC Bus +	0.2 to 0.6 VDC
Input T	DC Bus +	0.2 to 0.6 VDC
DC Bus -	Input R	0.2 to 0.6 VDC
DC Bus -	Input S	0.2 to 0.6 VDC
DC Bus -	Input T	0.2 to 0.6 VDC
Input R	DC Bus -	Charging

Meter (+)	Meter (-)	Reading
Input S	DC Bus -	Charging
Input T	DC Bus -	Charging
DC Bus +	L9	Charging
DC Bus +	L6	Charging
DC Bus +	L8	Charging
DC Bus +	L4	Charging
DC Bus +	L7	Charging
DC Bus +	L5	Charging
L9	DC Bus +	0.2 to 0.6 VDC
L6	DC Bus +	0.2 to 0.6 VDC
L8	DC Bus +	0.2 to 0.6 VDC
L4	DC Bus +	0.2 to 0.6 VDC
L7	DC Bus +	0.2 to 0.6 VDC
L5	DC Bus +	0.2 to 0.6 VDC
DC Bus -	L9	0.2 to 0.6 VDC
DC Bus -	L6	0.2 to 0.6 VDC
DC Bus -	L8	0.2 to 0.6 VDC
DC Bus -	L4	0.2 to 0.6 VDC
DC Bus -	L7	0.2 to 0.6 VDC
DC Bus -	L5	0.2 to 0.6 VDC
L9	DC Bus -	Charging
L6	DC Bus -	Charging
L8	DC Bus -	Charging

2. If necessary, refer to section 12.4.1.2 Checking Input Diodes (Isolated from Circuit) to test diodes further.

12.4.1.2 Checking Input Diodes (Isolated from Circuit)

This section describes how to test the input diodes (rectifiers) if some problem was discovered while testing them in the circuit. Refer to Figure 12-1 for test point location and to the table for values that should be read on the VOM. Use the diode tester function of the VOM.

Note
Testing the diodes isolated from the circuit helps avoid any interference from other connected components such as the DC link capacitors. Any charging display on the VOM is the result of the DC link capacitors trying to charge from the voltage applied to them from the meter.

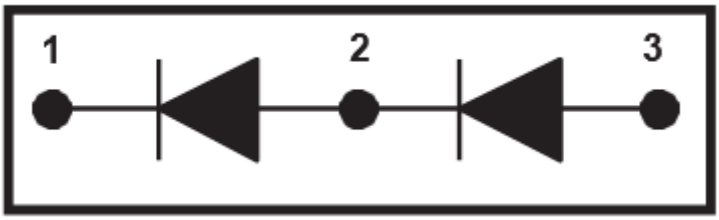


Figure 12-1: Diode Test Points

Table 12-5: Input Diode Test Reading (Diode out of Circuit)

Meter (+) Lead	Meter (-) Lead	Meter Reading (diode removed from circuit)	Meter Reading (diode in circuit)
2	1	0.2 to 0.6 volts DC	0.2 to 0.6 volts DC
2	3	OL	charging
3	2	0.2 to 0.6 volts DC	0.2 to 0.6 volts DC
1	2	OL	charging

12.4.1.3 Checking IGBTs (In Circuit)

This section describes how to test the IGBTs while they are installed in their operating circuit.

Note
Charging indication is due to the charging action of the DC Bus filter capacitors through the forward biased freewheeling diode across the opposite IGBT.

1. Refer to Table 12-6 for VOM connection points and readings.

Table 12-6: VOM Connection Points and Readings

Meter +	Meter -	Reading
DC Bus +	Output U	Charging
DC Bus +	Output V	Charging
DC Bus +	Output W	Charging
Output U	DC Bus +	0.2 - 0.6 volts DC
Output V	DC Bus +	0.2 - 0.6 volts DC
Output W	DC Bus +	0.2 - 0.6 volts DC
DC Bus -	Output U	0.2 - 0.6 volts DC
DC Bus -	Output V	0.2 - 0.6 volts DC
DC Bus -	Output W	0.2 - 0.6 volts DC
Output U	DC Bus -	Charging
Output V	DC Bus -	Charging
Output W	DC Bus -	Charging

2. If the readings are as in the table proceed to section 12.4.1.5 Control Power Supply Checks. Otherwise, troubleshoot as in section 12.4.1.4 Checking Single-Transistor IGBTs.

3. For a drive with a double or triple inverter (518 kVA and above) check resistors RS1 (10 ohm) in U, V, W phases and resistors RP and RN (25 ohm) in U, V, W phase. Refer to Table 12-7 if they are found not within spec, replace them. See the drawing set provided with the drive for more details.

Table 12-7: Resistor Values to be Checked if Bad IGBT Was Found

Resistor	Rated Value	Measured Value
RPU	25 ohm ±5%	
RNU	25 ohm +/-5%	
RPV	25 ohm ±5%	
RNV	25 ohm ±5%	
RPW	25 ohm ±5%	
RNW	25 ohm ±5%	
RS1U	10 ohm ±10%	
RS1AU	10 ohm ±10%	
RS1V	10 ohm ±10%	
RS1AV	10 ohm ±10%	
RS1W	10 ohm ±10%	
RS1AW	10 ohm ±10%	

Note

If an IGBT is found damaged or failed, all IGBTs in the phase must be replaced. The gain codes on the IGBTs in parallel must match and can only be off by one if in series.

The associated Gate Protect Board and Snubber Boards (two part numbers per phase) in the phase must also be replaced.

Inspect the Gate Drive Board for damage. If an indication of damage is seen, change this board.

For drives with double or triple inverters (518 kVA and above), check resistors RS1 (10 ohm) in U, V, W phases and resistors RP and RN (25 ohm) in U, V, W phase. Refer to Table 12-7 if they are found not within spec, replace them.

12.4.1.4 Checking Single-Transistor IGBTs

This section gives step-by-step procedures on how to test a single-transistor type IGBT removed from its operating circuit.

1. Attach the VOM leads as shown in the corresponding schematic and table. Use the diode function of the VOM for this test.

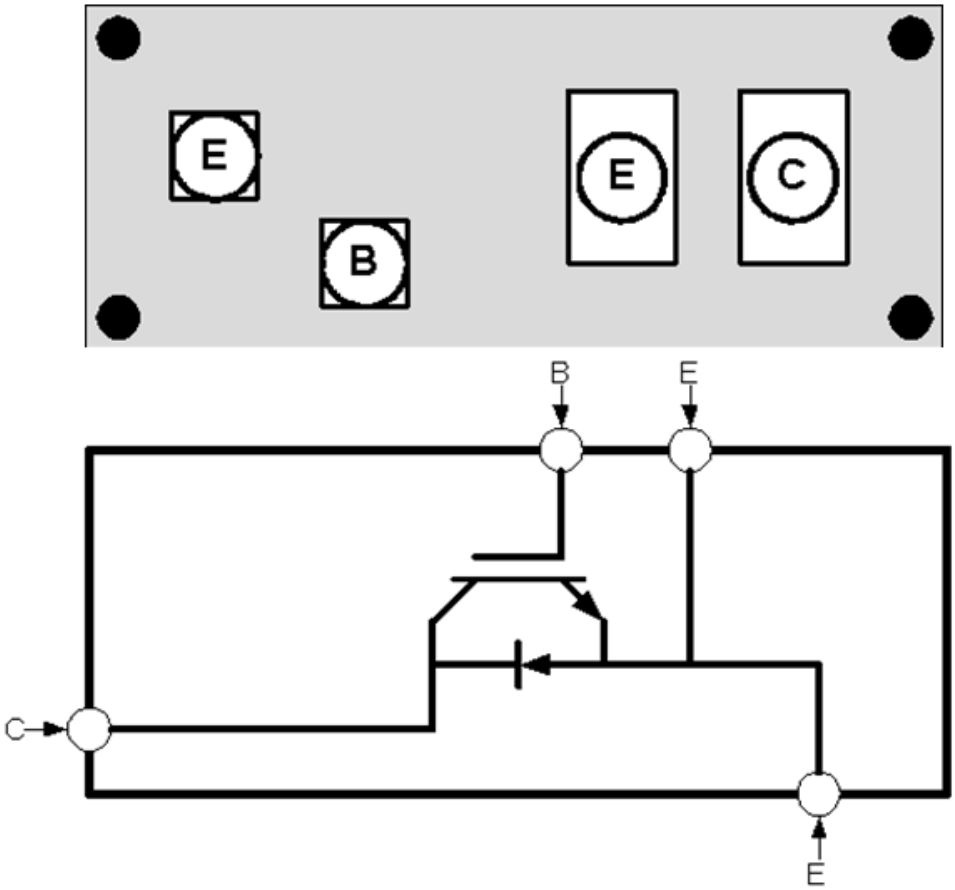


Figure 12-2: Single-Transistor IGBT Block Diagram and Schematic (module MG500Q1US11 shown)

Table 12-8: Single-Transistor Test Connection Points and Values

Meter Lead Connection Points		Meter Display
NEG	POS	Reading
C	E	0.2 to 0.6
E	C	OL (charging)
B	C	OL
C	B	OL
B	E	OL
E	B	OL

2. Ensure that the VOM readings match or approximate those shown in Table 12-8.

Note
If an IGBT is found damaged or failed, replace the associated gate protect board, snubber boards (two-part numbers per phase) and gate driver board in the phase.

For drives with double or triple inverters (518 kVA and above), check resistors RS1 (typically 10 ohm) in U, V, W phases and resistors RP and RN (typically 25 ohm) in U, V, W phase. If these resistors are not within spec, replace them.

12.4.1.5 Control Power Supply Checks

Perform the following checks to ensure that the drive's control circuits, and power supplies are operating properly.

1. Remove the input fuses (if they are not already removed).
2. Make sure the control-power leads are attached to the bus bars on the load side of the input circuit breaker, ahead of the input fuses.
3. Jumper the fuse indicator circuit to complete the circuit (if applicable).
4. Remove the MST timer (applicable for double and triple inverter drives).
5. Disconnect the fan circuit (CN11) in any VSD and the wire from terminal A or C on the Terminal board to reduce noise while testing.
6. Temporarily defeat the door interlock switches (if applicable).

Danger
Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

High voltage (480 volts) will be turned ON for the next phase of testing. Keep hands, tools, and personnel in the area away from high voltage risk areas.

7. When all connections are safely completed from Steps 1 through 6 above, close the Main Circuit Breaker (MCCB1).
8. Make sure any power LEDs on the gate drive board are illuminated.
9. Verify there is no DC Bus Voltage.
10. Use the VOM to make sure the control power transformer(s) (CPT1 and possibly an additional CPT) are functioning properly.
    - The display on the Toshiba G3 keypad should be flashing DC bus undervoltage.
    - The display on the G7 keypad should be flashing Moff.
    - The display on the controller should be flashing VSD_DC_UV

Warning
Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

DO NOT touch pins on the ES7 VSD Control Board together.

11. Ensure that all power supplies are working properly. Use a VOM to check the power supplies (+5 V, +15 V, -15 V, +24 V).
12. Ensure your readings correspond using the test points shown in Table 12-9 and Figure 12-4.

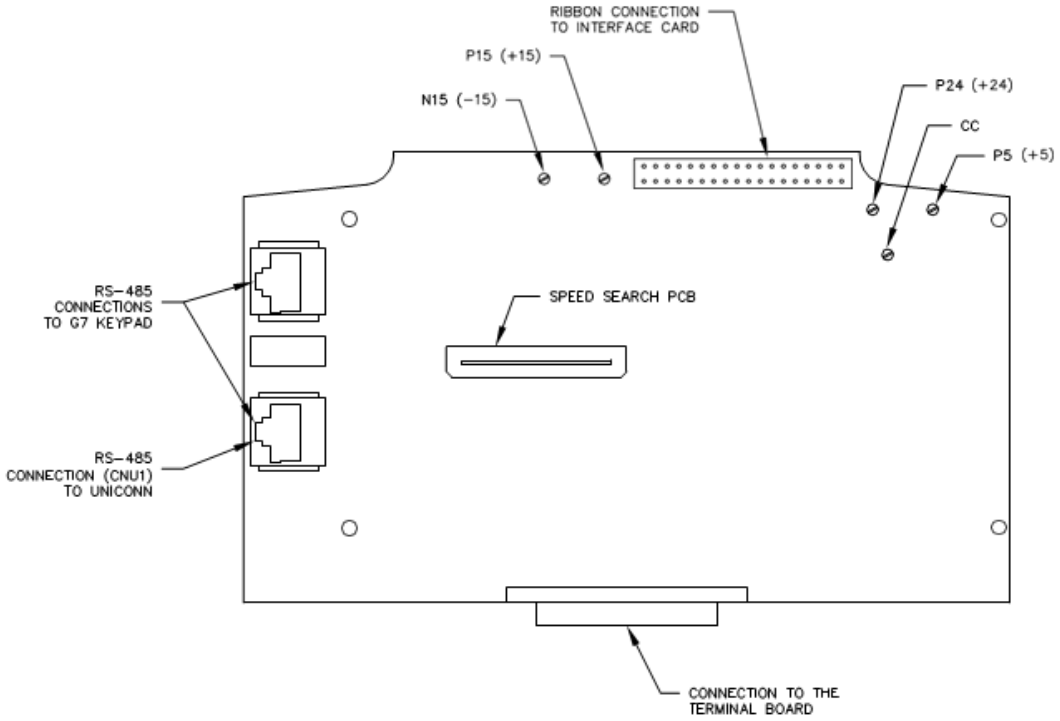


Figure 12-3: ES7 VSD Control Board (Control Power Test Points)

Table 12-9: ES7 Control Board Power Supplies Test Points and Readings

Power Supply (nominal volts)	Permissible Voltage Range (volts DC)	Test Point Probe	Test Point Common
+15	14.4 to 15.6	P15 see Figure 12-4	Terminal CC
-15	–14.4 to –15.6	N15 see Figure 12-4	Terminal CC
+5	4.8 to 5.2	P5 see Figure 12-4	Terminal CC
+24	21 to 27	P24 see Figure 12-4	Terminal CC

Figure 12-4: ES7 VSD Control Test Points

13. If the checks above are good, proceed to the next step. Otherwise, trace the signals back through the Gate Drive Board and Interface Board as shown in Table 12-10, Table 12-11, Figure 12-5 and Figure 12-6.

Table 12-10: ES7 VSD Gate Drive Board (42755) Test Point Readings

Power Supply	Positive (+) Meter Lead	Negative (-) Meter Lead	Reading
P24	IC1–I	IC1–Screw, see Figure 12-5	21 to 27 volts DC
P15	IC1–O	IC1–Screw, see Figure 12-5	14.5 to 15.5 volts DC
N15	IC2–O	IC1–Screw, see Figure 12-5	-14.4 to -15.5 volts DC
P5	Net 1–1	IC1–Screw, see Figure 12-5	4.8 to 5.2 volts DC

Table 12-11: ES7 Interface Board (PC61910P120X, X=B, C, or D) Test Point Readings

Power Supply	Positive (+) Meter Lead	Negative (-) Meter Lead	Reading
P24	P24 see Figure 12-6	OV reference point see Figure 12-6	21 to 27 volts DC
P15	P15 see Figure 12-6		14.5 to 15.5 volts DC
N15	N15 see Figure 12-6		-14.4 to -15.5 volts DC
P5	P5M see Figure 12-6 P5A for Slave A, if applicable, see Figure 12-6 P5B for Slave B, if applicable, see Figure 12-6		4.8 to 5.2 volts DC

Figure 12-5: ES7 VSD Gate Driver Board Test Points

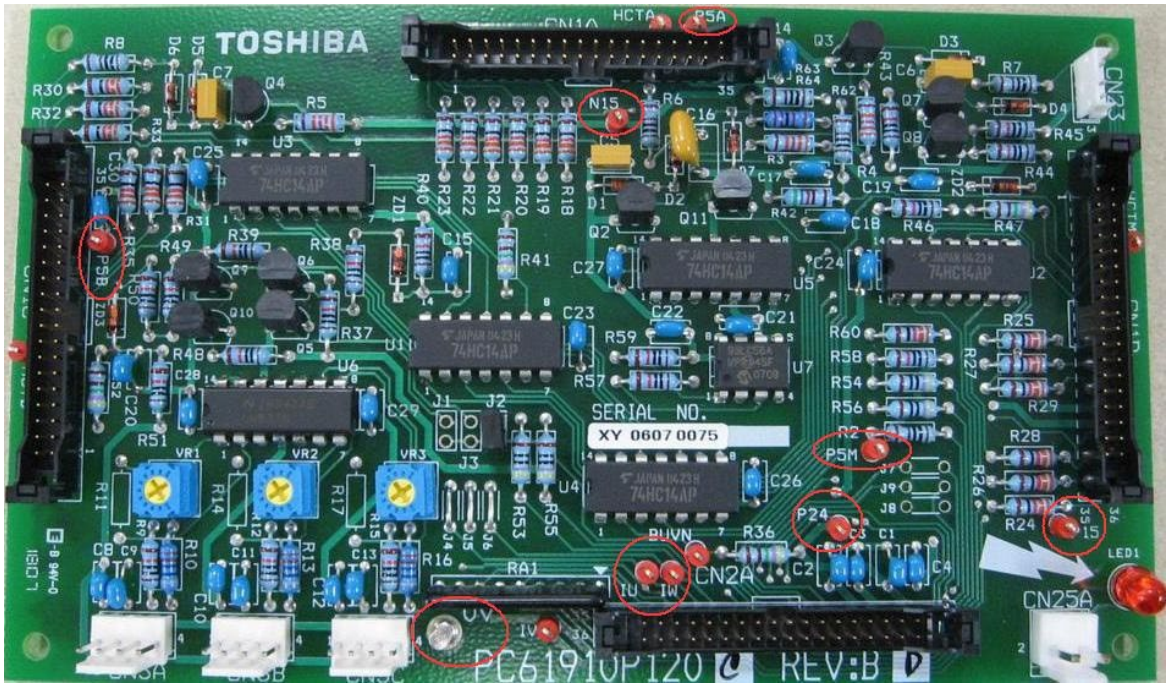


Figure 12-6: ES7 VSD Interface Board Test Points

12.4.1.6 Power Supply Checks

Refer to the *INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576) for power supply checks.

12.4.2 VSD OUTPUT TESTS

The procedure in this subsection checks the VSD output pulses to make sure the drive is operating per specification. DC Undervoltage Detection must be disabled to defeat the DC undervoltage/Moff/VSD_DC_UV warning and subsequent drive shutdown to perform this test.

Danger

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Do not use any feature of Disabling the DC Undervoltage Detection programming for any actions other than temporarily placing the drive in TEST MODE as described in this procedure without specific authorization from Toshiba International Corporation. Unauthorized modification of super-user parameters can lead to equipment damage.

To perform the output tests described in this section, disable the DC Undervoltage Detection using the Controller/StarView or Toshiba keypad included in Table 12-12. Refer to the correct procedure as follows.

Table 12-12: Super-User Reset-Required Parts

Part Number	Description
GCCG7KPCVRKIT	Diagnostic G7 keypad with back plate.
100168361	Cable for connecting the diagnostic Toshiba G7 keypad to the ES7

12.4.2.1 Disabling the DC Undervoltage Detection (Super User Test Mode)

In the Super User Test mode, Toshiba drives will ignore DC bus undervoltage and underload alarms. This is to be used during maintenance and troubleshooting.

12.4.2.1.1 Disabling the DC Undervoltage Detection with StarView NG (Super User Test Mode)

To place the VSD in Super User Test mode with StarView NG, perform the following steps:

1. Go to the **VSD Expert** screen. Select CONFIGURATION > VSD > VSD.
2. Select **Super User Mode** to turn on Super User Test mode.
3. Select **Yes** at the Confirmation prompt to enable Super User Test mode.

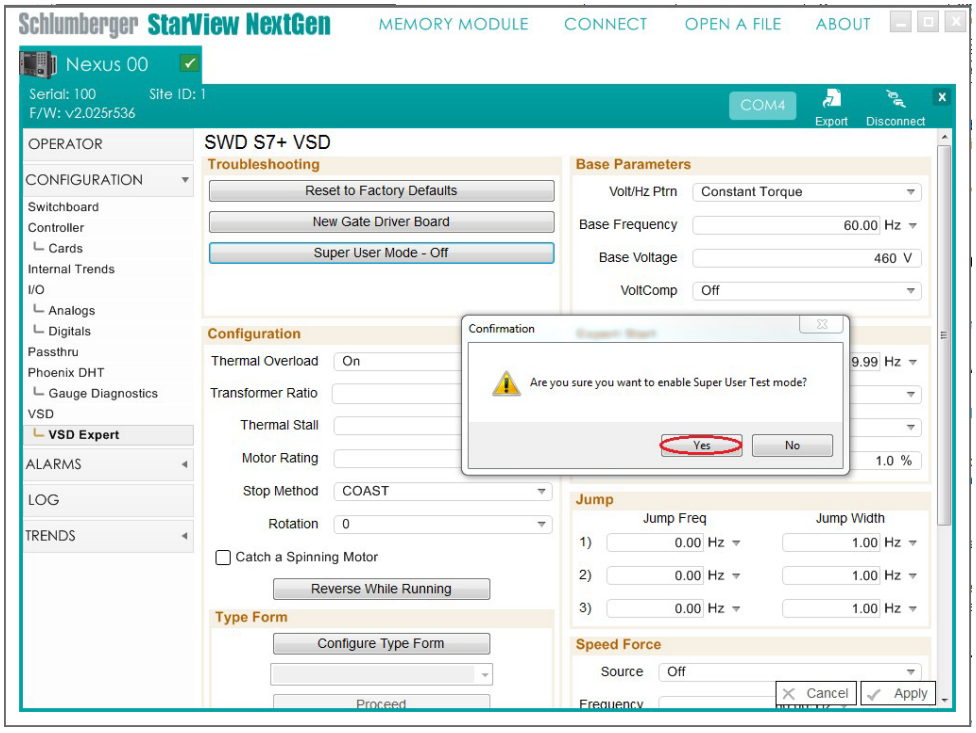


Figure 12-7: Enable Super User Test Mode

4. Once the drive is in Super User Test mode, proceed to 12.4.2.2 Gate Drive Pulse Test.

12.4.2.1.2 Disabling the DC Undervoltage Detection with Controller (Super User Test Mode)

To place the VSD in Super User Test mode with the controller, perform the following steps:

1. Press the **Menu** key.
2. Navigate to the **VSD Expert** screen for the analog input. Select VSD > Expert.

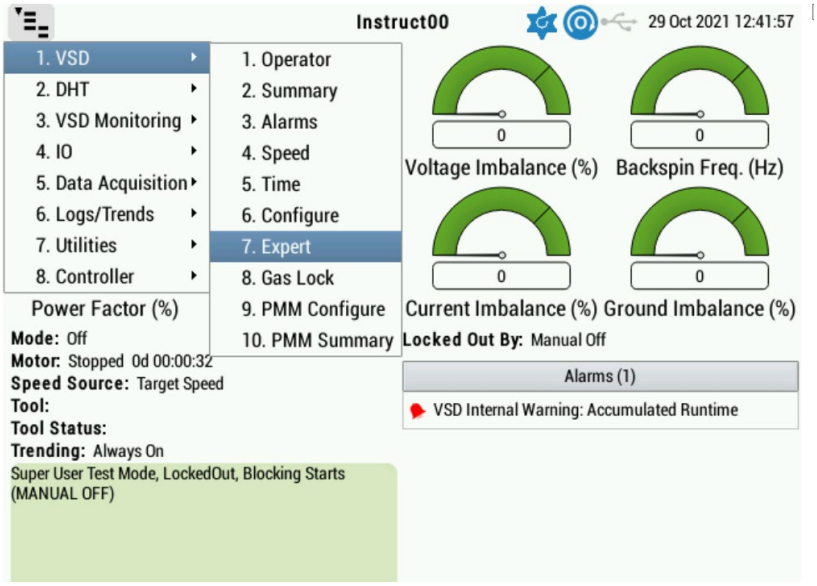


Figure 12-8: Navigate to Expert Screen

3. Select **Super User Mode** to turn on Super User Test mode. The Super User Mode will turn from **Off** to **On**.

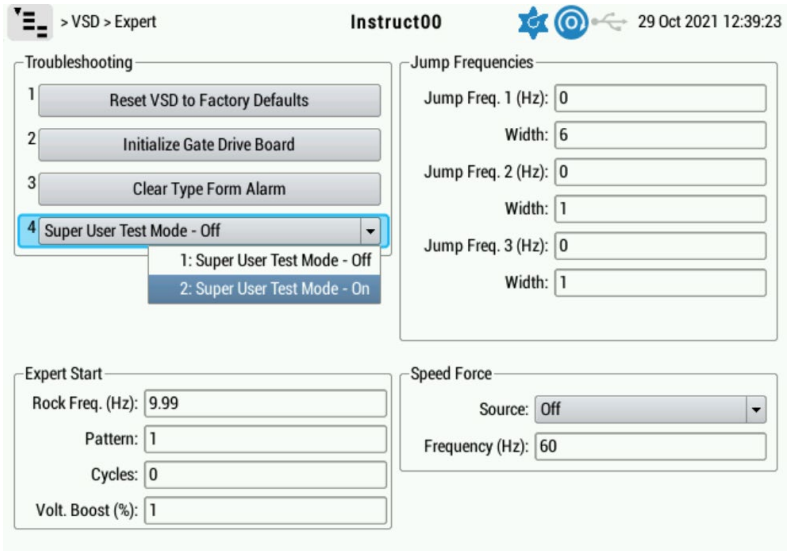


Figure 12-9: Turn on Super User Test Mode

4. Once the drive is in Super User Test mode, proceed to 12.4.2.2 Gate Drive Pulse Test.

12.4.2.1.3 Disabling the DC Undervoltage Detection in the Sensia ES7 VSD with the Toshiba Keypad (Super-user Mode)

Disable the DC Undervoltage Detection (MOff) as follows. (If any of the values are already changed, press ENTER, down, up, ENTER to activate.)

1. Press the **Program/Monitor Button** two times to get to Programming.
2. Scroll to **EOI OPTION SETUPS** and press **ENTER**.
   a. Scroll up to **LOCKOUT** and press **ENTER**.
   b. Scroll up to **PASSWORD** and press **ENTER**.
   c. Highlight the number box and press **ENTER**.
   d. Give the Password **13**, **ENTER, ENTER, 15, ENTER, ENTER, 12, ENTER**.

e. Press **ESC** three times.

3. Scroll up to **DIRECT ACCESS** and press **ENTER**.
   a. Highlight the box and place a checkmark in the **UNKNOWN NUMBERS OK** box. (If unable to go to FB91, cycle power and start over.)
   b. Change FB91 → **251, ESC**
   c. Change FB90 →**1, ESC**
   d. Change FA82 → **4, ESC**
   e. Change FA83 → **2**
4. Press **ESC** five times to return to the normal display screen. “Moff” should no longer be displayed.

Once DC Undervoltage Detection is disabled, proceed to 12.4.2.2 Gate Drive Pulse Test.

12.4.2.2 Gate Drive Pulse Test

After the VSD is in super-user mode, perform the following steps to check and verify proper waveform of the pulses at the output of the Gate Drive Board.

1. Run the VSD at 60 Hz.

Potential Severity: Major
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

Some test points on the Gate Drive Board are energized. Keep hands and tools clear of possible shock hazards including the input breaker terminals.

2. Use an oscilloscope to check the waveform. Refer to Table 12-13 for the Gate Drive Board output points. Make sure the scope is in DC input mode. The waveform should read 30 volts peak to peak (+15 to -15 volts) PWM square wave as shown in Figure 12-10**.**

Table 12-13: Gate Drive Board Output Test Points

Transistor	Probe	Common
IGBT1	CNU-1	CNU-3
IGBT3	CNV-1	CNV-3
IGBT4	CNW-1	CNW-3
IGBT5	CNX-1	CNX-3
IGBT6	CNY-1	CNY-3
IGBT2	CNZ-1	CNZ-3

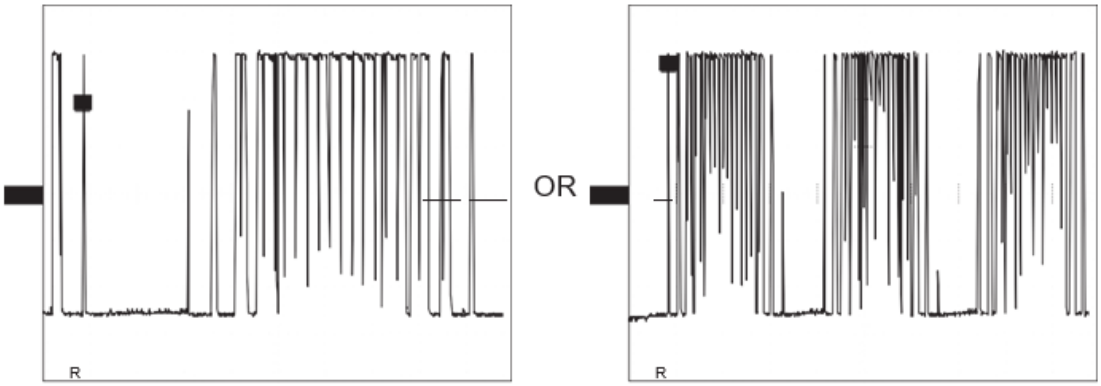


Figure 12-10: Gate Drive Board waveform

Left figure vertical scale = 5 volts per division, horizontal scale = 2 ms per division
Right figure vertical scale = 5 volts per division, horizontal scale 5 ms per division

3. Refer to Figure 12-11 for a diagram showing phase points and lead connections for the oscilloscope.

Notice that signals from the **master** and the **slave(s)** are synchronized with each other.

It is VERY important that they match exactly.

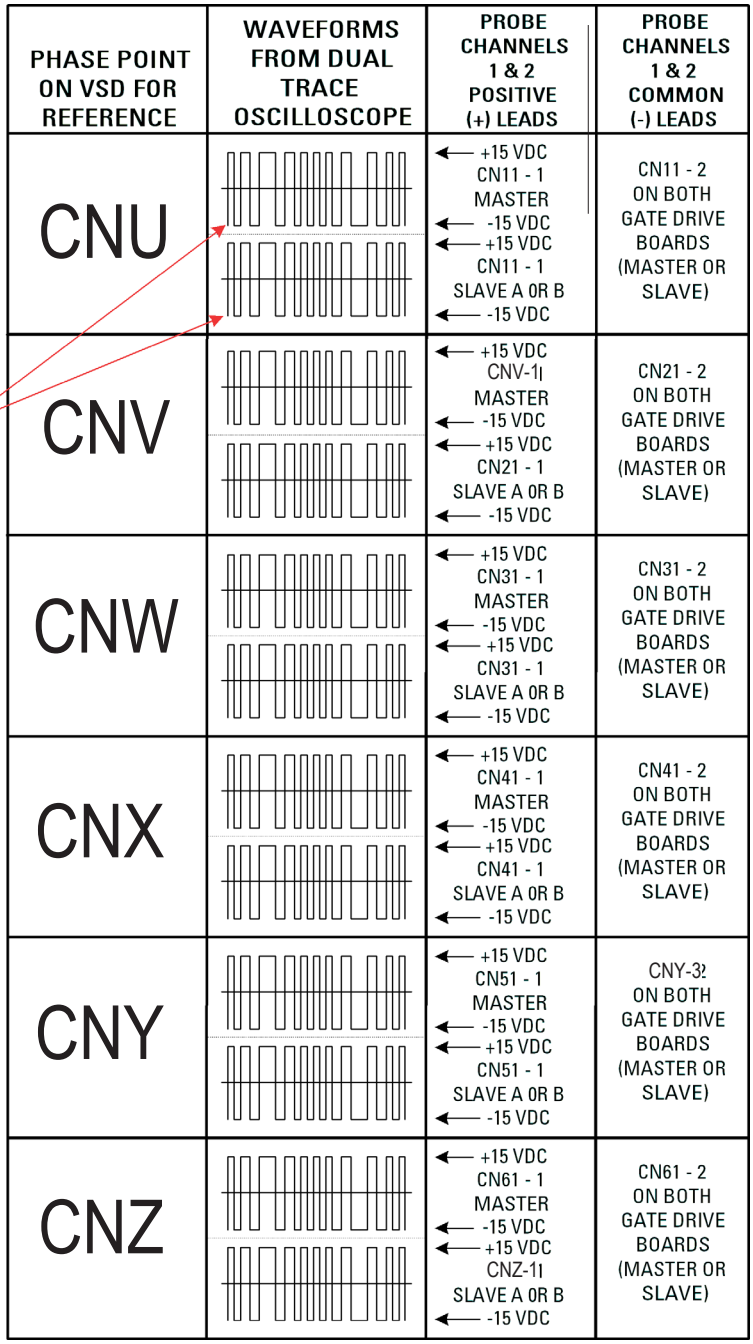


Figure 12-11: Gate Drive Board Connections

4. If the signal looks identical to the previous waveform example, proceed directly to the 12.4.2.3 Reduced Output Voltage Test. Otherwise, replace the Gate Drive Board or, if you have double or triple inverters, you can proceed to 12.4.2.2.1 Gate Drive Pulse Troubleshooting Procedures.

12.4.2.2.1 Gate Drive Pulse Troubleshooting Procedures

Note
You may need to remove the Interface Board while keeping it connected to get access to the points specified below

1. Verify if the signal is present at the entrance to Gate Drive Board (R1 through R6 with reference to IC1–Screw CC). Results should be similar to the waveform in Figure 12-12.
2. If the signal is good at the input but bad at the output, replace the Gate Drive Board.
3. If the signal is bad, check if the signal is leaving the Interface Board by checking the signal at R24 through R29 (master), R8 through R13 (slave A, if applicable), and R14 through R19 (slave B, if applicable). All signals reference to OV on the bottom of the Interface Board. The signal (on one side of the resistor) should look identical to Figure 12-12 and the approximate amplitude of the waveform should be from 4 to 5 volts.

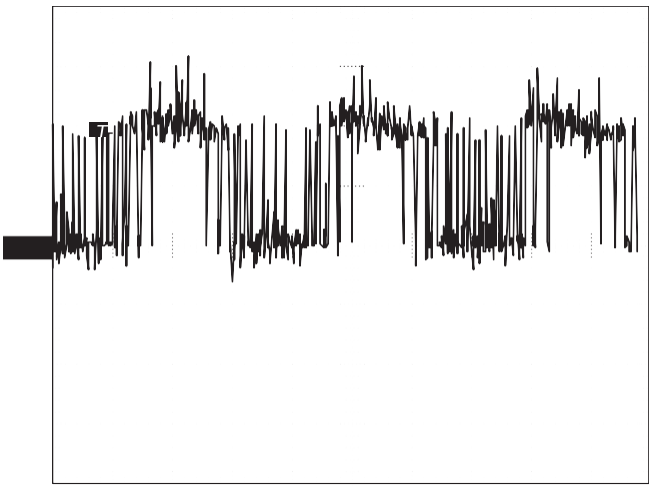


Figure 12-12: Waveform Signals Leaving Interface Board

Vertical scale = 2 volts per division, horizontal scale = 5 ms per division

4. If the signal is missing at the entrance to the Gate Drive Board but present at the output of the Interface Board, the problem is the cable.
5. If the signal is missing at the output of the Interface Board, the problem is either the Control Board or Interface Board or the cable between. See the appropriate schematics to trace the signal further.
6. Turn the power OFF.

12.4.2.3 Reduced Output Voltage Test

This procedure tests the VSD at reduced voltage on the DC bus. Perform the following steps to test the drive:

12.4.2.3.1 Single Inverter Drives (66 to 518 kVA at 40 degC)

1. Main power should be OFF.
2. Connect a 120-volt AC-capable jumper (cheater cord) to two of the bus bars on the input of the rectifier.
3. Connect the cheater cord to a Variac. The Variac should be set to 0 volts output.
4. Turn the Main Power ON.
5. Run the drive at 60 Hz.
6. Slowly increase the Variac until the DC bus reads approximately 30 volts DC.
7. Use an oscilloscope to observe waveform on the outputs U-V, V-W, U-W

Note
For the SWD, take the measurement before the filter.

8. The waveform should be 60 V peak to peak (+30 V peak to -30 V peak) as shown in Figure 12-13.

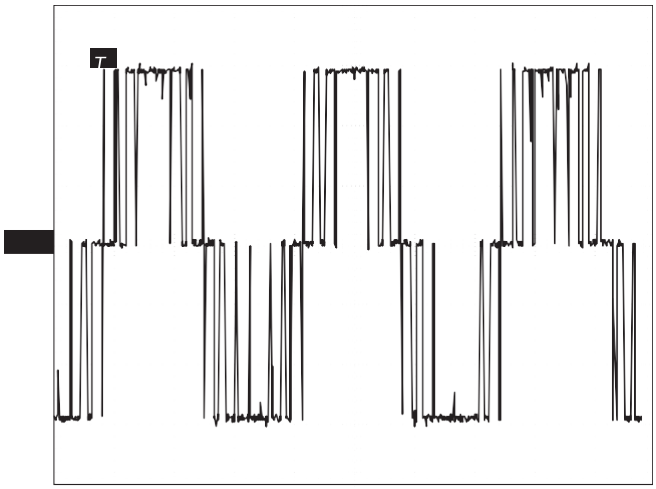


Figure 12-13: Reduced Output Voltage Waveform (Single Inverter Drive)

Vertical scale = 10 volts per division, horizontal scale = 5 ms per division

9. Decrease the Variac setting back to 0 volts output.
10. Turn the power OFF.

12.4.2.3.2 Double or Triple Inverter Drives (518 to 1500 kVA)

1. Perform an output waveform test at CN1B:
   a. With input power off, leave CN1B connected and disconnect CN1A (and CN1C, if applicable).
2. Connect a 120-volt AC-capable jumper (cheater cord) to two of the bus bars on the input of the rectifier. Connect the cheater cord to a Variac. The Variac should be set to 0 volts output.
3. Apply input power and disable the DC Undervoltage Detection again.
4. Run the drive at 60 Hz.
5. Slowly increase the Variac until the DC bus reads approximately 30 volts DC.
6. Use an oscilloscope to observe the waveform on the outputs U-V, V-W, U-W. The waveform should be approximately 60 V peak to peak (+30 V peak to -30 V peak) as shown in Figure 12-14.

Note
For the SWD, take the measurement before the filter

7. Decrease the Variac setting to 0 V.
8. Turn the power OFF and wait for the DC bus to discharge.
9. Perform an output waveform test at CN1C:
   a. ES7 VSD: Reconnect CN1A and disconnect CN1B (if the unit has three power units, CN1C remains disconnected as well).

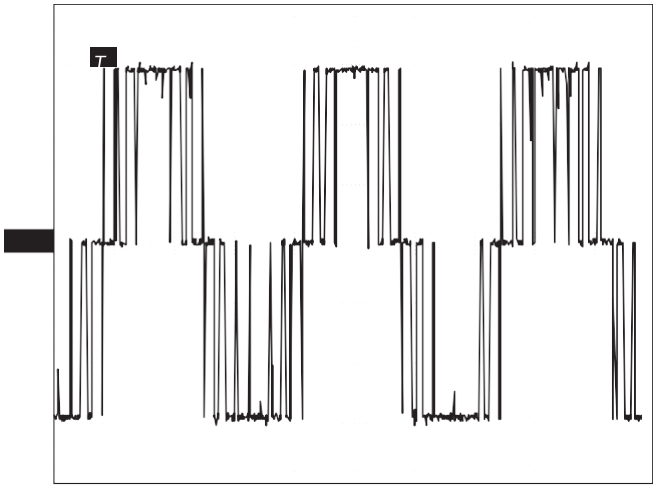


Figure 12-14: Reduced Output Voltage Waveform (Double or Triple Inverter Drive)

Vertical scale = 10 volts per division, horizontal scale = 5 ms per division

10. Apply input power and disable the DC Undervoltage Detection again.
11. Run the drive at 60 Hz.
12. Slowly increase the Variac until the DC bus reads approximately 30 volts DC.
13. Use an oscilloscope to observe the waveform on the outputs U-V, V-W, U-W. The waveform should be approximately 60 V peak to peak (+30 V peak to –30 V peak) as shown in Figure 12-14.

Note
For the SWD take the measurement before the filter

14. Decrease the Variac setting to 0 V.
15. Perform an output waveform test at CN1C (triple inverter):
    a. If the unit has only two power units, reconnect CN1B again and proceed to 12.4.2.4 Reduced Voltage Output Signal Timing Test for Double or Triple Inverter Drives (518 to 1500 kVA). If the unit has three power units, disconnect CN1A again, with CN1B still disconnected, and reconnect CN1C.
16. Apply input power and disable the DC Undervoltage Detection again.
17. Run the drive at 60 Hz.
18. Slowly increase the Variac until the DC bus reads approximately 30 volts DC.
19. Use an oscilloscope to observe the waveform on the outputs U-V, V-W, U-W. The waveform should be approximately 60 V peak to peak (+30 V peak to -30 V peak) as shown in Figure 12-13.
20. Decrease the Variac setting to 0 V.
21. Turn the power OFF and wait for the DC bus to discharge.
22. Ensure all the connections are properly plugged in: Reconnect CN1B and CN1A. All of CN1B, CN1CA, and CN1C should be connected.

12.4.2.4 Reduced Voltage Output Signal Timing Test for Double or Triple Inverter Drives (518 to 1500 kVA)

The following test sequence is used to test the timing of reduced voltage output to multiple VSD units. To test timing, perform the following steps:

1. Turn the Main Power ON and disable the DC Undervoltage Detection on the drive.

2. Run the drive at 60 Hz.
3. Slowly increase the Variac until the DC Bus reads approximately 30 volts DC.
4. Use an oscilloscope to observe the waveform on the outputs U-V, V-W, and U-W before the filter (if applicable).
5. The waveform should be 60 V peak to peak (+30 V peak to -30 V peak) (refer to Figure 12-17). At this point in the procedure, the outputs of both (or all three) power units are combined at the U, V, and W outputs.

Note
For the SWD, take the measurement before the filter

Note
Note the appearance of the PWM signal with respect to the waveform, observing the output of a single power unit. The signal should be stable, with little indication that the waveform now displayed is actually the output of multiple power units overlaying one another on the screen. The Interface Board is responsible for creating multiple reproductions of the single gate pulse signal originating on the Control Board. The Interface Board then routes these signals in phase with one another to their respective Gate Driver Boards. Significant differences in timing between these multiple signals at the U, V, and W outputs may indicate a faulty Interface Board (its multiple Gating Pulse outputs are out of phase) or a faulty Gate Driver Board (one board has a propagation delay time which is significantly different than the other(s)).

6. Decrease the Variac setting back to 0 volts output.
7. Turn the power OFF and remove the cheater cord and the Variac from the drive.

12.4.2.5 Sequence Checks

The following checks test for proper operation of drive shunt trip, timed contactor sequences, door interlock, fuse indicator, fan circuits, and other timed and monitored sequences. All sequences may not be applicable to every drive application.

Perform the following checks:

1. Verify that the power is turned OFF and there is no voltage present on the DC bus.
2. Remove the Variac and cheater cord from the drive, if not already done.
3. Reinstall the input fuses.
4. Reinstall the MST timer, if applicable.
5. Set the MST timer to minimum and apply power. The input circuit breaker should trip.
6. Reset the circuit breaker and set the MST between 0.3 and 1.0 seconds.
7. Apply power and ensure that MS2 picks up. Approximately one second later, MS1 should close.
8. If applicable, test the blown fuse indicator circuit by pulling the tab on one of the indicators. The input circuit breaker should trip.
9. Reset the input circuit breaker and, if applicable, remove the device defeating the door switch interlock.
10. Turn the main power ON. Test the door switch interlock circuit by opening the drive enclosure door. The input circuit breaker should trip.
11. Reset the input circuit breaker. Reconnect CN11 and in the ES7 VSD the wire to the A or C terminal on the Terminal Board, apply power, and test the fan circuit by running the drive.
12. Test all remaining sequences (differs by application/jobsite).
13. With power ON, program the correct parameters for the application into the VSD.

12.4.2.6 Full Output Voltage Test (without Motor)

This test checks the VSD for proper operation without a load (motor) attached. Perform the following steps:

1. Run the drive at 20 Hz. With a VOM (set to AC voltage mode) verify that the voltages between the three outputs (U-V, V-W, and U-W) are balanced (for SWD, take the reading before the sine wave filter). Because the drive signal is PWM instead of sinusoidal, a VOM set to AC volts may not read accurately, but all three outputs should give the same reading.
2. For SWD, also check at the output of the drive to make sure the sine wave filter is working correctly.
3. Run the drive up to 60 Hz. With a VOM (set to AC voltage mode) check to see that the voltages between the three outputs (U-V, V-W, and U-W) are balanced (for SWD, take reading before the filter). Because the drive signal is PWM instead of sinusoidal, a VOM set to AC volts may not read accurately, but all three outputs should give the same reading.
4. For SWD, also check at the output of the drive to make sure the sine wave filter is working correctly.
5. Verify the output waveform (at U-V, V-W, and U-W) with an oscilloscope. The waveform should look similar to one of the full voltage test waveforms (no motor load) in the Figure 12-15.

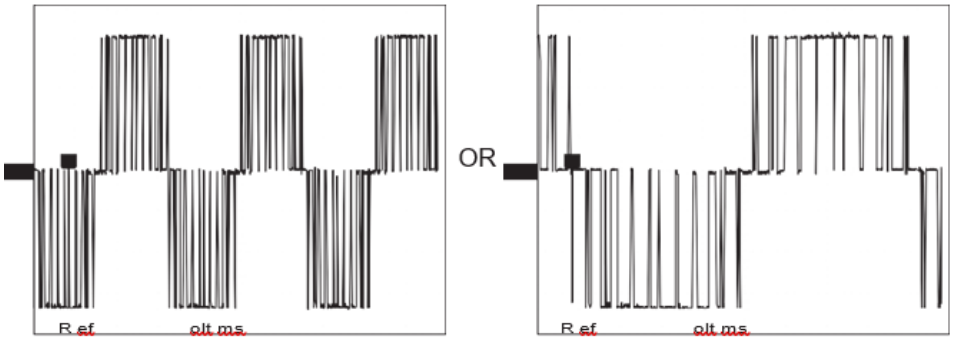


Figure 12-15: Full Voltage Test Waveform (No Motor Load)

Left figure vertical scale = 200 volts per division, horizontal scale = 5 ms per division
Right figure vertical scale= 200 volts per division, horizontal scale = 2 ms per division

6. For SWD, also verify the waveform at the output of the drive to make sure the sine wave filter is working correctly. The waveform should look similar to Figure 12-16.

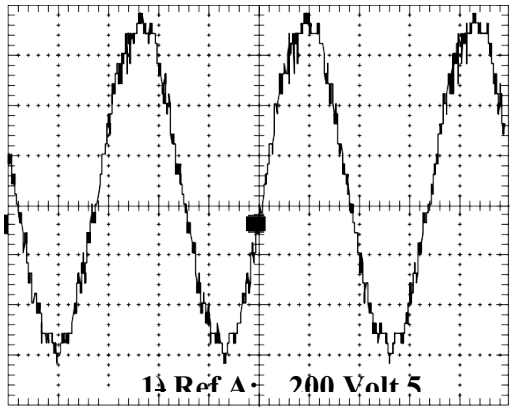


Figure 12-16: SWD Full Voltage Test Waveform at the Output

Vertical scale = 200 volts per division, horizontal scale = 5 ms per division

7. Turn the power OFF.

12.4.2.7 Full Output Voltage Test (with Motor)

This test checks the VSD for proper operation with a load (motor) attached. Perform the following steps:

1. Ensure all power is OFF. Reconnect the motor leads to the drive output lugs.
2. Apply power and run the drive at 20 Hz. Monitor the load current on the front (motor controller) display.
3. Run the drive up to 60 Hz.
4. Use a clamp-on ammeter to check for balanced current load between the power units if you have a double or triple inverter Sensia drive (518 to 1500 kVA).
5. Use a clamp-on ammeter to check for balanced current between the U, V, and W outputs to the motor windings. Monitor the drive performance for a reasonable period of time to ensure proper operation.

12.5 TYPEFORM SETUP

The controller has the ability to set the typeform.

Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

This operation must only be performed by qualified personnel since incorrectly setting the typeform could cause injury to the equipment and/or operator.

Note

If an interface board is changed in the VSD, the VSD/Controller may not start and one or both of the following alarms may occur in the Controller/StarView:

- "BAD TF" – This means that the typeform is not supported by the controller. This might occur when an interface board is changed in the VSD.
  - If this alarm is present, confirm that the typeform is incorrect and correct it using the Typeform Setup procedure (see 12.6.1.2 Typeform Reset with StarView NG).
- "Diff. TF" – This means that the typeform recorded in the controller is different from the typeform read from the drive due to the interface board being changed or the controller being moved to a different drive.
  - If this alarm is present due to a new interface board, correct the typeform using the Typeform Setup procedure.
  - If this alarm is present due to the controller being replaced with a different controller, the controller's history will have to be cleared in order to clear this alarm and allow the controller to work with a different VSD. This can be done using StarView under controller Special Features > Clear Logs.

To set the typeform, StarView must be used as there is no provision to do it from the controller's keypad.

12.6 SUPER-USER RESETS

Note

A Superuser Reset may be performed using the Toshiba keypad or the Controller/StarView. This function is not possible using the HMI. This type of reset is usually performed only when troubleshooting a VSD and should only be performed in the following events.

The super-user reset should be used in the event one or more of the following is true for the application:

- The inverter control board is changed.
- The VSD is not operating as expected in reference to the proper output current.

The super-user reset is used to return the VSD to the factory settings. This will reset all of the programmed parameters in the VSD that are associated with the inverter controls. These include but are not limited to:

- maximum output amperage
- volts-per-hertz settings (base speed)
- minimum frequency
- maximum frequency
- start frequency
- acceleration rate (ramp frequency)
- deceleration rate

Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Explosives

The super-user reset should only be performed by qualified personnel; serious equipment damage may result if not done properly.

Refer to Table 12-14 for a list of the required parts or tools to perform the super-user reset using the Toshiba keypad.

Table 12-14: Superuser Reset-Required Parts

Part Number	Description
100716089	Toshiba G7/ES7 diagnostic keypad kit with protective plate
100168361	Cable for connecting the diagnostic Toshiba G7 keypad to the ES7 drive

12.6.1 PERFORMING A RESET USING THE STARVIEW NG

12.6.1.1 Reset to Factory Defaults with StarView NG

To reset the VSD to factory defaults using StarView NG:

1. Go to the VSD Expert screen. Select CONFIGURATION > VSD > VSD Expert.
2. Select Reset to Factory Defaults.

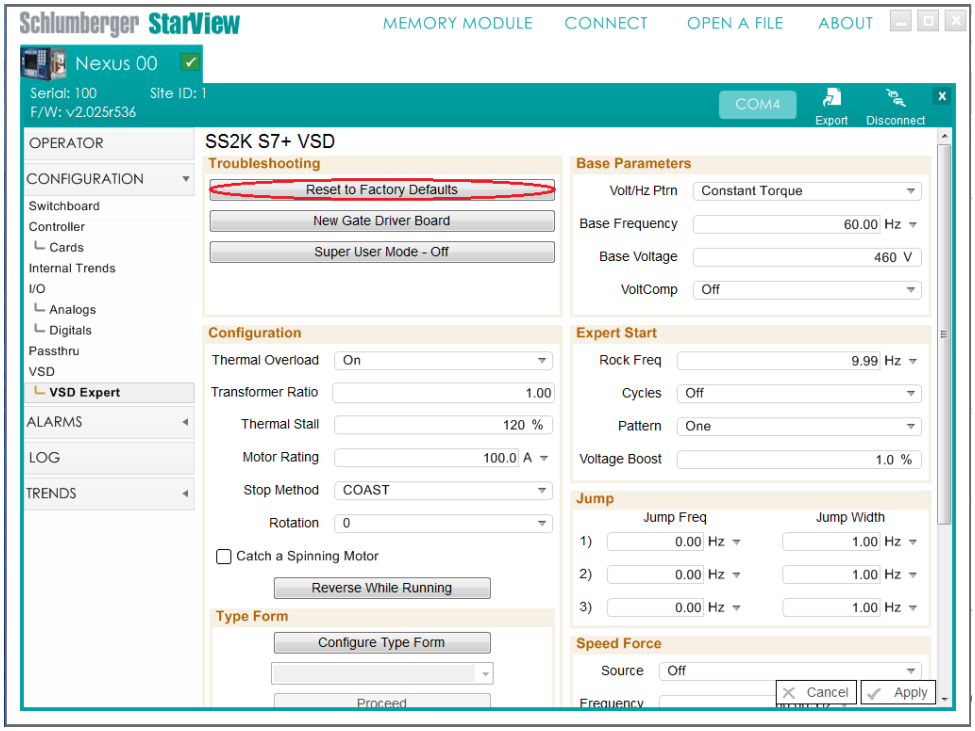


Figure 12-17: Reset VSD to Factory Defaults

12.6.1.2 Typeform Reset with StarView NG

This procedure will reset the typeform to factory default settings to ensure the software recognizes the inverter type. Perform this reset after a “Reset to Factory Defaults”.

To reset the typeform using StarView NG:

1. Go to the VSD Expert screen. Select CONFIGURATION > VSD > VSD Expert.
2. Select Configure Type Form.
3. You will be given a warning, accept the warning if you are qualified to do so.

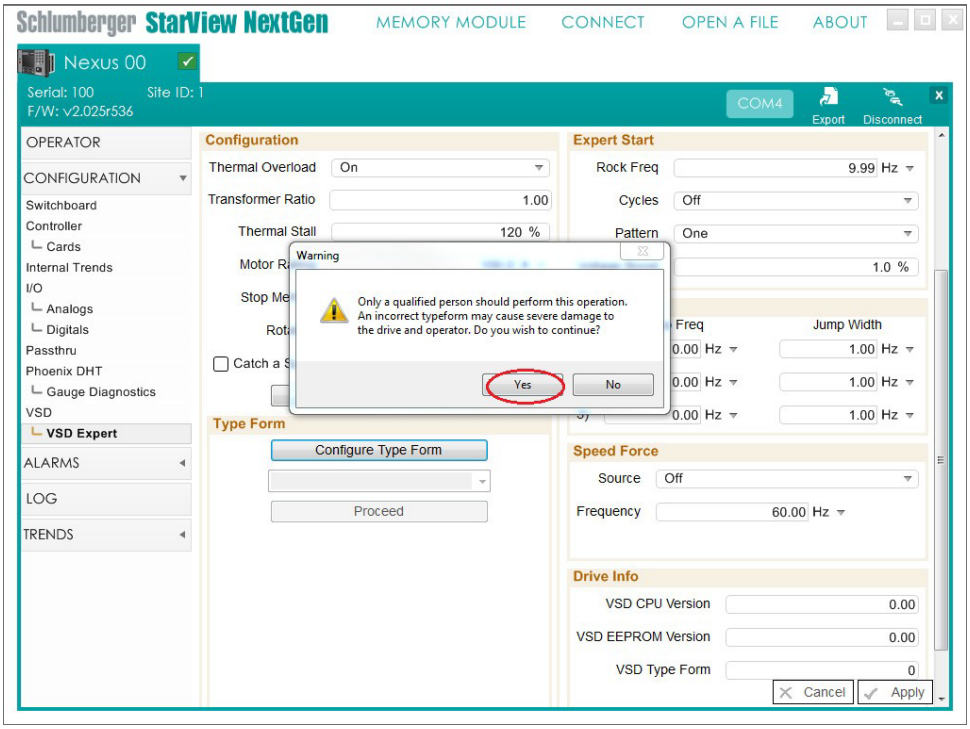


Figure 12-18: Reset Typeform to Factory Defaults

4. Select the correct drive/kVA for the VSD from the drop-down list.

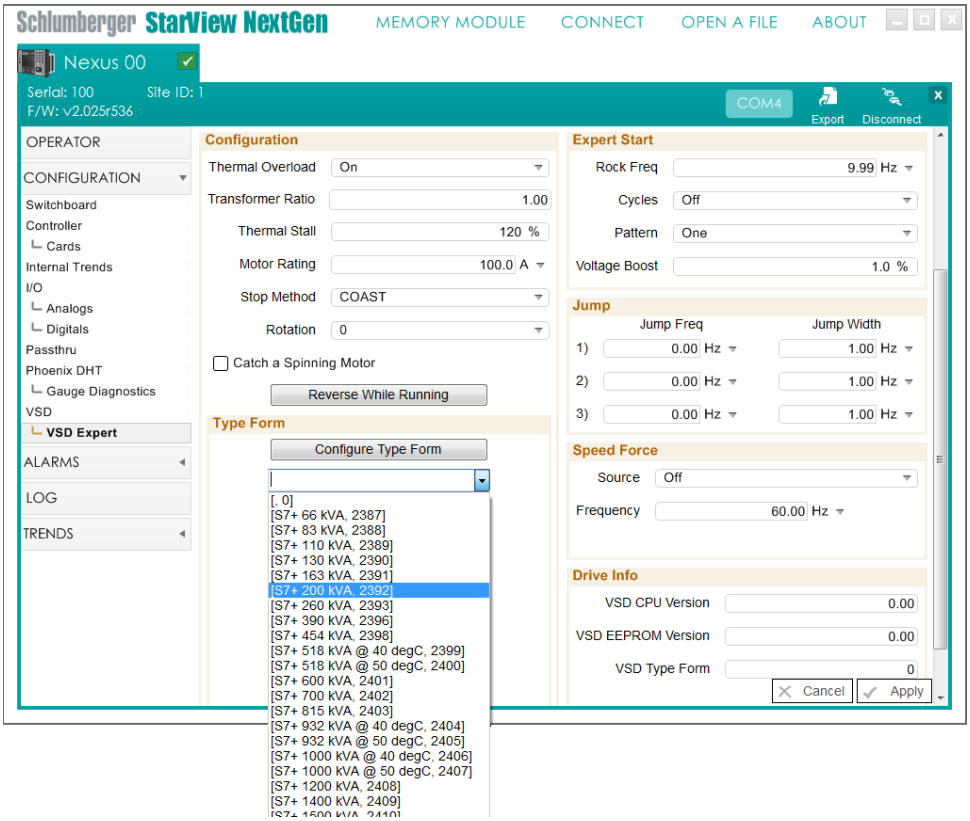


Figure 12-19: Select Drive and kVA

5. Confirm the kVA value, then select Proceed to set the typeform.

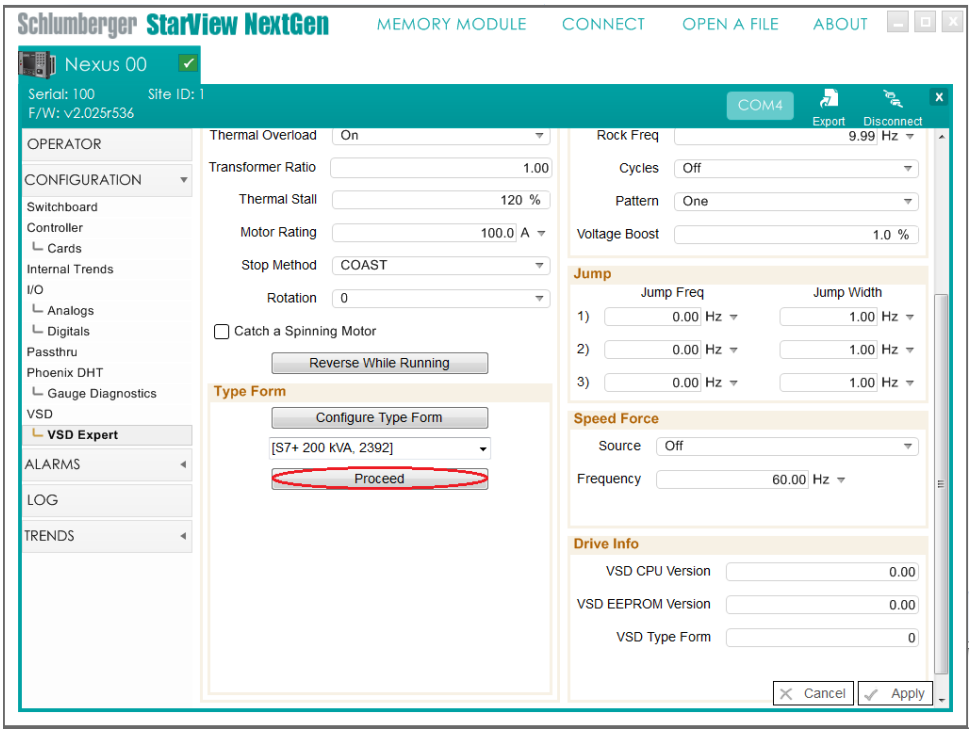


Figure 12-20: Set Typeform

12.6.2 PERFORMING A VSD RESET USING THE CONTROLLER

12.6.2.1 Reset VSD to Factory Defaults with the Controller

This parameter restores the controller in all the drives to the set point values set at the factory. All user edits and configuration changes are lost.

To reset the VSD to factory defaults with the controller, perform the following steps:

1. Press the Menu key.
2. Navigate to the VSD Expert screen for the analog input. Select VSD > Expert.

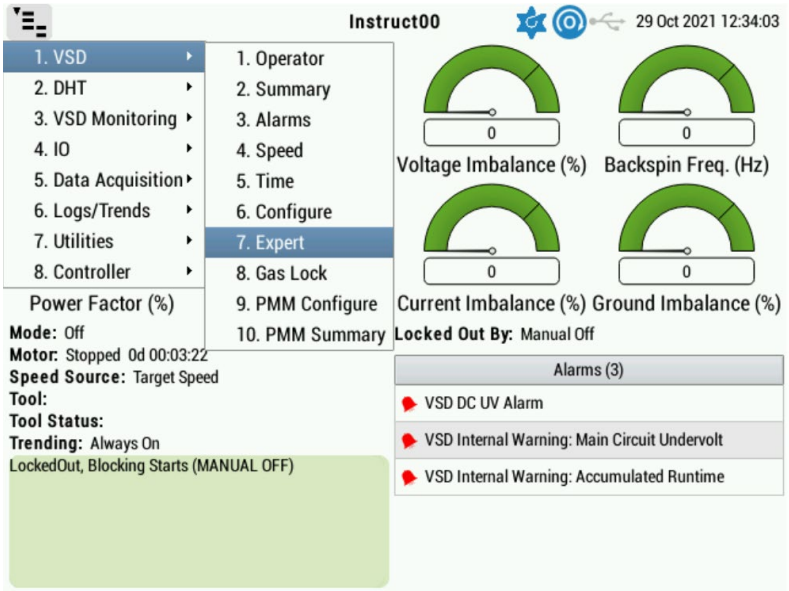


Figure 12-21: Navigate to Expert Screen

3. Select Reset VSD to Factory Defaults.

Figure 12-22: Reset VSD to Factory Defaults

12.6.2.2 Typeform Reset with the Controller

The controller cannot perform typeform resets. Refer to section 12.6.1.2 Typeform Reset with StarView NG.

12.6.3 PERFORMING A RESET USING THE G7 DIAGNOSTIC KEYPAD

To reset the VSD to factory defaults and reset the Typeform with the G7 keypad, perform the following (both are reset in this one procedure).

1. From Program → EOI Option Setups → Lockout → Password.

Note
If errors are made while entering the Password, press ESC to return back to **Program** menu and restart from step 1.

---

2. Press the Rotary Encoder to highlight the Password field and enter the password.
   a. Using the **Rotary Encoder**, scroll to **13** and press the **Rotary Encoder** twice.
   b. Scroll to **15** and press the **Rotary Encoder** twice.
   c. Scroll to **12** and press the **Rotary Encoder** once.
   d. Press ESC three times.
3. From **Program → Direct Access**, scroll to **Unknown Numbers OK** and place a check in the box by selecting the box and press the **Rotary Encoder** once. Press the **Up Arrow** once and then the **Rotary Encoder**.
4. Scroll to the **Parameter Number** field. Press the **Rotary Encoder** and scroll to FB91. Press the **Rotary Encoder.**

Note
If unable to access the Direct Access number FB91, restart from step 1.

---

5. Press the **Rotary Encoder** and scroll to **251** (to enter the Super User mode). Press the **Rotary Encoder** and then press **ESC**.
6. Scroll to **FF92** and press the **Rotary Encoder**. Press the **Rotary Encoder** and scroll to the desired **Type Code** as indicated in Table 12-17. Press the **Rotary Encoder** and then **ESC**.

7. Scroll to **FB04** and press the **Rotary Encoder**. Press the **Rotary Encoder** and scroll to **251**.
8. Press the **Rotary Encoder** and the system will reset (the **MS1** relay will make a clicking sound).
9. From **Program** → **Utility Parameters** → **Type Reset**, press the **Rotary Encoder** at the Reset Type field and scroll to Restore **Factory Defaults**.
10. Press the **Rotary Encoder** and scroll down to the **Reset** button.
11. Press the **Rotary Encoder**.
12. At the **Confirm Reset** screen, press the **Rotary Encoder**. **Reset EOI Memory** is briefly displayed and the system restarts.
13. Upon a successful restart the user is queried for a **Run the Wizard**? selection. Highlight **I will Manually Configure**. → **Finish**. and press the **Rotary Encoder**.
14. At the **Wizard: Finished** screen, press the **Rotary Encoder** (system returns to the **Frequency Command** screen).

12.7 454-1500 KVA DIP SWITCH SETTINGS

The tables below provide dip switch settings for gate driver board (42755P4F) and interface board (PC61910P109A) for drives 454 – 1500 kVA. The smaller sizes 66 – 390 kVA settings are hardwired. A similar document will be provided for spare parts from Toshiba directly.

Table 12-15:ES7 Models, 454 - 1500 kVA, Without Sinewave Filter

Drive kVA	DIP Switch Location	DIP Switch Setting										Gate Drive Board Type
		1	2	3	4	5	6	7	8	9	10	
454	42755P4F	OFF	ON	ON	ON	ON	OFF	ON	OFF	-	-	42755P4F
518 @ 40C	42755P4F	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	-	-	42755P4F
518	PC61910P109A	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4E
600	PC61910P109A	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4E
700	PC61910P109A	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4E
815	PC61910P109A	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4F
932	PC61910P109A	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4F
1000	PC61910P109A	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4F
1200	PC61910P109A	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON	42755P4F
1400 @ 40C	PC61910P109A	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON	42755P4F
1500 @ 40C	PC61910P109A	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	42755P4F

Table 12-16: ES7 Models, 454 - 1500 kVA, Sinewave Filter

Drive kVA	DIP Switch Location	DIP Switch Setting										Gate Drive Board Type
		1	2	3	4	5	6	7	8	9	10	
454	42755P4F	OFF	ON	ON	ON	ON	OFF	ON	OFF	-	-	42755P4F
518 @ 40C	42755P4F	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	-	-	42755P4F
518	PC61910P109A	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4E
600	PC61910P109A	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4E
700	PC61910P109A	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4E
815	PC61910P109A	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4F
932 @ 40C	PC61910P109A	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4F

Drive kVA	DIP Switch Location	DIP Switch Setting										Gate Drive Board Type
		1	2	3	4	5	6	7	8	9	10	
1000 @40C	PC61910P109A	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	42755P4F
932	PC61910P109A	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON	42755P4F
1000	PC61910P109A	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON	42755P4F
1200	PC61910P109A	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON	42755P4F
1400 @ 40C	PC61910P109A	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON	42755P4F
1500 @ 40C	PC61910P109A	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	42755P4F

12.8 TROUBLESHOOTING THE CONTROLLER

Refer to the *INSTRUCT ESP Intelligent Controller Manual* (InTouch ID 6128576) for detailed troubleshooting information.

12.9 COMMON FAULT DISPLAYS

12.9.1 ES7 VSD TYPEFORM ERROR PROCEDURE

1. Verify DC control power supplies.
2. If they are in good order, check Item FF92 (Inverter Typeform) using the Toshiba G7 keypad and compare it to the following chart.
   a. If different, press the Rotary Encoder on the Toshiba keypad and scroll to the desired Type Code as indicated in the table above. Press the Rotary Encoder and then ESC. Do NOT leave the drive with an incorrect setting in Item FF92.
   b. If the same, what has changed recently? Verify cables, wiring, board numbers, and Typeform detection circuit.

Table 12-17: ES7 Typeform Codes

Typeform	kVA size	Type Code: G7 Keypad Item FF92/Controller/StarView	Type Code: Hexadecimal Equivalent Value
HX7+4660	66 kVA	2387	953
HX7+4830	83 kVA	2388	954
HX7+411K	110 kVA	2389	955
HX7+413K	130 kVA	2390	956
HX7+416K	163 kVA	2391	957
HX7+420K	200 kVA	2392	958
HX7+426K	260kVA	2393	959
HX7+439K	390 kVA	2396	95C
HX7+445K	454 kVA	2398	95E
HX7+451K-40	518 kVA @ 40 degC	2399	95F
HX7+451K-50	518 kVA @ 50 degC	2400	960
HX7+460K	600 kVA	2401	961
HX7+470K	700 kVA	2402	962
HX7+481K	815 kVA	2403	963
HX7+493K-40	932 kVA @ 40 degC	2404	964
HX7+493K-50	932 kVA @ 50 degC	2405	965
HX7+410L-40	1000 kVA @ 40 degC	2406	966
HX7+410L-50	1000 kVA @ 50 degC	2407	967
HX7+412L	1200 kVA	2408	968
HX7+414L	1400 kVA	2409	969
HX7+415L	1500 kVA	2410	96A

12.9.2 ES7 VSD OVERHEAT ALARM/TRIP (PRESS CLEAR)

This trip indicates the drive interpreting a short on the CN9 (heat detection circuit). This can mean a failed thermistor or other problem. Fans will usually activate at this time as well.

Appendix A: **Menu Maps**

Refer to the *LCS-ENG-M0013 INSTRUCT ESP Intelligent Controller Configuration Manual* for the ES7 for controller menu maps.

Appendix B: **Reference Material**

This appendix contains documents that do not readily belong in the main chapters of the manual. Often, newly released information will be included in reference material before being incorporated to the main manual sections.

B.1 HARMONICS WORKSHEET

Please answer the following questions as completely as possible. This information will be used to run a computer simulation of your drive application to generate an estimate of the harmonic levels produced by any VSD loads. If some of the questions cannot be answered, some assumptions will be made about the system. Refer to the drawing(s) included in this manual and the drive cabinet for complete system details. When the questions below are completed, contact Artificial Lift InTouch Support for assistance.

Note

In the questions below, PCC refers to common point(s) of coupling on Figure B-1.

1. What is the utility input voltage and frequency to the main transformer (PCC1)? _____Volts _____Hz
2. What is the utility system short circuit duty amperage (Isc) immediately before the main transformer for the facility (PCC1)? _____Amps (*this is optional - provided by the utility - required only if PCC1 is the PCC of concern*)
3. What is the main transformer (T1) _____kVA? and the percent impedance? _____%
4. What is the impedance ratio of the main transformer (T1) _____ to _____? (Inductance:Resistance - Typically 10:1 for large transformer, ratios higher than 10:1 will have negligible impact on results)
5. What is the bus fault current (Isc) after the main transformer (at PCC2)? _____Amps
6. What is the main bus voltage of the (secondary of the main transformer T1)? _____Volts
7. What is the inductance or distance of the power line from the main transformer (PCC2) to the main plant power bus (PCC3) _____?
8. What is the inductance or distance of the power line from the main plant bus (PCC3) to the VSD isolation transformer_____?
9. What is the VSD isolation transformer (T2) kVA and % impedance? _____kVA_____ % (transformer directly before the VSD)
10. What is the impedance ratio of the input transformer (T2) _____? (Inductance:Resistance - Typically 10:1 for large transformer, ratios higher than 10:1 will have negligible impact on results)
11. Is an AC line reactor going to be used? _____(YES / NO) If so, what is the impedance or reactance in microHenries? _____µH
12. What is the system's nominal fundamental (other non— harmonic) load current on the main power bus? _____Amps
13. Are there other VSDs in the system? If so, how many? All information on the transformer associated with these VSDs must be supplied.
14. Are there any other harmonic on the system that need to be considered in this calculation? If so, please give the values of these harmonics.

15. What is the point of common coupling for the harmonics measurements (PCC 1-7)? Refer to Figure B-1.

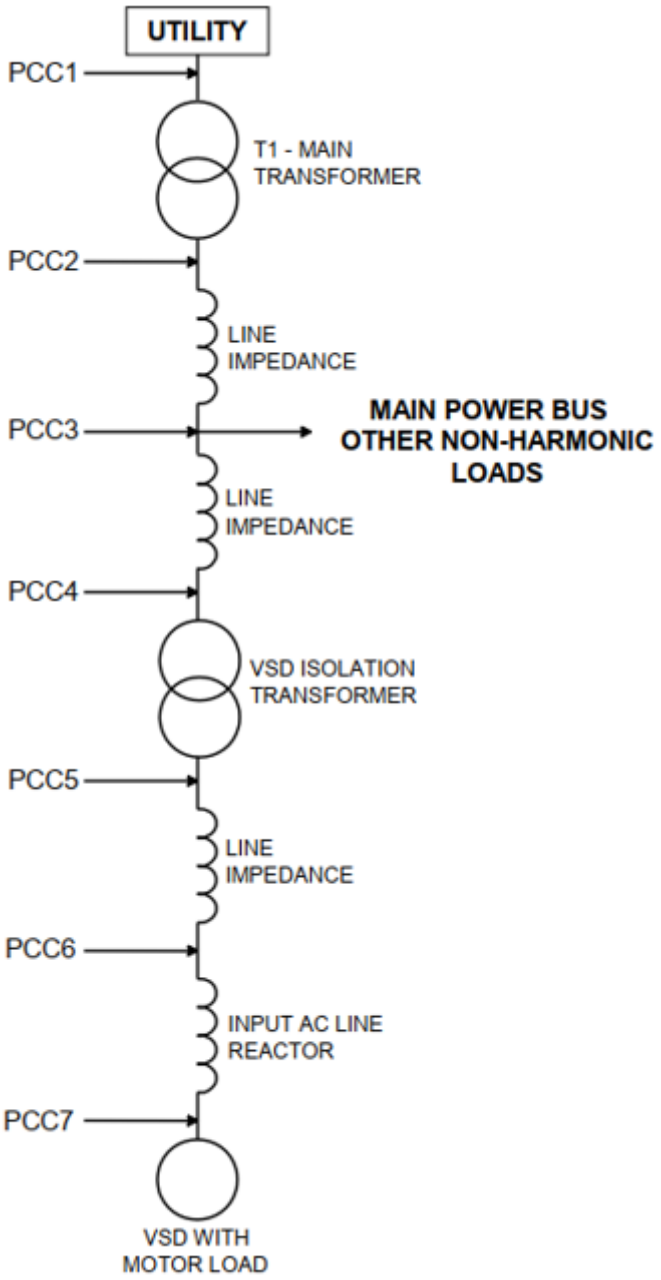


Figure B-23: VSD Points of Common Coupling

In this diagram, PCCs listed on the left identify common points of coupling.

B.2 APPLICATION DATA AND ISSUE IDENTIFICATION TABLE

Figure B-2 provided here is used in the Troubleshooting section of this manual. This table provides information for InTouch to assist in the diagnosis and solution of a problem in the field. It is essential to have the answers to the questions on this sheet ready when requesting assistance in order to get the problem solved as quickly as possible.

Contact/LDAP:		Location:
Date:		
VSD Information		
VSD serial number:	Typeform:	Part Number:
Please provide the UniConn .ste file along with the information contained in this table		
Please provide pictures if applicable		
Input Transformer	Manufacturer:	kVA:
Primary:	Secondary:	Impedance:
Output Transformer	Manufacturer:	kVA:
Primary:	Secondary:	Impedance:
Input filter	Manufacturer:	Part number:
Output filter	Manufacturer:	Part number:
Additional equipment (SCADA, analog, digital, etc) details:		
Conditions (Ambient temperature, wind, rain, snow, heat, humidity, dust, salt, etc):		
Installation Details (Indoor, outdoor, offshore, etc):		
Connection Details		
Input voltage:	Frequency:	
Installation type (ESP, HPS, etc):		
No of cables per phase, cable type:		
% load of VSD:		
Motor Status		
Problem found during periodic inspection?		
Problem found when motor was started?		
Problem found during acceleration?		
Problem found during deceleration?		
Problem found when motor not running?		
Frequency of problem		
First time?		
How many times?		
Does the problem occur every time the motor is operated?		
When did the problem first occur?		
Error Message		
What was the error message on the UniConn/HMI/EOI?		

Figure B-24: Application Data and Issue Identification Table (p. 1 of 2)

Detailed description of problem:

Troubleshooting performed:

Repairs made, list of failed components found:

Temporary diagnosis and corrective action:

Conclusions / Recommendations:

Figure B-25: Application Data and Issue Identification Table (p. 2 of 2)

B.3 ROM VERSIONS AND HISTORY

This section contains a table that lists all available ROM versions and describes the VSD and SWD versions with which they are compatible.

Table B-18: Control Board ROM Versions

Version	Description/History	Effective Date
V7000	Probably not applicable to any active drives.	12/5/97
V7001	Changed to facilitate a communication match for compatibility with the HMI.	12/24/97
V7002	Added typeforms for 518 kVA drives and larger. If an older ROM was installed in such a drive, a typeform error would display, but there were no problems with the drive.	5/22/98
V7003	Changed software to implement DC Bus voltage detection. In very rare cases (high harmonic content) the MS1 contactor would open and reset. This problem was reported by a distributor of VSDs.	unknown
V7004	Never implemented. This rev would have enabled 1400 kVA capability.	unknown
V7005	Never implemented. Was to add new defaults that HMI usually makes for use with W992.	unknown
V7006	Added 1400 kVA capability plus ground fault alarm function.	unknown
V7007	Implemented recently to add 230 V functionality for Carrier Corp. No shipments of this ROM have been made to Sensia to date. As of 2/12/2003 existing ROM stock still being shipped. New p/n is 53909 (v7007). Part number 52796 (v7006) is now obsolete.	2/12/2003
V7008	Difference is on motor overload trip. Upon motor overload trip you cannot clear the trip and run the drive again until the motor overload count decreases to 0, which may take a few minutes. For the old version, after powering off the drive, the count is cleared. After power on, you can run the drive immediately. This function supports NEC 2005 standard. New p/n is 58270. The old manufacturer's p/n was 53909.	03/03/2006

Note

Any newer ROM versions are backward compatible with previous ROM versions. To obtain the latest ROM version, order p/n **TIC_58270**.

Appendix C: **VSD Nameplate**

The numbers on the VSD nameplate on the front (see Figure C-1) and inside (see Figure C-2) of the VSD are as follows:

- **Serial #** – The first 2 digits 09 is the year that the VSD was manufactured in, the next 2 digits (3 and 4) 01 is the month that the VSD was manufactured in, and the last 5 digits 00240 is the overall serial number for the VSD. (This VSD was made in January of 2009, 480 VAC, 200 KVA, Circuit Breaker, NEMA 3R, and 6 Pulse).
- **Part Number** – This number 100243556 is the part number that Toshiba Manufactures the VSD under for Sensia.
- **Type Form #** – This number ST7B420KCB specifies the VSD type, input voltage, size, and options. This information can be looked up on the VSD drawings in detail (see Figure C-3).

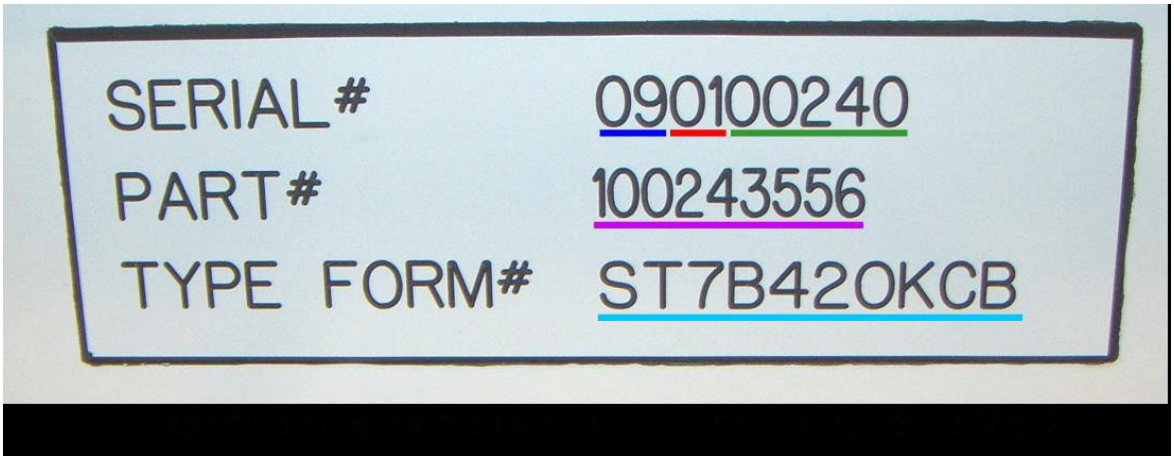


Figure C-26: Example of a Nameplate on the Front of a Sensia VSD

Note
There may be differences between the input voltage on this label (460 volts) and the posted input voltages of the VSD of (480 volts) as shown in Figure C-2. Sensia VSDs are rated for 480 VAC as this is what “calculated” KVA for the VSDs use and the nameplate amperage seen on this label.

Note
Disregard the input amperage as this value changes depending on what the input waveform to the VSD looks like and the 0-90 Hz rating, which changes according to the controller on the VSD.

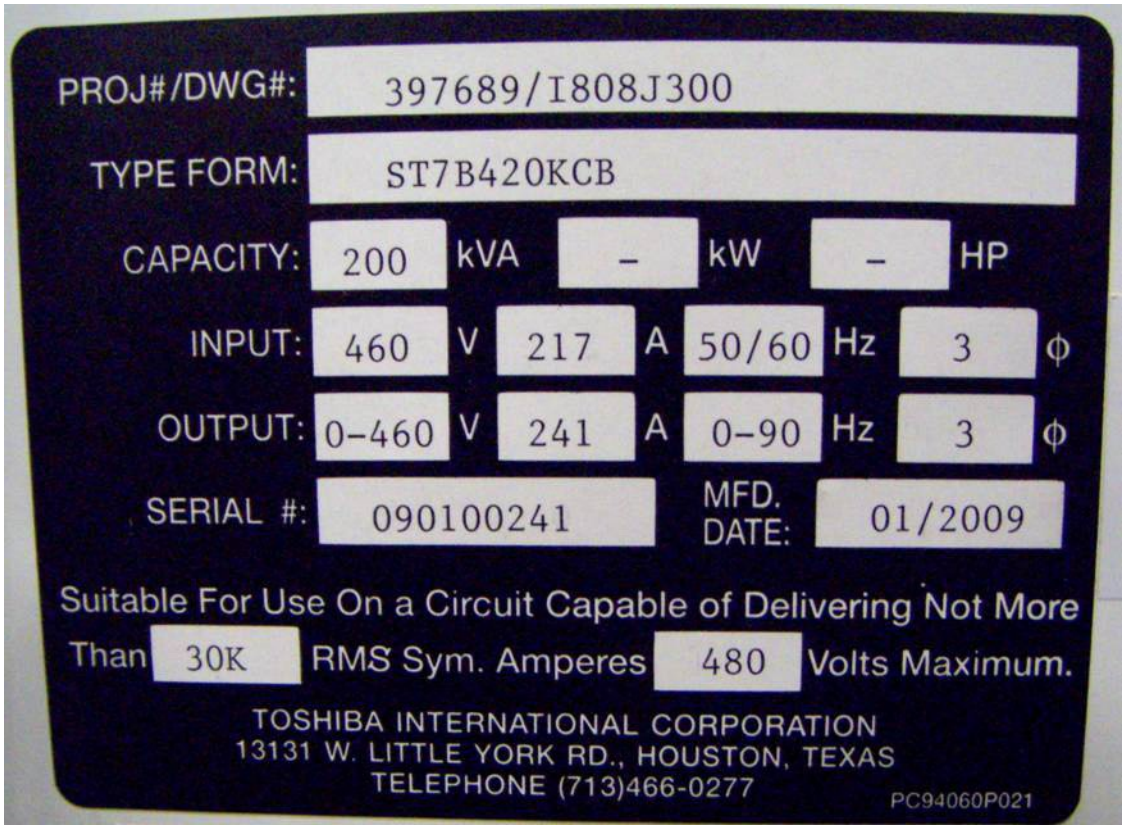
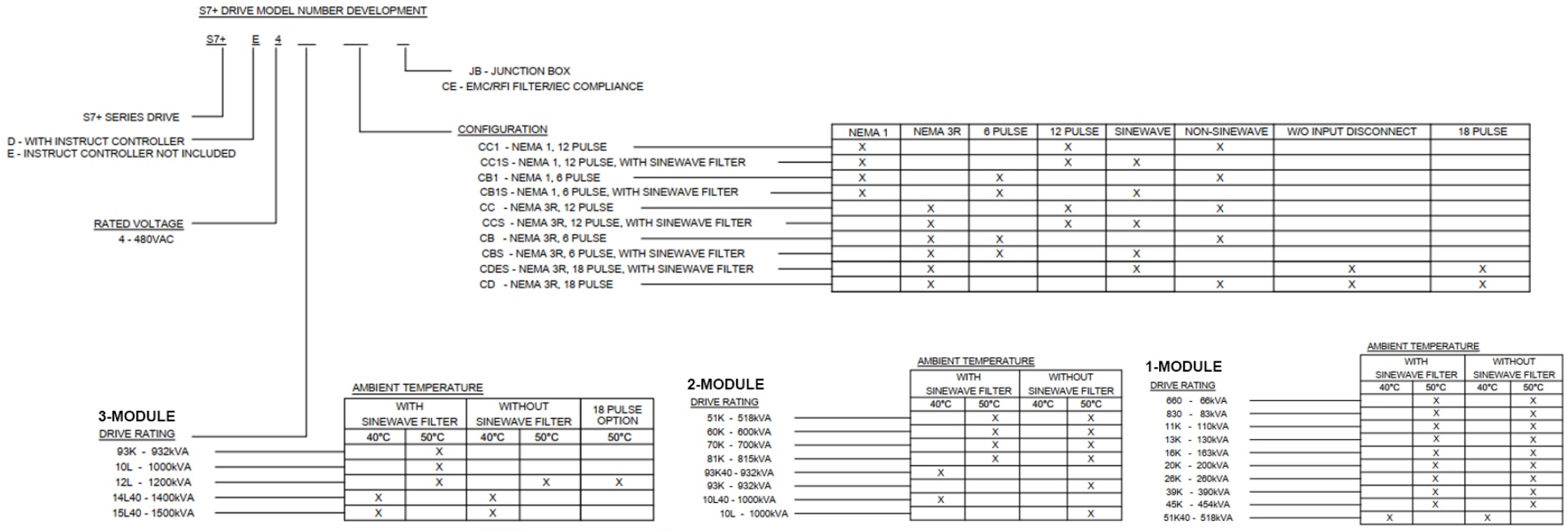


Figure C-27: Example of Inside Door Label

Figure C-3 is an example of the information that can be seen on the drawings for the VSDs. This explains the Type Form # that is seen on the nameplate on the front and inside door of the VSDs.

Note
Please refer to the drawings that were sent with the VSD that you are servicing for the correct interpretation of this number.



CONFIGURATION	NEMA 1	NEMA 3R	6 PULSE	12 PULSE	SINEWAVE	NON-SINEWAVE	W/O INPUT DISCONNECT	18 PULSE
CC1 - NEMA 1, 12 PULSE	X			X		X		
CC1S - NEMA 1, 12 PULSE, WITH SINEWAVE FILTER	X			X	X			
CB1 - NEMA 1, 6 PULSE	X		X			X		
CB1S - NEMA 1, 6 PULSE, WITH SINEWAVE FILTER	X		X		X			
CC - NEMA 3R, 12 PULSE		X		X		X		
CCS - NEMA 3R, 12 PULSE, WITH SINEWAVE FILTER		X		X	X			
CB - NEMA 3R, 6 PULSE		X	X			X		
CBS - NEMA 3R, 6 PULSE, WITH SINEWAVE FILTER		X	X		X			
CDES - NEMA 3R, 18 PULSE, WITH SINEWAVE FILTER		X			X		X	X
CD - NEMA 3R, 18 PULSE		X				X	X	X

3-MODULE

DRIVE RATING	AMBIENT TEMPERATURE: WITH SINEWAVE FILTER 40°C	WITH SINEWAVE FILTER 50°C	WITHOUT SINEWAVE FILTER 40°C	WITHOUT SINEWAVE FILTER 50°C	18 PULSE OPTION 50°C
93K - 932kVA		X			
10L - 1000kVA		X			
12L - 1200kVA		X		X	X
14L40 - 1400kVA	X		X		
15L40 - 1500kVA	X		X		

2-MODULE

DRIVE RATING	AMBIENT TEMPERATURE: WITH SINEWAVE FILTER 40°C	WITH SINEWAVE FILTER 50°C	WITHOUT SINEWAVE FILTER 40°C	WITHOUT SINEWAVE FILTER 50°C
51K - 518kVA		X		X
60K - 600kVA		X		X
70K - 700kVA		X		X
81K - 815kVA		X		X
93K40 - 932kVA	X			
93K - 932kVA				X
10L40 - 1000kVA	X			
10L - 1000kVA				X

1-MODULE

DRIVE RATING	AMBIENT TEMPERATURE: WITH SINEWAVE FILTER 40°C	WITH SINEWAVE FILTER 50°C	WITHOUT SINEWAVE FILTER 40°C	WITHOUT SINEWAVE FILTER 50°C
660 - 66kVA		X		X
830 - 83kVA		X		X
11K - 110kVA		X		X
13K - 130kVA		X		X
16K - 163kVA		X		X
20K - 200kVA		X		X
26K - 260kVA		X		X
39K - 390kVA		X		X
45K - 454kVA		X		X
51K40 - 518kVA	X		X	

Figure C-28: Example of Drive Model Number Interpretation

Appendix D: **Special Symbols**

To identify special hazards, symbols may appear on INSTRUCT products in conjunction with the **DANGER**, **WARNING** and **CAUTION** signal words. These symbols indicate areas that require special and/or strict adherence to the procedures to prevent serious injury to personnel or loss of life.

Electrical Hazard Symbol
A symbol that is comprised of an equilateral triangle enclosing a lightning bolt indicates a hazard of injury from electrical shock or burn.

Explosion Hazard Symbol
A symbol that is comprised of an equilateral triangle enclosing an explosion indicates a hazard of injury from exploding parts.

Hot Surface Symbol
A symbol that is comprised of an equilateral triangle enclosing a heat-emitting surface indicates a hazard of injury from hot surfaces or components.

Read Manual Symbol
A symbol that is comprised of a circle enclosing a manual indicates that the manual must be read before operation.

Appendix E: **Warning and Fault Messages**

This section lists the fault messages that may be displayed during the operation of the VSD. Each trip code listed is accompanied by a possible cause. In the event that the source of the malfunction cannot be determined, contact InTouch for additional help.

Table E-19: ES7 Warning Alarms

Bit	Comms Manual Description	LCD Screen	Description	Possible Causes/ Troubleshooting
0	Over-current Alarm	Over-Current	ASD output current greater than F601 setting.	• Defective IGBT (U, V, or W). • ASD output to the motor is connected incorrectly. • ASD output phase-to-phase short. • The ASD is starting into a spinning motor. • Motor/machine jammed. • Mechanical brake engaged while the ASD is starting or while running. • Accel/Decel time is too short. • Voltage Boost setting is too high. • Load fluctuations. • ASD operating at an elevated temperature.
1	ASD Overload Alarm	*ASD Overload	Load requirement in excess of the capability of the ASD.	• The carrier frequency is too high. • An excessive load. • Acceleration time is too short. • DC damping rate is set too high. • The motor is starting into a spinning load after a momentary power failure. • The ASD is improperly matched to the application.
2	Motor Overload Alarm	Motor Overload	Load requirement exceeds the ability of the motor.	• Improper V/f setting. • Motor is locked. • Continuous operation at low speed. • Startup frequency setting adjustment required.
3	Overheat Alarm	*Over-Heat	ASD ambient temperature excessive.	• ASD is operating at an elevated temperature. • ASD is too close to heat-generating equipment. • Cooling fan vent is obstructed (see Mounting the ASD on pg. 22). • Cooling fan is inoperative. • Internal thermistor is disconnected.

Bit	Comms Manual Description	LCD Screen	Description	Possible Causes/ Troubleshooting
4	Over-voltage Alarm	*Over-Voltage	DC bus voltage exceeds specifications.	• ASD attempting to start into a spinning motor after a momentary power loss. • Incoming commercial power is above the specified range. • Decel time is too short. • Voltage spikes at the 3-phase input; install inductive filter. • DBR required. • DBR resistance value is too high. • DBR function is turned off. • Over-Voltage Stall feature is turned off. • System is regenerating. • Load instability. • Disable the Ridethrough function (F302).
5	Main Circuit Insufficient-voltage Alarm	Main Power Under Voltage	Under-voltage condition at the 3-phase AC input to the ASD.	• Low 3-phase commercial voltage.
6	Control Circuit Insufficient-voltage Alarm	*Control Power Under Voltage	Under-voltage condition at the 5, 15, or the 24 VDC supply.	• Defective **Control Board**. • Excessive load on power supply. • Low input voltage.
7	Under-current Alarm	Low-Current Operation	With the **Low-Current Trip** (F610) parameter enabled, the output current of the ASD is below the level defined at F611 and remains there for a time longer than the setting of F612.	• Output current too low.
8	Excess-torque Alarm	Excessive Torque	Torque requirement is in excess of the setting of F616 or F617 for a time longer than the setting of F618.	• ASD is not correctly matched to the application. • F616 or F617 setting is too low. • Obstructed load.
9	Brake Resistor Overload Alarm	*Braking Resistor Overload	Excessive current at the **Dynamic Braking Resistor**.	• Deceleration time is too short. • DBR configuration improperly set.

Bit	Comms Manual Description	LCD Screen	Description	Possible Causes/ Troubleshooting
11	Communication Error Alarm (scan transmission)	Communication Error (scan error)	Internal communications error.	• Improperly programmed ASD. • Improper communications settings. • Improperly connected cables.
12	Communication Error Alarm (RS485/Common Serial / Message Transmission)	Communication Alarm2 (RS232/RS485/TTL error)	External communications error.	• Improperly programmed ASD. • Improper communications settings. • Improperly connected cables.
13	Reserved			
14	Reserved			
15	Reserved			

Table E-20: ES7 Trips

Trip Code (Decimal)	Comms Manual Description	LCD Screen	Possible Causes/Troubleshooting
0	No error	No Error	• No active faults.
1	Over-Current During Acceleration	Over-Current During Acceleration	• Improper V/f setting. • Restart from a momentary power outage. • The ASD is starting into a rotating motor. • ASD/Motor not properly matched. • Phase-to-phase short (**U**, **V**, or **W**). • **Accel** time too short. • **Voltage Boost** setting is too high. • Motor/machine jammed. • Mechanical brake engaged while the ASD is running. • ASD current exceeds 340% of the rated FLA on ASDs that are 100 HP or less during acceleration. On ASDs that are greater than 100 HP, this fault occurs when the ASD current exceeds 320% of the rated FLA during acceleration.
2	Over-Current During Deceleration	Over-Current During Deceleration	• Phase-to-phase short (U, V, or W). • Deceleration time is too short. • Motor/machine jammed. • Mechanical brake engaged while the ASD is running. • ASD current exceeds 340% of the rated FLA on ASDs that are 100 HP or less during deceleration. On ASDs that are greater than 100 HP, it occurs when the ASD current exceeds 320% of the rated FLA during deceleration.

Trip Code (Decimal)	Comms Manual Description	LCD Screen	Possible Causes/Troubleshooting
3	Over-Current During Constant Speed Running	Over-Current During Fixed Speed	• Load fluctuations. • ASD is operating at an elevated temperature. • ASD current exceeds 340% of the rated FLA on ASDs that are 100 HP or less during a fixed-speed run or if during a fixed-speed run the ASD overheats. On ASDs that are greater than 100 HP, it occurs when the ASD current exceeds 320% of the rated FLA on a fixed-speed run.
4	Over-Current at Startup at the Load	Over-Heat During Run	• Cooling fan inoperative. • Ventilation openings are obstructed. • Internal thermistor is disconnected. • Improper V/f setting. • ASD or the motor is improperly matched to the application.
5	Over-Current of U-Phase Arm	U-Phase Over-Current	• Low impedance at the U lead of the ASD output.
6	Over-Current of V-Phase Arm	V-Phase Over-Current	• Low impedance at the V lead of the ASD output.
7	Over-Current of W-Phase Arm	W-Phase Over-Current	• Low impedance at the W lead of the ASD output.
8	Input Phase Failure	Input Phase Failure	• 3-phase input to the ASD is low or missing at the R, S, or T input terminals.
9	Output Phase Failure	Output Phase Failure	• 3-phase output from the ASD is low or missing at the U, V, or W output terminals or at the input to the motor.
10	Over-Voltage During Acceleration	Over-Voltage During Acceleration	• Motor running during restart.
11	Over-Voltage During Deceleration	Over-Voltage During Deceleration	• Deceleration time is too short. • DBR value is too high. • DBR required (DBR setup required). • Stall protection is disabled. • 3-phase input voltage is out of specification. • Input reactance required.
12	Over-Voltage During Constant Speed Running	Over-Voltage During Fixed Speed	• Load fluctuations. • 3-Phase input voltage out of specification. • DBR required (DBR setup required).
13	ASD Overload	ASD Overload	• Acceleration time is too short. • DC Injection current is too high. • Improper V/f setting. • Motor running during restart. • ASD or the motor is improperly matched to the application.
14	Motor Overload	Motor Overload	• Improper V/f setting. • Motor is locked. • Continuous operation at low speed. • Load requirement exceeds ability of the motor. • Startup frequency setting adjustment required.

Trip Code (Decimal)	Comms Manual Description	LCD Screen	Possible Causes/Troubleshooting
15	Overload of Generative Brake Resistor	Dynamic Braking Resistor Overload	• Deceleration time is too short. • DBR setting adjustment required. • Overvoltage Stall setting adjustment required
16	Overheat Trip	Over-Heat	• Cooling fan inoperative. • Ventilation openings are obstructed. • Internal thermistor is disconnected.
17	Emergency Off	Emergency Off	• Output signal from the ASD is terminated and a brake may be applied if so configured. • Emergency Off command received via EOI or remotely.
18	EEPROM Error (write error)	EEPROM Fault	• EEPROM write malfunction. • Make a service call.
19	Initial Read Error of Control EEPROM	EEPROM Read Error	• Control EEPROM read malfunction. • Make a service call.
20	Initial Read Error of Main Circuit EEPROM	EEPROM Read Error	• Main Circuit EEPROM read malfunction. • Make a service call.
21	RAM Error	ASD RAM Fault	• Internal RAM malfunction. • Make a service call.
22	ROM Error	ASD ROM Fault	• Internal ROM malfunction. • Make a service call.
23	CPU Error	CPU Fault	• CPU malfunction. • **Control Board** malfunction. • Make a service call.
24	Communication Error Trip	Communication Error Interruption	• Communication time out error. • Communication malfunction. • Improper or loose connection. • Improper system settings.
25	Gate Array Error	Gate Array Fault	Defective Gate Array or Gate Array malfunction
26	Current Detector Error	Low -Current Detector Error	• Improper Low- Current detection level settings at F609 – F612.
27	Option Unit Error	Optional Expansion Input Terminal Board 1 Error	• Optional Expansion Input Terminal Board 1 is defective.
28	Flash Memory Error	Flash Memory Error	• Flash memory malfunction. • Make a service call.
29	Under-Current Trip		
30	Insufficient Voltage at Main Circuit Trip	Main Power Under-Voltage	• Input 3-phase voltage is too low. • Momentary power failure longer than the time setting of F628.

Trip Code (Decimal)	Comms Manual Description	LCD Screen	Possible Causes/Troubleshooting
31	Insufficient Voltage at Control Circuit Trip	Control Power Under-Voltage	• This fault is caused by an under-voltage condition at the 5, 15, or the 24 VDC supply. • 3-phase input voltage low.
32	Excess Torque Trip	Over-Torque	• A torque requirement by the load in excess of the setting of F616 or F617 for a time longer than the setting of F618. • The ASD is improperly matched to the application. • The load is obstructed.
33	Ground Fault (Software Detection) Trip	(Earth) Ground Fault - Software or Hardware	• Ground fault at the motor. • Ground fault at the output of the ASD. • Current leakage to **Earth Ground**. • Ground fault detected by the software.
34	Ground Fault (Hardware Detection) Trip	(Earth) Ground Fault - Software or Hardware	• Ground fault at the motor. • Ground fault at the output of the ASD. • Current leakage to **Earth Ground**. • Ground fault detected by the software.
35	Fuse Error	DC Fuse Open	Internal DC bus fuse is open.
36	Over-Current of Generative Brake Resistor	Dynamic Braking Resistor Overcurrent	• ASD inability to discharge the bus voltage during regeneration. • No dynamic braking resistor (DBR) installed. • Deceleration time is too short. • Improper DBR setup information. • Defective IGBT7 (or IGBT7 circuit). • 3-phase input voltage is above specification.
37	Dc Section Over-Current During Acceleration		
38	Dc Section Over-Current During Deceleration		
39	Dc Section Over-Current During Constant Speed Running		
40	Auto Tuning Error	Autotune Error	• Autotune setting F400 is set to Auto Calculation and there is a problem with the Motor Constant readings.
41	ASD Type Error	ASD Typeform Error	• Firmware information (typeform) loaded into the **Gate Driver** board is inconsistent with the device in which the firmware is being used. • The **Gate Driver** board has been replaced. • The **Gate Driver** board is defective.
42	Sink / Source Selection Error	Sink/Source Setting Error	• Improperly positioned **Sink/Source** jumper on the Terminal board or on an option device (see J100 at the Terminal Board of the ASD). • **Sink/Source** configuration is incorrect.

Trip Code (Decimal)	Comms Manual Description	LCD Screen	Possible Causes/Troubleshooting
43	Magnetic Brake Error (Applicable To System Sequence)		
44	Encoder Disconnection	Encoder Signal-Loss Error	• ASD is configured to receive a signal from a shaft-mounted encoder and no signal is being received while running. • Disconnection at the Encoder circuit. • Motor is stopped and is generating torque via torque limit control. • ASD is not configured properly.
45	Speed Error	Speed Error	• Result of a motor speed that is greater than the commanded speed when using an encoder for speed control. • Improper encoder connection or setup information. • Defective encoder.
46	Excess Positional Deviation	Position Deviation Error	• Operating in the Position Control mode and the resulting position exceeds the limits of the F631 setting.
49	Key Error	Key Failure	• Same key input for 20 seconds or more.

Appendix F: **ES7 VSD Support Resources**

F.1 PRODUCT DOCUMENTATION

This manual is the main product documentation for the Sensia ES7 Drive.

F.2 GUIDES AND RELEASE NOTES

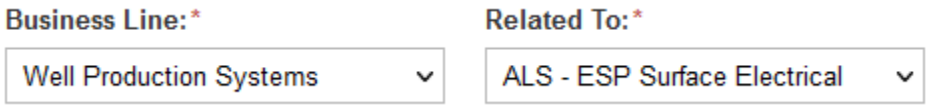
General guides, best practices, technical alerts and software release notes for the ES7 Drive are available at InTouch 3250348 Reference Page.

F.3 TECHNICAL SUPPORT

You can reach us via the Lift Control Systems Custom Service email:

liftcontrolsystems@sensiaglobal.com

For Schlumberger customers, an InTouch ticket should be raised to Well Production System – ALS-ESP Surface Electrical helpdesk.



F.4 HOW TO REACH US

You can find more information about Sensia and the E20P Drive information here:

Sensia Home Page:	https://www.sensiaglobal.com/
Sensia Lift Control Solutions Page:	https://www.sensiaglobal.com/Sensia-Lift-Control-Systems
Lift Control Drives Page:	https://www.sensiaglobal.com/Sensia-Lift-Control-Systems/Lift-Control-Drives
Contact Us:	https://www.sensiaglobal.com/Contact