sensia
Rockwell Automation + Schlumberger

LIFT CONTROL SYSTEMS

INSTRUCT LIFT CONTROL SYSTEMS

ES7 VSD Configuration via ESP Controller

Configuration Manual

MODEL: INSTRUCT ESP Intelligent Controller
INSTRUCT ES7 Intelligent VSD

Manual No: LCS-ENG-M0013 , Rev. 01

Publisher Notes

DISCLAIMER

Whilst Sensia has taken every care in the preparation of this document, it cannot accept responsibility for printing errors or omissions and does not warrant that it is correct and comprehensive in every particular. Equipment supplied should always be operated by persons with an appropriate level of skill and training.

Sensia shall not be liable for incidental or consequential damages resulting from the furnishing, performance or use of this material.

Sensia pursues a policy of continuous improvement, and information given herein may be updated without notice. Further, this information is proprietary to Sensia, and must not be disclosed to any third party except as may be required to operate the equipment supplied in accordance with the purposes for which it was sold by the persons properly licensed to operate it.

Our manuals may contain links to protected online resources that you cannot access. If you are unable to access a document link, please prepare an email request that includes (1) the name of the document and (2) a copy of the link and address it to lcs.support@sensiaglobal.com. Our support team will provide you with the requested information.

COPYRIGHT NOTICE

TRADEMARKS & SERVICE MARKS

REVISION HISTORY

REVISION	DESCRIPTION OF CHANGE	SENSIA ISSUER	DATE
1	Initial release.	Lift Control Systems	18 April 2022

Table of Contents

List of Figures

List of Tables

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 legislation, 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**

This configuration manual describes how to use the INSTRUCT ESP Intelligent Controller to configure the ES7 Low-Voltage Variable Speed Drive (VSD) for various artificial lift applications. It is written for users who understand the physical set up of the well, and the characteristics and relationships among flow, pressure, temperature, and signal noise in the well.

This manual shall be read in conjunction with these drive and controller manuals:

- INSTRUCT ESP Intelligent Controller Manual (InTouch ID 6128576)
- ES7 Low Voltage Drive Manual (InTouch ID 4197006)

1.1 DOCUMENT SCOPE

This document assumes that the controller is already installed in the ES7 drive and is ready to be started. If the drive is delivered without the controller, refer to Section 6.5.2 & 8.2 of the ES7 Low Voltage Drive Manual (InTouch ID 4197006) to install the controller in the drive.

This document describes:

- theory of operation
- VSD settings screens
- VSD communication configuration
- basic VSD configuration
- application-specific configuration
- VSD commissioning

1.2 SUPPORTED DRIVE TYPEFORM CODES

The following is a list of ES7 drive typeform codes that the controller currently supports. In the event of a control board or gate driver board replacement, the typeform may have to be reset. Refer to Figure 1-1 and Figure 1-2 for equipment photos.

Table 1-1: Controller Support Drive Typeform Codes

Typeform	kVA size	Type Code: G7 Keypad Item FF92/INSTRUCT/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

Typeform	kVA size	Type Code: G7 Keypad Item FF92/INSTRUCT/StarView	Type Code: Hexadecimal Equivalent Value
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

Figure 1-1: ES7 12P 260 kVA Sine Wave Drive

Figure 1-2: ES7 18P 260 kVA Sine Wave Drive

Section 2: **Theory of Operations**

Variable speed motor control uses a variable speed drive (VSD) to control speed/frequency of the motor. The controller changes modes to operate as a VSD controller. All motor protection requirements are set using the controller. Using the feedback from the VSD, the controller performs the motor protection. The available voltage and frequency can be changed by the VSD. In the event a VSD trip occurs, the drive turns off the output going to the motor. In the event the controller detects a trip condition, the VSD is instructed to turn off the output. Figure 2-1: VSD Interface shows a simplified block diagram of a controller VSD system.

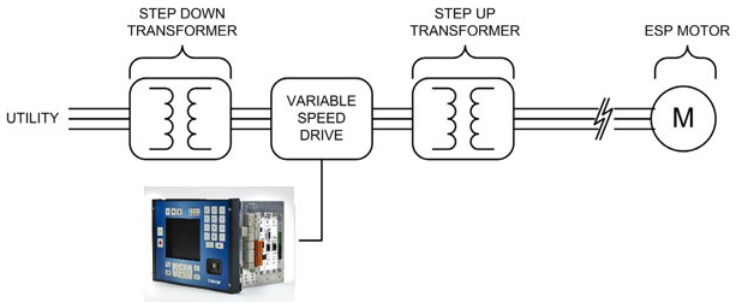


Figure 2-1: VSD Interface

The controller uses a serial communication cable to interface to the VSD. The RS-485 port on the control card of the controller can be used for the communication. Optionally, a communication card can be inserted into one of four slots in the controller to facilitate communication.

Warning

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

The communication card and other expansion cards are not “hot-swappable”. Power to the controller must be turned off prior to insertion of the card into an expansion card slot.

2.1 VARIABLE SPEED DRIVE CONTROLS

The VSD is a self-contained drive system controlled by the controller. The controller accepts operation / configuration parameters via the keypad, SCADA or StarView Wellsite Display Software and sends these parameters to the VSD.

Table 2-1 summarises all the parameters that are configured and viewed through the controller.

Table 2-1: VSD Control Parameters

Parameter	Description
Stop Mode	Controls how the VSD stops the motor in a shut down that is manually triggered or automatically triggered. The two options are: **Coast**: Power is removed from the motor allowing it to coast to a stop. **Decel**: The VSD powers the motor to a controlled stop according to deceleration time set.

Parameter	Description
Rotation	Allows the VSD to run in the opposite direction. This can be toggled between “0” and “1” to change the rotation from the previous operating condition. This is used during commissioning in the event the pump operates backwards, to avoid having to make wiring changes. The change to the rotation direction takes effect on the next start. The **Rotation Direction** is also controlled by **Reverse While Running**.
Carrier Frequency	Sets the pulse width modulation (PWM) switching frequency.
Reset VSD to Factory Defaults	Resets the VSD to factory defaults.
Drive Info	Provides view-only information on the VSD, typically for troubleshooting purposes.
Target Speed	Allows adjustment of the VSD / motor running frequency in Hertz. When the VSD is running, changing this setting ramps the VSD to the new frequency as soon as the ACCEPT key is pressed. The ramp rate depends on the acceleration / deceleration settings. This screen is also accessible from the live values screen in the motor table.
Maximum Speed	Establishes the upper operating frequency limit. The VSD will not operate above this limit.
Minimum Speed	Establishes the lower operating frequency limit. The VSD will not operate below this limit except when performing a ramp from a start or to a stop.
Startup Frequency	Controls the frequency at which the inverter begins to operate during a start. The VSD starts at this frequency and ramps to the **Target Speed**. This parameter can be set between 0 and 10 Hz and is typically set to around 7 Hz for ESP applications. For PMM, it is typically set to around 3 Hz.
	 Warning Potential Severity: Serious Potential Loss: Assets Hazard Category: Electrical, Machinery equipment hand tools For DHT applications in which a three-phase choke is used with the DHT interface card, setting this frequency to 0 Hz may damage the DHT interface card.
Startup Voltage Boost	Controls the amount of voltage added to the starting voltage to provide increased torque for acceleration. You may change voltage Boost to any value between 0 and 30%.
Ramp Frequency	Facilitates the calculation of the acceleration / deceleration times during operation. This parameter sets the frequency at which the **Acceleration Ramp Time** and **Deceleration Ramp Time** parameters occur. The **Ramp Frequency** is fixed at 90.00 Hz and cannot be changed.
Accel Ramp Time	Sets the time to accelerate from 0 Hz to the **Ramp Frequency**. Target speed changes are affected by this value. *Acceleration time to x Hz (seconds) =* *Accel Ramp Time * (x – Start-Up freq.)/Ramp freq.*

Parameter	Description
Decel Ramp Time	Sets the time to decelerate from the **Ramp Frequency** to 0 Hz. Target speed changes are affected by this value. *Deceleration time to x Hz (seconds) = Decel Ramp Time * (x / Ramp freq.)*
Accel/Decel Pattern	Sets the acceleration and deceleration patterns used to ramp up/down the frequency according to the acceleration and deceleration times on the voltage / frequency curve. “Linear” (recommended for ESP applications) and S-Pattern.
Base Speed	Sets the frequency at which the maximum output voltage of the VSD is output. The Volts/Hertz curve for the VSD is constructed using these parameters. • Base Speed • VSD Base Frequency Voltage Selection (for applicable VSDs) • Fixed Base Voltage
VSD Base Freq Volt Sel	Determines how the output voltage of the VSD behaves by enabling or disabling the Voltage Compensation function. This function provides an output waveform adjustment that compensates for changes in the input voltage.
Base Voltage	Sets the maximum value of the output voltage of the drive. With Voltage Compensation disabled, this value is the output voltage at the base frequency. Regardless of the programmed value, the output voltage cannot be higher than the input voltage. The actual output voltage will be influenced by the input voltage of the VSD and the Supply Voltage Compensation setting above. See InTouch ID# 5709381 for more details on voltage compensation.
PWM Carrier Freq	Sets the pulse width modulation (PWM) carrier frequency (the frequency at which the VSD transistors switch). This parameter can be changed while running on VSDs. This parameter is fixed and cannot be changed on SWD VSDs to protect the SWD filter.
V/Hz Pattern	Selects different voltage/frequency characteristics for motor control. For ESP applications, the setting “Constant Torque” is recommended. • Constant Torque • Variable Torque This is a feature of the VSD drive and the VSD manual should be consulted for further details.
Catch A Spinning Motor	Allows the VSD to start safely into a spinning motor (either forward or reverse direction). The VSD will detect the rotation speed and adjust the VSD output voltage and frequency to match before applying power.
Reverse While Running	Reverses the direction of motor operation while the VSD is running. The VSD will decelerate and start in the other direction automatically. The **Rotation Direction** parameter will automatically indicate the new direction.
Underload Tracking	Enables the VSD to adjust the underload trip point over time based on nominal operating parameters. Users can enable and disable it by selecting the Enable Underload Tracking check box. The Tracking Target can be set anywhere from 1% to 100%.
Speed Force	Forces the VSD to operate at a specific frequency during an event captured on the controller digital inputs. For details see section 2.2.1 Speed Force.

Parameter	Description
Rocking Starts	Rotates the motor in short bursts in the event of a stuck motor or heavy load. For details see section 2.2.2: Rocking Start.
VSD Thermal OL	Sets the thermal overload protection level for the motor. This feature can only be turned ON/OFF.
VSD Thermal Stall	Controls the activation level of the stall protection. It is adjustable from 10% to 200% of the rated VSD current. When the stall level is reached, the VSD will begin stalling by lowering the frequency and voltage to prevent overcurrent tripping. If the stall does not clear within the time limits of the VSD, a trip will occur.
VSD Jump Frequency VSD Jump Width	Allows setting of up to three frequency bands to be configured as dead zones for the Target Speed. For details, see section 2.2.3: Jump Frequency.
Feedback	For details, see section 2.2.4: Feedback.
Extended Ramp	Permits the customization of the ramp rate beyond the capability of the VSD. For details, see section 2.2.5 Extended Ramp Rate.
Gas Lock Protection	Automatically detects and deals with gas lock condition. For details, see section 2.2.6 Gas Lock Protection.
TypeForm Reset	Resets the VSD to factory defaults.
VSD Information	Provides view-only information on the VSD, typically for troubleshooting purposes.

Table 2-2: VSD Operating Parameters

Parameter	Description
VSD Frequency	The “run” frequency output by the VSD. This should typically be the same as the Target Speed while the VSD is running, although the value will change as the VSD ramps up or down.
VSD Load	The live value of the VSD output current and the percentage loading of the full rated VSD output current. The current is an average of all three VSD phases measured by the drive and displayed by the controller. There are no controller alarms associated with this parameter. Alarming is performed using the VSD Motor Amps.
VSD Motor Amps	Displays the calculated value of the current delivered by the VSD to the motor. This value is calculated from the VSD Drive Amps read from the drive and the VSD Transformer Ratio. Two alarms are associated with this parameter: • VSD Underload (VSD UL). This alarm is typically set to 85% of nominal operating current. Setting this value is subjective as there are dependencies on pumping fluid. However, VSD Underload should not be less than 60% of motor nameplate current.

Parameter	Description
	• VSD Overload (VSD OL). This alarm is typically set to 110% of nominal operating current. Using a VSD, there is no issue with motor inrush currents.
VSD Motor Amps (cont'd)	These two alarms use the standard controller alarm configurations detailed in section **5.3 Alarms and VSD Warnings**. The VSD Overload alarm uses an inverse time curve. For proper operation, these parameters require the output transformer ratio to be set. The VSD can only monitor the output power, which is not necessarily the motor power if a transformer is used. The controller can provide the motor protection taking into account the transformer ratio.
VSD Voltage	Represents the incoming RMS voltage to the drive and the output RMS voltage. The output voltage will vary during motor operation.
VSD Power	Represents the incoming power to the drive and the output power to the motor. The output power will vary during motor operation.
VSD Alarm Control	Provides access to settings that control how the controller acts on alarms from the VSD and on the communication link between the controller and VSD. For more information, consult the VSD Operating Manual.

2.1.1 SPEED FORCE

Speed Force is used to force the VSD to change to a specific frequency during an alarm event. The controller digital inputs are used as the alarm source.

When the selected digital input goes into an alarm condition, the VSD **Target Speed** will change to the **Speed Force Frequency**. If the input alarm clears, the **Target Speed** will return to its normal setting. During the change in motor speed, the **Accel/Decel Ramp Times** are used.

Note

The Speed Force function will not work if the associated digital input alarm is set to "bypass."

Table 2-3: Speed Force Parameters

Parameter	Description
Speed Force Source	The digital input to be used for the Speed Force. Digital inputs 1 to 6 are available.
Speed Force Freq	The VSD output frequency / motor speed to be used when Speed Force is activated.

2.1.2 ROCKING START

The Rocking Start is used to agitate a stuck pump or used during a pump start up in sanded well condition. Once configured, the feature operates only once and must be re-configured if repeat operations are required. The parameters are summarized in Table 2-4.

Table 2-4: Rocking Start Parameters

Parameter	Description
Rocking Cycles	The number of rotation pulses that will occur in a single operation. This does not represent a change in direction.
Rocking Target Freq	The frequency the VSD drive will generate for the motor during the rocking operation.
Rocking Method	The rocking pattern desired. • 1: STOP – JOG REVERSE – STOP – JOG FORWARD • 2: JOG REVERSE – JOG FORWARD • 3: JOG REVERSE – JOG REVERSE – JOG FORWARD – JOG FORWARD

The selected rocking method is performed for the selected number of rocking cycles at the selected rocking target frequency. Refer to Figure 2-2.

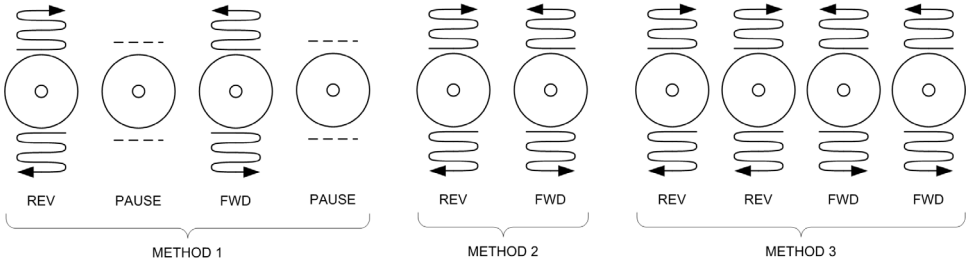


Figure 2-2: Rocking Methods

Refer to InTouch Content ID 3928493 for important information on using Rocking Start.

Warning

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

Rocking Start should only be used as a last resort for starting a pump.

2.1.3 JUMP FREQUENCY

The Jump Frequency applies to the frequency zones, or motor speed, where the VSD drive cannot be safely operated. This is used to prevent the VSD from changing to a motor speed that would resonate the ESP pump.

The controller can configure up to three frequency bands to act as dead zones for the target frequency. The VSD will not operate in these dead bands except during acceleration ramp-up on start and decelerate ramp-down on stop.

Example

Setting the VSD Jump Frequency to 10 Hz with a width of 2 Hz will result in a dead band from 8-12 Hz.

Table 2-5: Jump Frequency Parameters

Parameter	Description
VSD Jump Frequency	The center frequency location where the jump is to occur.
VSD Jump Width	The spread from the center frequency that the dead band occupies.

2.1.4 FEEDBACK

The controller provides a feedback feature for controlling motor speed to a target value. The controller constantly monitors the feedback data and incrementally changes the VSD output frequency. The rate of change and the amount of change is configurable. During operation, the VSD output frequency will fluctuate up and down. Table 2-6 describes the configuration parameters.

Table 2-6: Feedback Parameters

Parameter	Description	
VSD Speed Source	Analog input 1 to 4 as a **target**.	The controller will control the VSD speed/frequency based on the value of this input.
	Analog input 1 to 4 as **feedback**.	The controller will control the VSD speed/frequency to match the value of the analog input.
	Pump intake pressure for when a Phoenix Interface Card is used.	This parameter acts like **Analog input 1 to 4 as feedback**. If the intake pressure increases, the controller can be configured to slow down the VSD.
	Pump discharge pressure for when a Phoenix Interface Card is used.	This parameter acts like **Analog input 1 to 4 as feedback**. If the discharge pressure increases, the controller can be configured to slow down the VSD.
	VSD motor amps.	This parameter acts like **Analog input 1 to 4 as feedback**. If the motor amps increase, the controller can be configured to slow down the VSD.
	Target speed.	Feedback is disabled and the controller will control the VSD to match this frequency.
If Feedback Increases	This parameter defines the action the controller should perform when an analog input changes. The sensor operation may be proportional or inversely proportional with changes to motor speed.	
Feedback Set point	The analog input target value. The VSD will change motor speed in an attempt to match the target value. This value is an engineering unit which is defined by the analog input configuration. For details, see section 4.6.2: Analog Input of INSTRUCT ESP Intelligent Controller Manual (InTouch ID 6128576)	
Feedback Step Size	This parameter defines the amount the motor speed should change during each change step. If the configured step size is too large for the application, the feedback will constantly hunt and exceed the feedback value. If the configured step size is too small, the controller will not be able to maintain control, the feedback data will exceed **Feedback Values,** and the system will alarm.	

Parameter	Description
Feedback Step Interval	This parameter defines how often the change step takes place. This time takes into account the time required for a change in motor speed to affect the sensor on the analog input. Configuration considerations are similar to those for **Feedback Step Size**.
	Note It may take 10 minutes for a change in motor speed to be detected via a pressure change on the surface.
Feedback Value High & Low Alarm	These parameters set the maximum and minimum range of the window in which the controller will perform feedback operations. If the controller is unable to maintain control within this range, the system will alarm. These parameters have no units associated with them as the data type will vary.
Feedback Deadband	The feedback deadband is a range of values around the target value for which the controller will make no speed adjustments to the VSD. Outside the deadband range, the controller will make an adjustment in an attempt to reach the target value.
	Note Starting with firmware version 1.401r1, the controller is able to adjust the deadband of the VSD feedback mode between the range of 0.1% and 10.0%, with a factory default setting of 1.0%. Previous versions of firmware were limited to a non-adjustable 1.0% deadband.

The implementation of feedback parameters is very flexible and can best be explained with examples.

Example

A remote analog signal (analog input 1) will control the speed of the VSD. The controller feedback parameters will be configured as:

Parameter	Configuration
VSD Speed Source	Analog input 1 as target
Analog input 1	Configure to ensure engineering units reflect the engineering units of Hz.
If Feedback Increases Feedback Set point Feedback Step Size Feedback Step Interval Feedback Values Feedback Deadband	N/A

Example

The controller analog 1 is connected to a surface pressure sensor. The controller is expected to operate the VSD to maintain a specific surface pressure.

The controller feedback parameters will be configured as:

Parameter	Configuration
VSD Speed Source	Analog input 1 as feedback.
Analog input 1	Configure analog input 1 to ensure the input data is converted to engineering units that reflect the pressure readings of the sensor.
If Feedback Increases	If feedback increases (pressure rises), the controller should control the VSD to reduce motor speed.
Feedback Step Size	Configure the controller to increment motor speed changes by a specific value.
Feedback Step Interval	Configure the controller to perform the **Feedback Step Size** in a specific interval.
Feedback Value High & Low Alarm	Configure the maximum and minimum pressure values in which the system will operate.
Feedback Deadband	Set the desired deadband value.
Feedback Set Point	Set the desired operating pressure.

2.1.5 EXTENDED RAMP RATE

The extended ramp rate (ERR) is an enhancement to the standard ramp rate available on the VSD. This feature allows a user to customize a ramp rate that is far longer than the ramp rates the VSD can normally provide. The ERR operates in the region between **Min Speed** and **Target Speed**. The VSD will use the standard ramp process to go from the **Start Up Frequency** to the **Min Speed** and then switch to ERR to ramp to the **Target Speed**. Table 2-7 summarizes these parameters.

Table 2-7: Extended Ramp Rate Parameters

Parameter	Description
Extended Ramp Rate	Function to enable or disable this feature
Extended Ramp Step Size	The amount the speed/frequency will change during each step. This entry is limited to values between 0.01Hz and 1Hz.
Extended Ramp Step Interval	The time duration between each step change. This entry is limited to values between 1s and 1000s.

The **Extended Ramp Rate** target is the **Target Speed**. To calculate the duration of a ramp, use the following calculation:

Equation 2-1: VSD Ramp Time

$$\frac{Target\ Speed - Min\ Speed}{Step\ Size} \times Step\ Interval = Ramp\ Time$$

To calculate the **Extended Ramp Step Size** and **Extended Ramp Step Interval** based on a target ramp time use the following:

Equation 2-2: VSD Ramp Time Using Step Interval and Step Size

$$Step\ Interval = \frac{Ramp\ Time \times Step\ Size}{Target\ Speed - Min\ Speed}$$

$$Step\ Size = \frac{Target\ Speed - Min\ Speed}{Ramp\ Time} \times Step\ Interval$$

2.1.6 GAS LOCK PROTECTION

The controller has a gas lock protection (GLP) feature, which can automatically detect and deal with gas lock condition. When GLP is enabled, the controller automatically uses motor current to detect gas lock events. When this event is detected, the controller will slow the pump down and subsequently return to the previous operating speed. The GLP parameters are summarized in Table 2-8.

Table 2-8: Gas Lock Protection Parameters

Parameter	Description
GLP Parameters – Settings	
Enable Gas Lock Protection	Use a check mark to enable the GLP feature. It can be used in all operating modes and with all VSD types. When GLP is enabled, the motor underload alarm will be bypassed regardless of its action setting.
GLP Frequency (Hz)	The frequency at which the VSD will operate during a GLP cycle. It should be slower than the normal operating frequency of the system, as the slower speed is what clears the gas from the ESP.
	Note The GLP Frequency setting is not bound by the minimum frequency setting, i.e., the GLP Frequency can always be set as low as 20Hz regardless of minimum frequency configured for the VSD. A typical setting is 20 - 40Hz but may be different depending on a well's condition.
GLP Cycle Time (Sec)	The length of a GLP cycle (seconds). The time spent running at the actual GLP Frequency will be equal to this time setting minus the time required to decelerate from the previous operating frequency (i.e., the deceleration ramp is included in the GLP cycle time setting).
GLP Max Cycles	The maximum number of consecutive GLP cycles allowed by the controller before tripping the system. Note that "consecutive" means that the system is still determined to be in a gas lock condition, even after a GLP cycle has been applied. If it is determined that a gas lock condition is not

Parameter	Description
	present, the counter for the trip is returned to zero. Typical setting is 3.
GLP Automatic Restarts	The maximum number of times the controller will automatically attempt to restart the VSD before entering the lockout state. It is similar to the automatic restart setting for all other controller trips, with the same restrictions and configuration requirements (i.e., the controller must be in AUTO mode, etc.) Typical setting is 3.
GLP Automatic Restart Delay (Min)	The amount of time (minutes) that the controller will wait after a trip before attempting to automatically restart the VSD. Its effect is similar to all other alarms which have this parameter. This setting is highly wellsite dependent, but the default setting is 30 minutes, which is typical for most other alarms.
GLP Parameters – Motor Amps	
Set Point (Amp)	The motor amps reading below which a gas lock condition is suspected
Activation Time (Sec)	The amount of time (seconds) that the motor amps reading can stay continuously below the set point before the controller will declare a gas lock event
GLP Parameters – Motor Temperature	
Bypass	Use the check mark to bypass the GLP motor temp detection method or uncheck to use it. **Note** It is generally recommended to bypass the motor temperature method of detecting gas lock. ONLY use this setting in circumstances where the motor amps detection method is proven not to be sufficient.
Set Point (F or C)	The expected motor temperature value above which gas lock is suspected
Activation Time (Sec)	The amount of time (seconds) that the motor temperature reading can stay continuously above the set point before the controller declares a gas lock event
GLP Parameters – Manual Override	
Start Gas Lock Cycle	Forces the system to begin a GLP cycle. The controller will immediately decelerate the drive down to the GLP Frequency.

Parameter	Description
Stop Gas Lock Cycle	Forces the system to end the current GLP cycle. The controller will immediately accelerate the drive as appropriate for the currently configured operating mode.
GLP Parameters – Status	
Cycle Engaged	When checked, it indicates that the controller is in a GLP cycle. This is a read -only status indicator, letting the operator know if the operation is in the middle of a Gas Lock Cycle condition. If required, the operator can use the manual override button to immediately start or end a Gas Lock Cycle.
Time Left (Sec)	The number of seconds remaining in the current GLP cycle
Cycles	The number of consecutive GLP cycles, for the purposes of tripping the system. See the setting for **GLP Max Cycles.**

For additional information, refer to the Gas Lock Protection guidelines (InTouch ID 6923767).

Note

The motor undercurrent alarm is automatically bypassed whenever GLP is enabled, even if the action for the motor undercurrent alarm is configured to a non-bypass setting. That is, when GLP is enabled, it supersedes the normal motor undercurrent alarm.

2.1.7 POWER RIDE THROUGH

A Power Ride Through feature was added to INSTRUCT when FW 2.117r002 was released. It enables a VSD to continue running through power sags without trips.

When triggered, the feature will slow the VSD to preserve power, and as long as the DC bus voltage remains higher than 66%, the drive will continue to run without stopping.

Below this 66% threshold, the drive will stop until power is restored. If power is restored and the controller remains powered without rebooting, the drive will automatically restart the ESP within 3 seconds of it being stopped using the Catch a Spinning Motor feature. The power sag should not last more than 250ms. However, the effectiveness of the Power Ride Through feature is highly dependent on the loading of the drive at the time of the power dip and how long the power dip remains.

Note: Under certain conditions, use of the Power Ride Through feature mode could cause errors in the volts/hertz curve for the motor, resulting in the motor amps being higher than usual. Activating the VSD input voltage alarm is recommended in these cases to avoid prolonged power sags.

The feature can be found under INSTRUCT **Menu** > **VSD** > **Configure**.

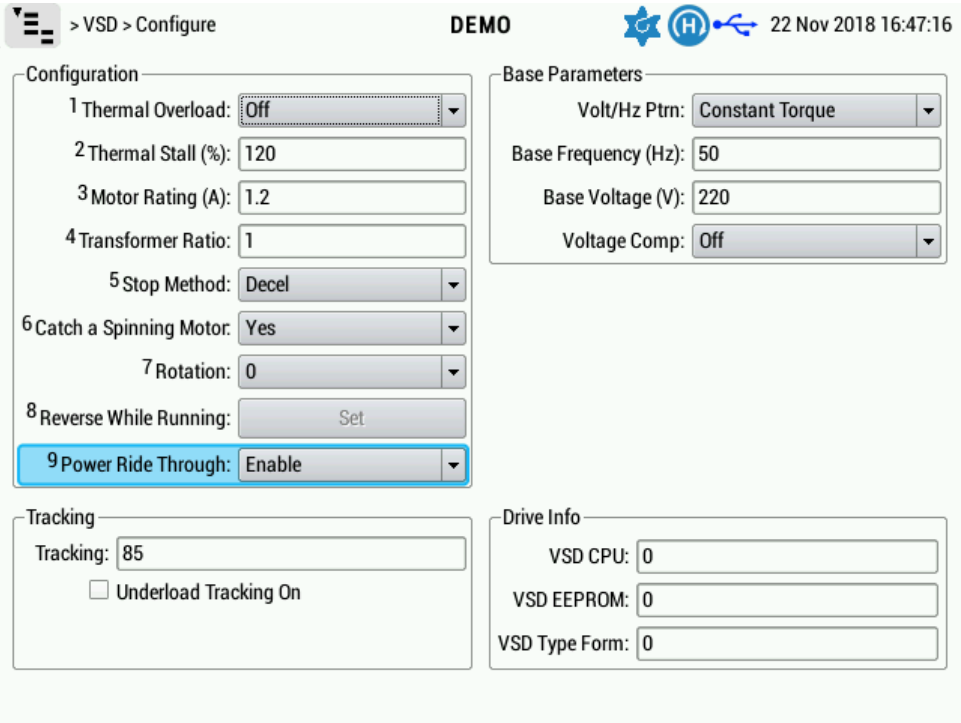


Figure 2-3: Power Ride Through

2.1.8 PMM TUNING

Section to be populated when PMM support is fully qualified.

Section 3: **VSD Settings Screens**

3.1 VSD MENUS

The following menus are available when “Instruct ES7” is selected for Device Function:

1. Operator
2. Summary
3. Alarms
4. Speed
5. Time
6. Configure
7. Expert
8. Gas Lock
9. PMM Configure
10. PMM Summary

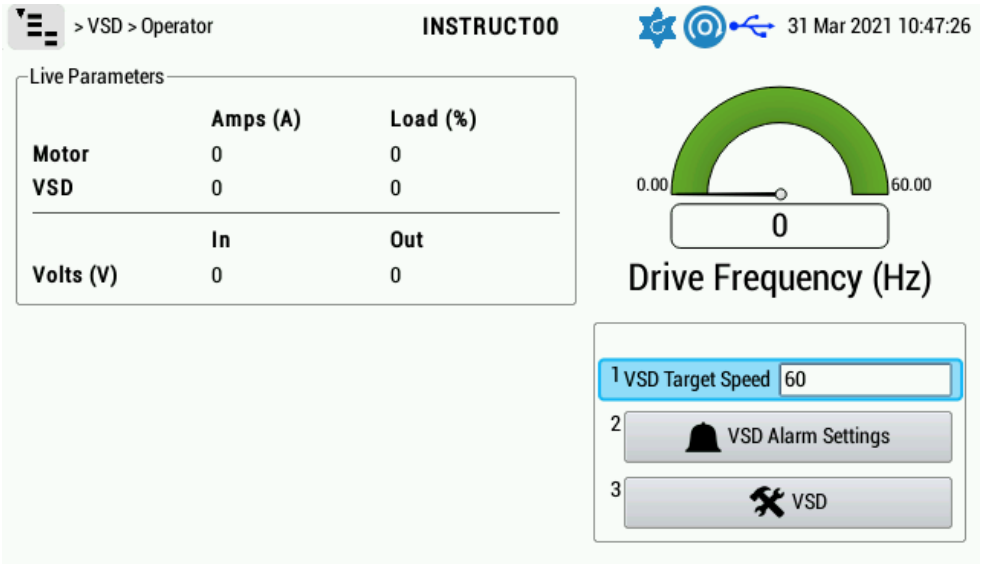


Figure 3-1: Operator Screen

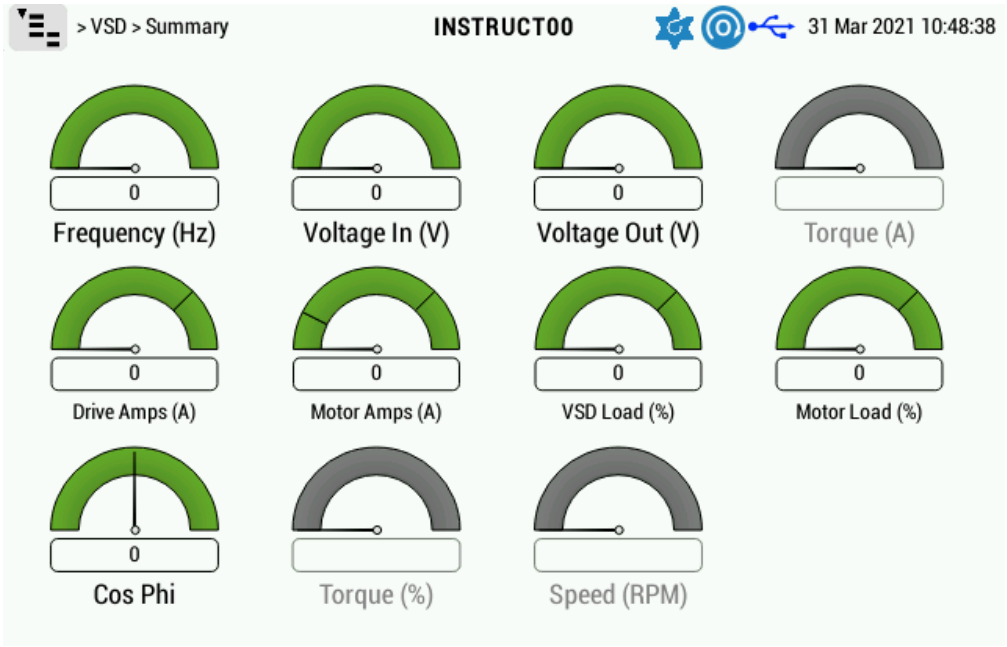


Figure 3-2: Summary Screen

Figure 3-3: Alarms Screen

Figure 3-4: Speed Screen

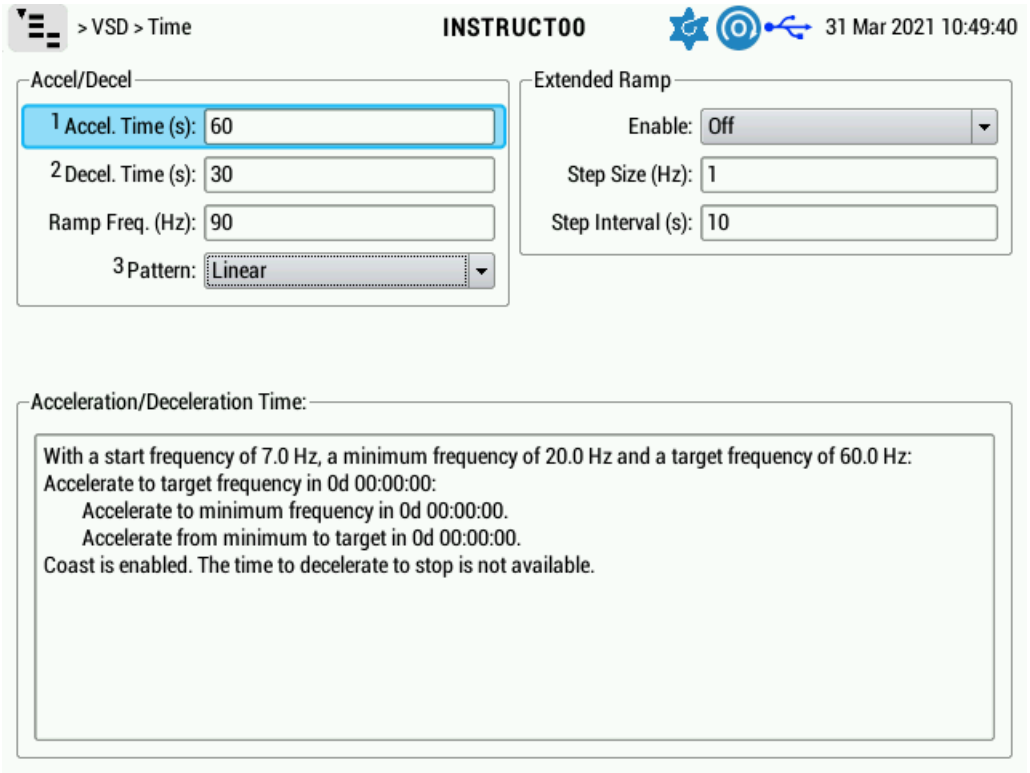


Figure 3-5: Time Screen

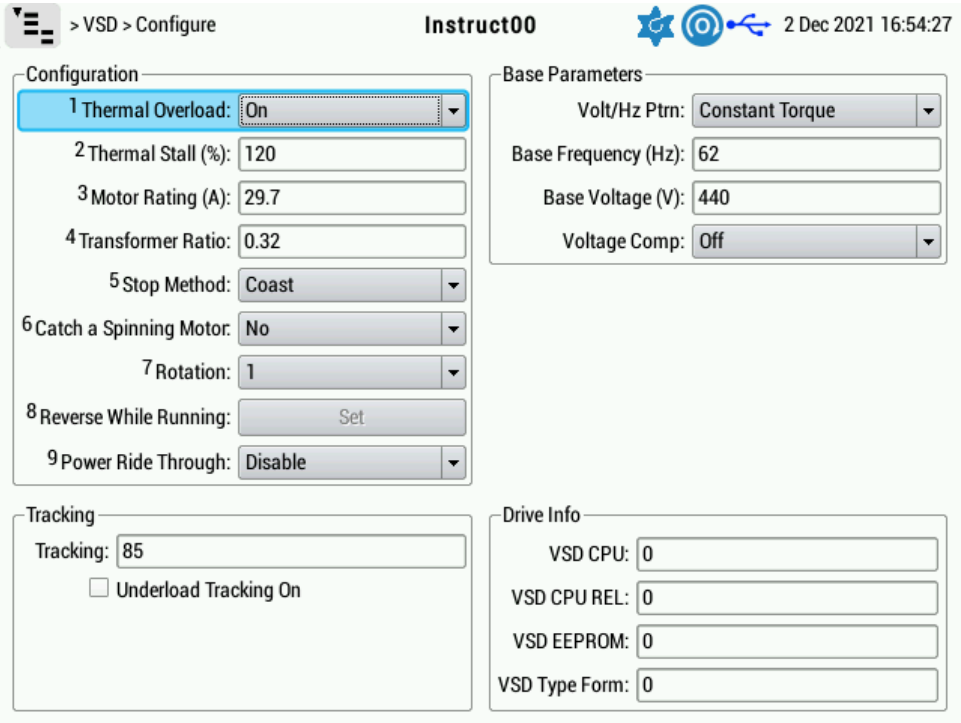


Figure 3-6: Configure Screen

Figure 3-7: Expert Screen

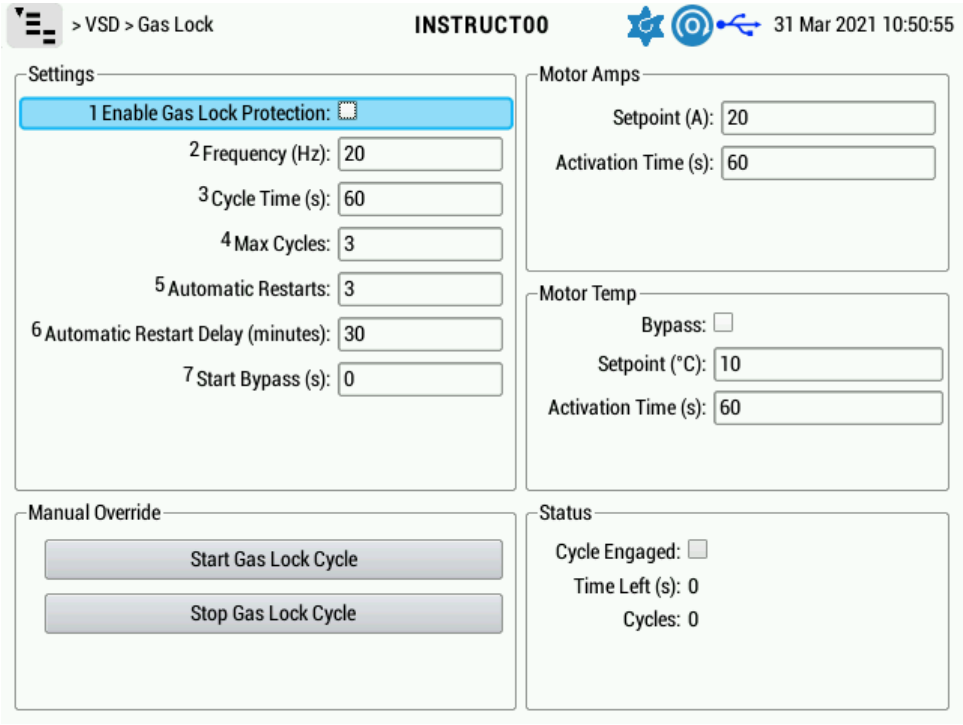


Figure 3-8: Gas Lock Screen

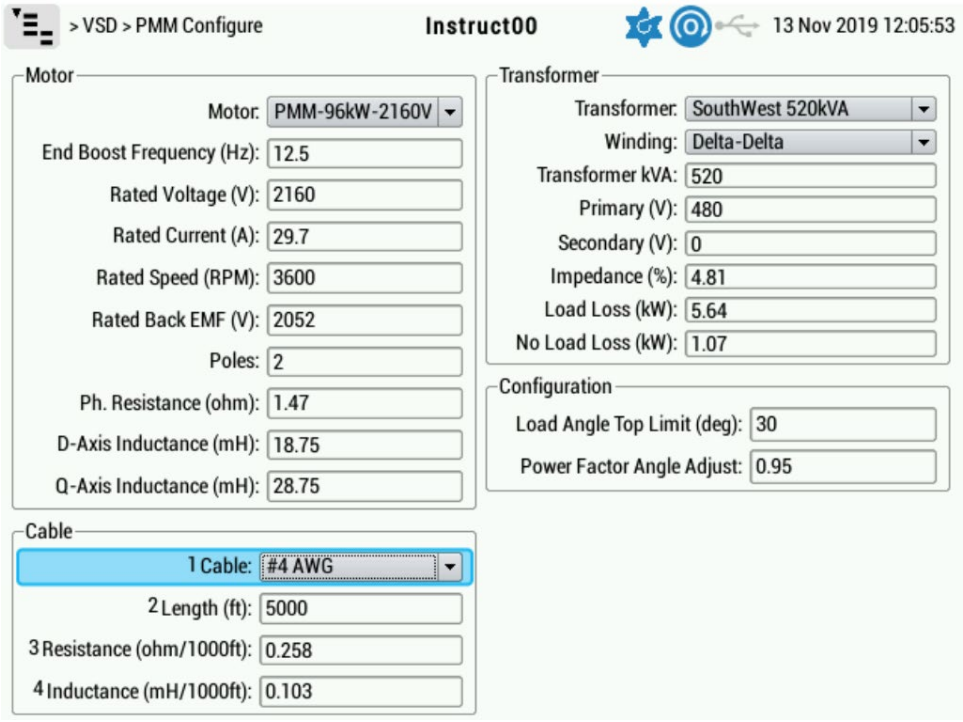


Figure 3-9: PMM Configure Screen

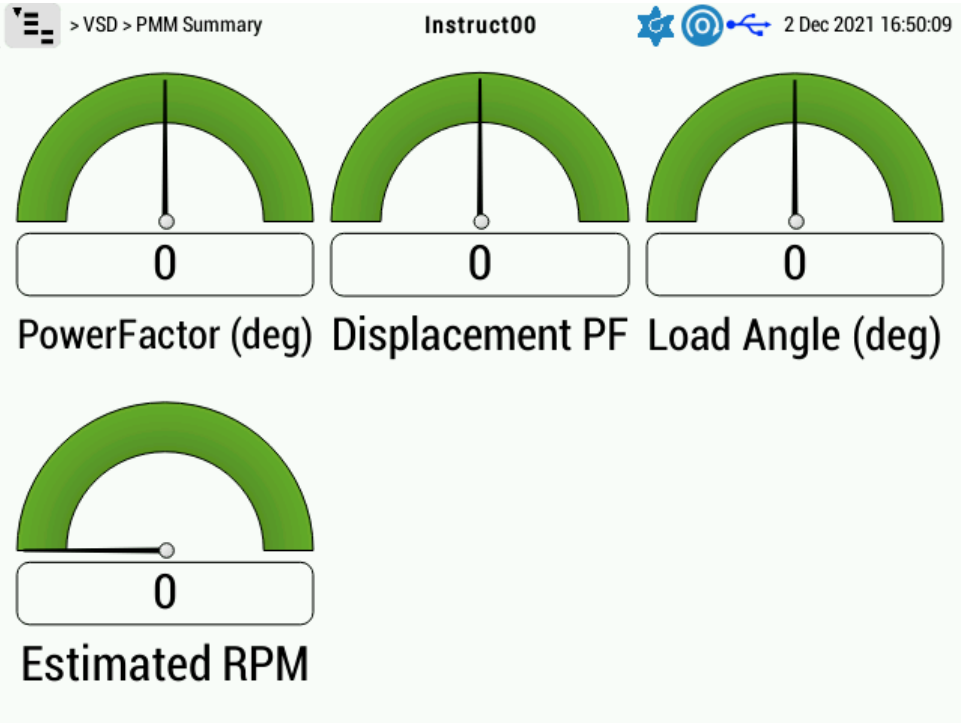


Figure 3-10: PMM Summary Screen

Section 4: **Initial Communication Setup Settings**

This section provides instructions for configuring the VSD for communication between the controller and the ES7 VSD and initial start-up.

4.1 CONTROLLER CONFIGURATION

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.

The following figure depicts the configuration of the Controller RS-485 port, but any of the four expansion slots could also be configured for the VSD, as required. As seen at the top of the screen, navigation is via the sequence **Menu** > **Controller** > **RS485**.

Table 4-1: 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 4-1: INSTRUCT Control Card RS-485 Port

Note:

The RX+ and RX- terminals are reversed as compared to the Communication Card (P/N 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.

Figure 4-2: Controller Menu Tree

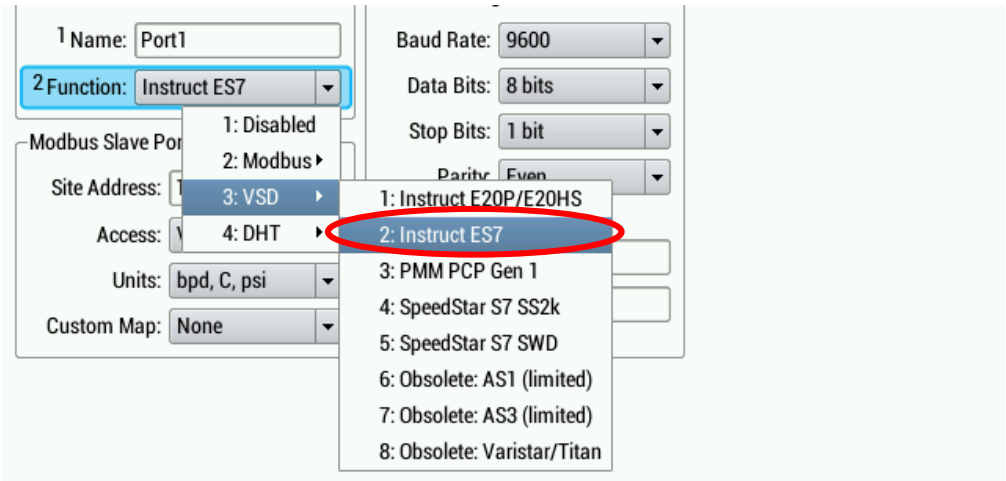
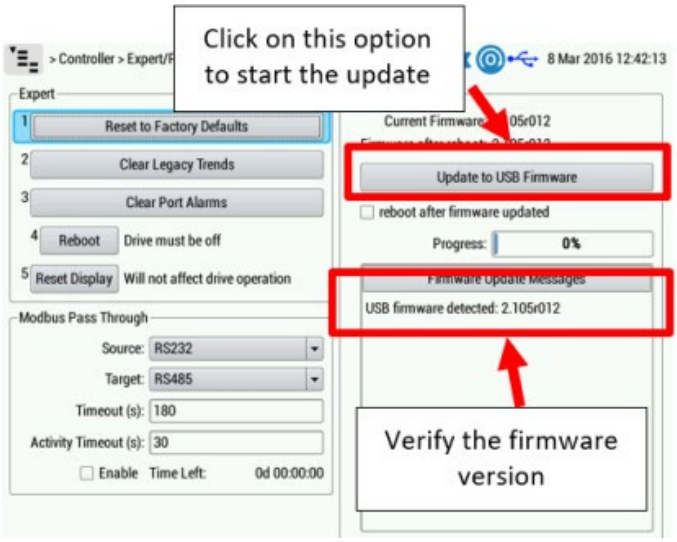


Figure 4-3: Port Configuration

4.2 CONTROLLER FIRMWARE UPGRADING

1. Download the latest firmware version based on InTouch content 6145281 (for released firmware) or InTouch content 7079236 (Release Candidate) and transfer this firmware to a USB flash drive.
2. Plug in the USB flash drive inside the INSTRUCT and make sure that the USB flash drive is detected.

3. On the INSTRUCT, Go to **Home** > **Menu** > **Controller** > **Expert/Updates** and then select the "**Update to USB Firmware**" button.



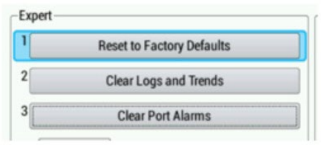
Note:

If the "reboot after firmware updated" checkbox is selected, the controller will reboot automatically. If that option is not selected, push the "Reboot" button to manually reboot the INSTRUCT.

Note:

This firmware update will take approximately 18 minutes on the INSTRUCT.

4. Reset the controller to the factory default settings by pressing **Home** > **Menu** > **Controller** > **Expert/Updates**. Then select "**Reset to Factory Defaults**".



Note:

A factory reset can only be done when the controller is in the "**Off**" state.

Note:

The controller communication settings will have to be reconfigured after a reset to factory default is performed.

Section 5: **VSD Setup for ESP Application**

For an ESP application, configure the Device Function where the drive is connected by selecting “Insruct ES7” under Function.

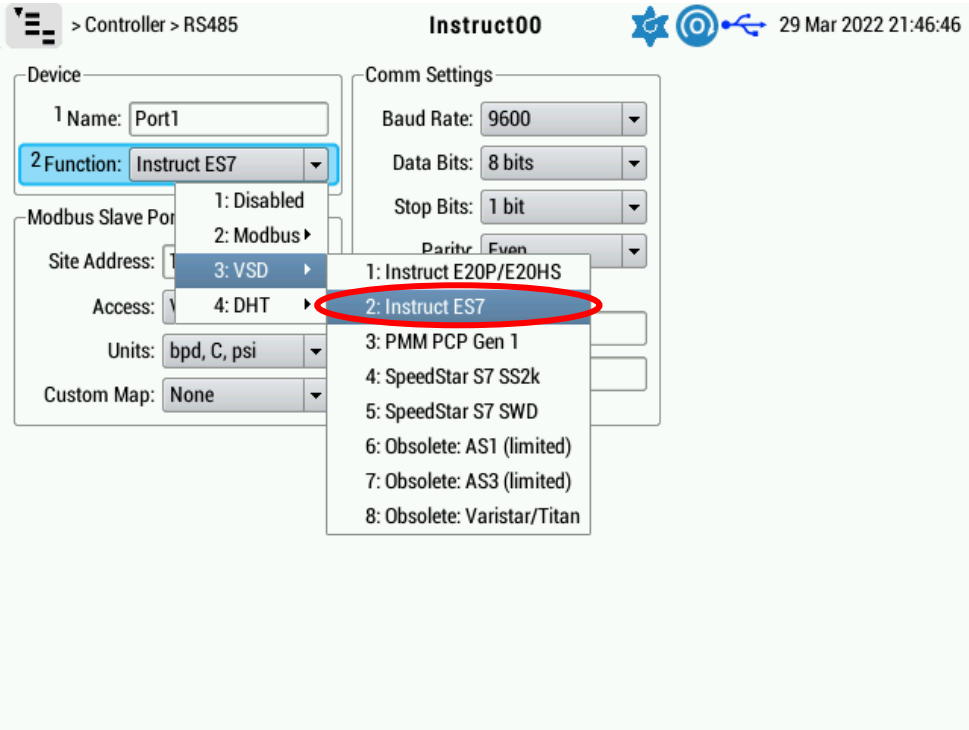


Figure 5-1: Controller Port Configuration

5.1 BASIC VSD CONFIGURATION

The settings below can be accessed with the navigation sequence **Menu > VSD > Configure**.

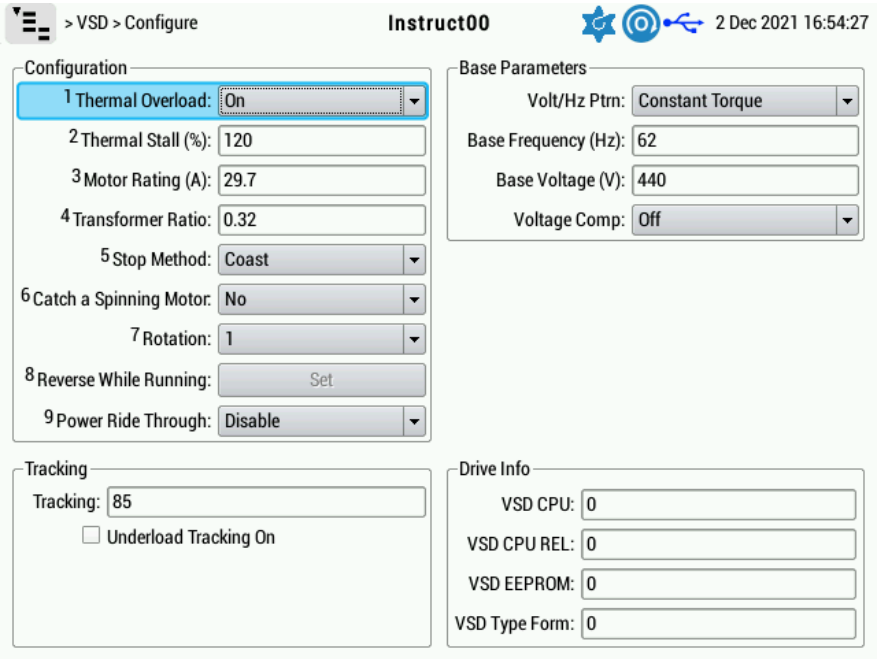


Figure 5-2: VSD Configuration

Term	Definition
Volt/Hz Ptm	Default should be set to **Constant Torque**.
Base Frequency (Hz):	The maximum planned running speed. This is the frequency at which the drive delivers its full power rating – the speed at which its output voltage equals input voltage for LV VSD.
Base Voltage (V)	The maximum output voltage of the drive at base frequency. Regardless of the programmed value, the output voltage cannot be higher than the input voltage.
Voltage Compensation	Provides an output waveform adjustment that compensates for changes in the input voltage. It can be enabled/disabled.
Thermal Overload	Allows the VSD to reduce the operating frequency in an attempt to avoid an over-heat trip. It can be enabled/disabled.
Thermal Stall (%)	The output current level at which the output frequency will reduce in an attempt to prevent an over-current trip. It can be adjusted to any value between 0 and 200%.
Motor Rating (A)	Ampacity of the motor
Transformer Ratio	The ratio of primary voltage to secondary voltage. For example, if the secondary voltage were 3000V and the primary voltage were 480V, the transformer ratio would be 0.16.
Stop Method	Select either **Coast** or **Decel**. If coast is selected, the output from the VSD when the stop button is pressed will be cut immediately and the ESP will coast to a stop. If deceleration is selected, the ESP will stop according to the deceleration time set.
Catch a Spinning Motor	This setting will catch the back-spinning ESP by first synchronizing the output speed with the drive output and bringing the ESP back to zero speed before accelerating back up in the normal direction.
Rotation	Allows for a drive to operate in forward or reverse rotation of the ESP.
Reverse while Running	Allows the ESP to rotate in the opposite direction while running by first slowing down the ESP to zero speed and reversing the rotation bit before accelerating in the opposite direction using the acceleration/deceleration specified times.
Power Ride Through	Power Ride Through feature was added to INSTRUCT as of the release of firmware version 2.117r002. This setting enables a VSD to continue running through power sags without trips. Refer to **2.1.7 Power Ride Through** for a detailed explanation.

5.1.1 INDUCTION MOTOR CONFIGURATION

Refer to InTouch #4197006 for instructions on downloading the Output Voltage Calculator to calculate the optimal **base frequency**.

Base voltage should be set at or below the **input voltage**. It is best for it to be set at least 10 volts below input voltage. For example, if **input voltage** is 450V, set **base voltage** to 440V.

Turn on voltage compensation to prevent the output voltage from increasing beyond the required motor voltage if the input voltage increases.

Base frequency, the frequency where the maximum output voltage from the drive is achieved, can be calculated by the follow expression:

$$Fbase = \frac{Tx\ ratio * Vin * Nameplate\ Motor\ Hz}{Nameplate\ Motor\ Volts}$$

Since **base voltage** is lower than input voltage, **base voltage** will be used in the above formula for *Vin*.

A fixed volts/Hz control algorithm is used. Ignoring cable losses for now, and assuming a motor with a nameplate voltage 1884V at 60 Hz, 52.1A, the closest tap setting on the step-up transformer is 1900V delta connection.

Figure 5-3: Transformer Taps

Tx ratio = 1900/400 = 4.75. This is **not** the ratio you use to configure the controller.

Assume the following:

Vin = 470V

Vcomp = ON

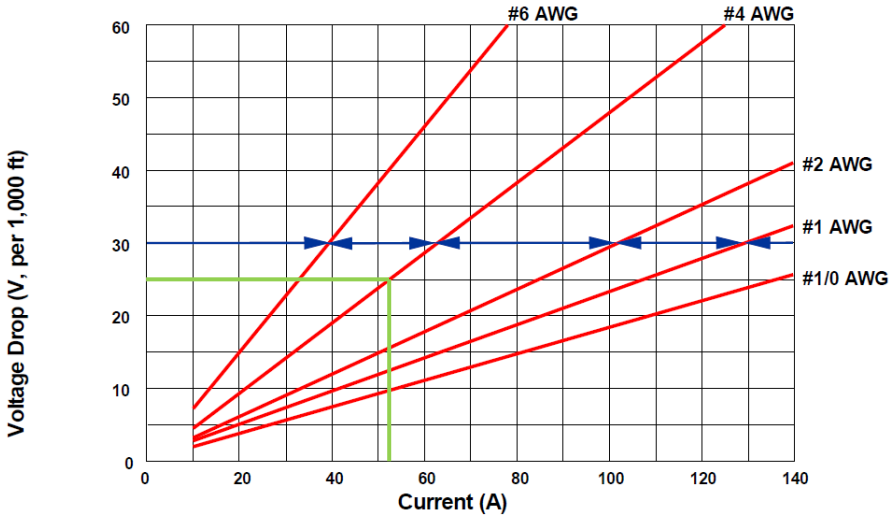
Vbase = 460V

Since *Vbase* is lower than *Vin*, *Vbase* is used for *Vin* in the following equation.

$$fbase = \frac{(4.75) * (460V) * (60Hz)}{1884V} = 69.6Hz$$

$V_{out} = \frac{Foperating}{Fbase} * Tx\ ratio * Vin = \frac{60\ (Hz)}{69.6\ (Hz)}$ *4.75*460V = 1884V

Considering voltage drop in the cable, the chart below can be used to determine the voltage drop per 1000 ft based on the cable size.



Assuming the cable length required is 8000 ft and a #4 AWG cable is being used, the motor current is 52.1A. The voltage drop is ~ 25V per 1000 ft. 8000/1000 = 8*25V = 200V. The surface voltage required is now 1884 + 200V = 2084V. In this case, the transformer will need to be tapped up to 4D 2100V and *Fbase* will need to be recalculated.

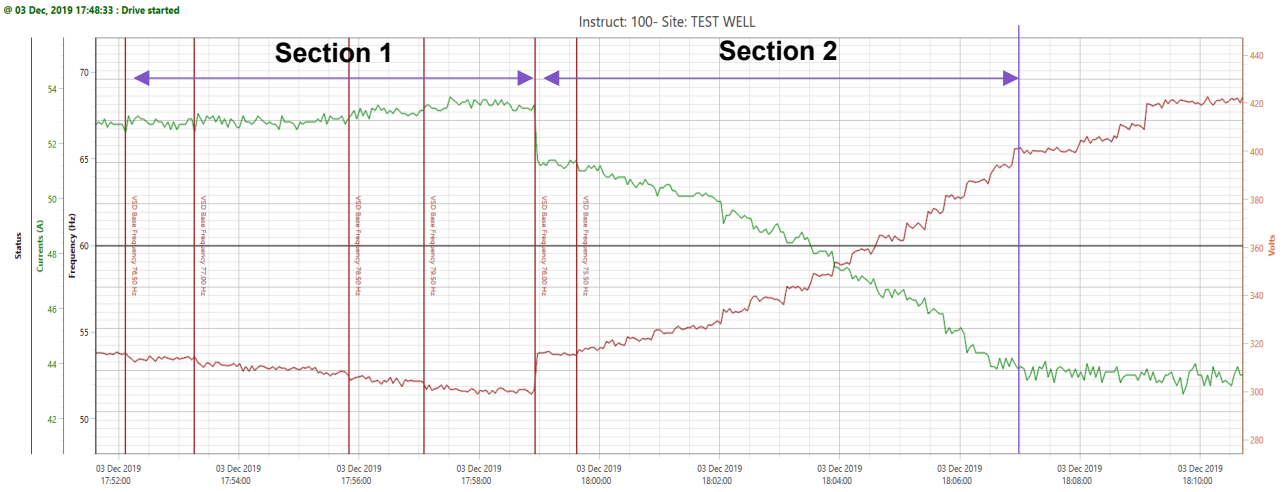
TAP POSITION			
SW1	SW2	△	⊣
3	D	1850	3204
3	E	1900	3291
4	A	1950	3377
4	B	2000	3464
4	C	2050	3551
4	D	2100	3637

Figure 5-4: Transformer Taps Adjusted for Voltage Drop in Cable

$$fbase = \frac{(5.25) * (460V) * (60Hz)}{2084V} = 69.5Hz$$

$V_{out} = \frac{60\ (Hz)}{69.5\ (Hz)}$ * 5.25*460V = 2084V

In this case, considering the voltage drop in the cable, the f_{base} is 69.5 Hz to reach the required surface voltage of 2084V at 60 Hz.



Green – Motor Current
Red – VSD output Voltage
Black – Operating Frequency

Section 1: Base frequency was increased, lowering the output voltage. Not much change is observed in motor current until it started to increase. This indicates that the motor needs more voltage.

Section 2: Base frequency was decreased in steps, and motor current started to decrease immediately. Base frequency continued to decrease until motor current stopped decreasing. This is the most efficient operating point. Increasing the voltage further beyond this point would have wasted power.

5.2 STARTING FEATURES CONFIGURATION

The starting features can be accessed with the navigation sequence **Menu > VSD > Expert**.

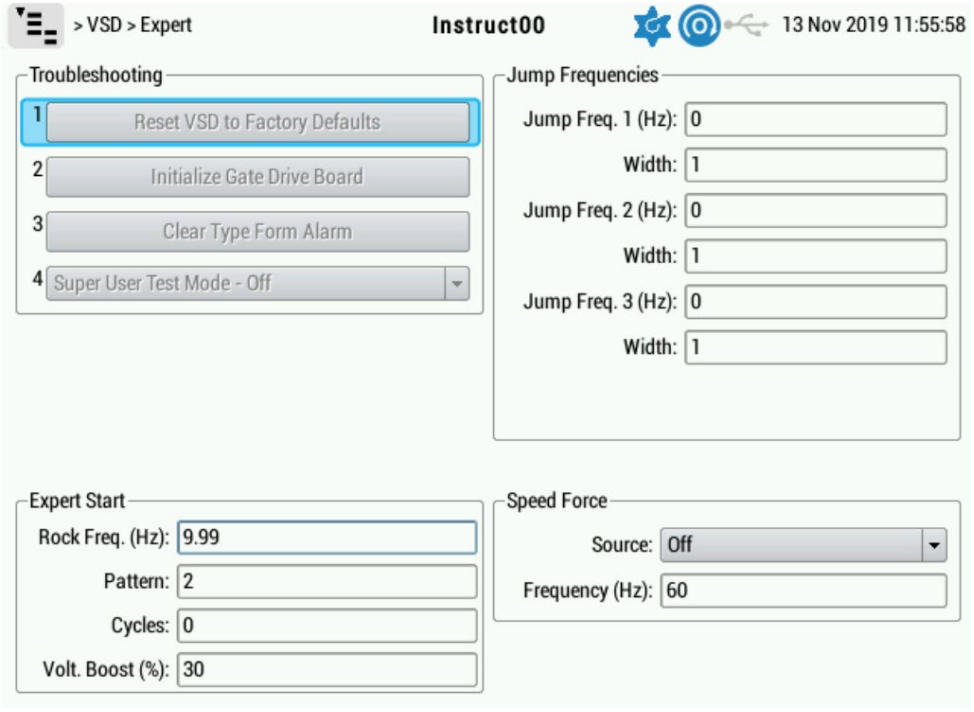


Figure 5-5: Starting Features

1. Set the Rocking **Cycles** to 0 to deactivate the rocking start. Rocking Start should only be used as a last resort for starting in case of a stuck pump or during a pump start-up in a sanded well condition.
2. **Voltage Boost** should only be used for induction motors. Set **Voltage Boost** to zero for Permanent Magnet Motors (PMM).

5.3 ALARMS AND VSD WARNINGS

Alarms are associated with all measured and monitored values. These alarms have parameters that define when and what they do when they become active.

Alarms with a Hi or Lo label are associated with the high and low limits on the metered variable. If the alarm condition is active, it will appear on the **Home** screen and on the **Alarms** screen. Navigate to the associated function's Alarm screen to edit the alarm setpoints and actions.

Each alarm has the following settings associated with it:

Term	Definition	
Name	A user-editable name associated with the alarm. This is the label that will be displayed on the screen when the alarm is active and that will be entered into the log.	
Action	The action that the alarm performs. Selectable alarm actions are:	
	BYPASS	Performs no action. Nothing is logged and a shutdown will not occur.
	LOG	Logs the alarm occurrence in the Event Log.
	STOP	Performs a shutdown of the motor. Automatic restarts can occur in Auto mode.
	LOG+STOP	Performs a shutdown of the motor and logs the shutdown and alarm occurrence in the Event Log. Automatic restarts can occur in Auto mode.
Setpoint	A value that, when violated by a metered live value, results in the activation of an alarm. The setpoint has the same units as the metered value. For analog variables, there are two types of setpoints: high and low. High setpoints trigger an alarm when the metered value exceeds the value of the setpoint. Low setpoints trigger an alarm when the metered value falls below the setpoint. For digital inputs, the setpoint is the digital state the controller will alarm on—either OPEN or CLOSE.	
Trip Time (seconds)	The duration that the alarm must be active before STOP actions occur. Timing begins each time the metered value violates the setpoint. This value can be used to reduce nuisance trips in metered variables that are noisy or have a lot of variation in the live reading.	
Restarts	The maximum number of restarts allowed for shutdowns by this alarm before a lockout condition is generated to prevent automatic restarts. This feature limits the number of manual and automatic starts of a motor to a safe level and prevents excessive cycling that could lead to equipment damage.	
Restart Delay (minutes)	The countdown time that must elapse before an automatic restart can occur. All alarms must be clear before the restart occurs. The restart delay (countdown) can be manually bypassed by pressing the **Start** key from the **Control Screen** during the countdown.	

Term	Definition
Start Bypass (seconds)	A temporary bypass time delay added to the Trip Time for starting only. A setting of 0.0 seconds disables this function. Any other number bypasses the alarm to allow a start and keeps it bypassed for the time set. A temporarily bypassed alarm will be displayed on the **Status Screen** when active but will not cause a shutdown. When Start Bypass is enabled, starting can occur when an active alarm is present.
Maintenance Bypass (minutes)	Allows for the temporary bypass of a specific alarm during operation for on-the-fly wiring changes or a maintenance procedure such as chemical injection. This bypass timer is available for Digital Input Alarms, Underload Alarm, and VSD Underload Alarm. To activate a Maintenance Bypass for an alarm, enter the Maintenance Bypass timer value. While the motor is running, the **Maint. Bypass** button will be enabled on the **Start** screen pop-up indicating that this feature is available but not active. **This button must be pressed to activate.** The controller will display the message “MaintBypass” in the marquee area during Maintenance Bypass. Once the timer has expired, the bypassed alarm will become active. The Maintenance Bypass function must be reset and activated each time it is to be used as the controller clears the timer value and deactivates this function after each use.

VSD warnings, by default, are bypassed and not logged by the controller. To enable the logging of the VSD warnings by the controller, navigate to **Menu > VSD > Alarms** and change the **Action** selection under the **VSD Warning** from “Bypass” to “Log.”

The ES7 VSD is clocking the runtime of the drive. After the VSD runtime exceeds a predefined time, an accumulated run time warning will be triggered. Despite this warning, nothing will prevent the continued running of the drive. This warning can be suppressed by checking the **Suppress Accum RT warning** checkbox under **VSD Warning**.

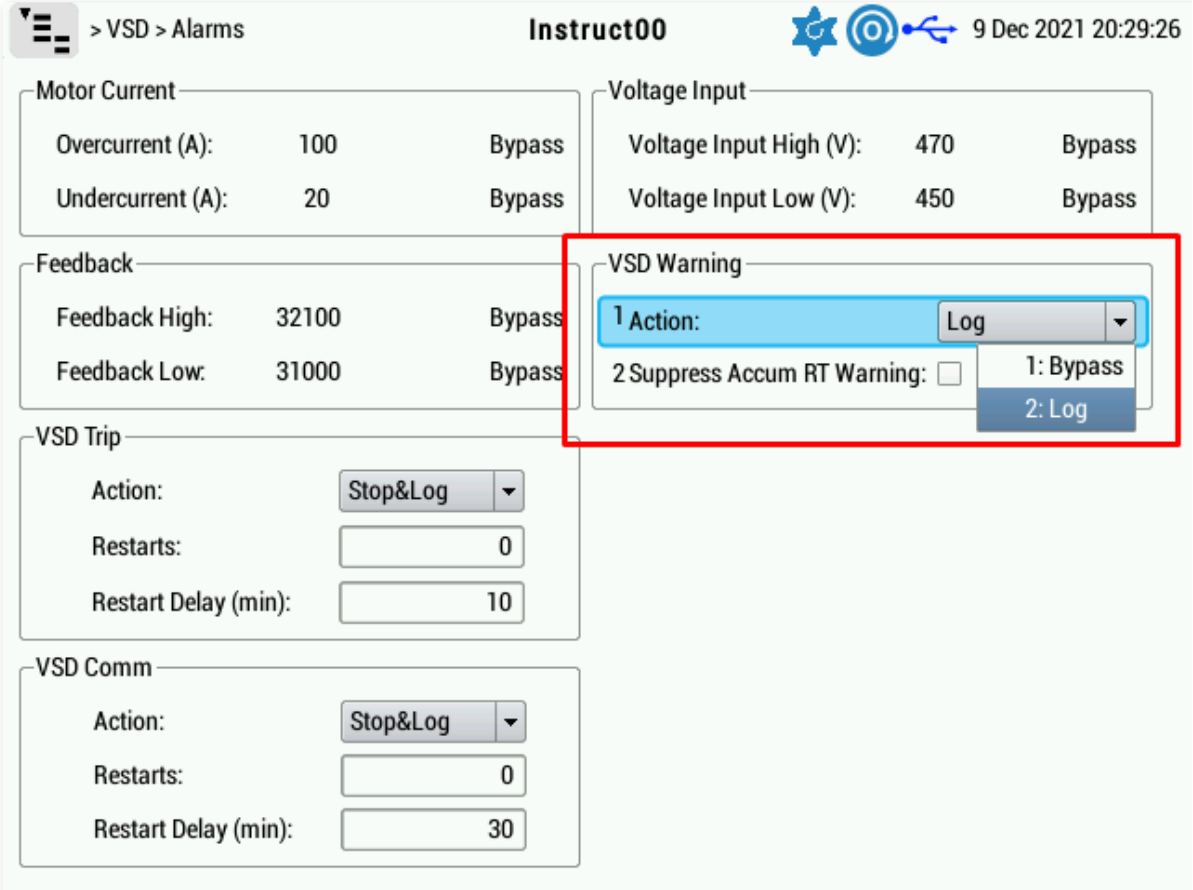


Figure 5-6: Alarms and VSD Warnings

5.4 PMM SETUP AND TUNING

To be populated when PMM control has passed our qualifications.

Section 6: **VSD Commissioning**

This section describes the procedures for starting up and commissioning new VSD installations.

6.1 CONTROLLER/VSD VERIFICATION

For the VSD, perform all relevant Startup and Commissioning steps as detailed in the ES7 Low Voltage Drive Manual (InTouch ID 4197006).

1. Verify that power is available on the controller. Simply check whether the Power Status LED is lit.
2. Verify that communication between the drive inverter control board and the controller is established properly. To do this, ensure that **VSD Comm** (*) alarm does not appear (along with other active alarm(s)). If **VSD Comm*** appears, go to the Alarms screen, and select **Unlatch** then ensure that **VSD Comm** (*) alarm has disappeared.

   Note
   This step assumes that the controller has been setup properly for a VSD application. If communication was not setup for a VSD, VSD Comm* will not appear.

3. If the VSD Comm display still blinks:
   a. Check that the proper communication cable is used between the controller and the Drive Control Unit and that it is securely connected. Also ensure that the cable is firmly connected at both ends.
   b. If an option card is being used to interface with the VSD, ensure that the correct Communication Card is used, and it has been inserted properly into one of the controller expansion card slots. Both screws on the card faceplate should be screwed in until the face plate is flush with the controller side wall.
   c. Check the Function setting of the communications port connected to the VSD or expansion card slot where the Communication Card is inserted. All default communication settings should be used. A factory reset may be required if the settings have been changed.

      Note
      This step assumes that the controller has been set up properly for a VSD application.

6.2 CONTROLLER PARAMETER SETUP

1. Go into the **VSD Speed** screen (Menu > VSD > Speed) and set the following minimum parameters for typical ESP applications.

   VSD Speed Source

   For most applications, setting this to **Target Speed** means the drive will run at the speed entered for the **Target Speed** parameter. Setting this to **Analog In 1/2/3/4** means the running speed will follow the signal level connected to the selected Analog Input channel.

   Target Speed

   Set as the desired operating speed.

   Maximum Speed

   Set according to the application requirement.

   Minimum Speed

   Set according to the application requirement.

For ESP, set this at the minimum frequency where the ESP can still pump fluid to surface. This should be confirmed with DesignPro software or other comparable sizing program.

Start-up Frequency

Set according to the application requirement.

For most ESP applications, set this value between 7 and 10 Hz.

For PPM applications, set the value around 3 Hz.

Using frequency settings that are too low could lead to the pump stalling during start-up.

2. Go into the **VSD Time** screen (Menu > VSD > Time) and set the following minimum parameters:

Ramp Frequency and Accel Time

Set according to the speed at which you want to ramp up from Start-Up Frequency to Target Speed.

Decel Time

Set according to the speed at which you want to ramp down from Target Frequency to either the next target speed or to stop the ESP.

Accel/Decel Pattern

The default setting should be Linear.

3. Go into the **VSD Configure** screen (Menu > VSD > Configure) and set the parameters according to the application. Refer to **5.1 Basic VSD Configuration.**
4. Go into the **VSD Expert** screen (Menu > VSD > Expert) and set the parameters according to the application.
5. Enable the **Tracking Underload** feature, which can be accessed through the VSD Configure screen (Menu > VSD > Configure).
6. Go into the **VSD Alarms** screen (Menu > VSD > Alarms), set the **Motor Current Hi** and **Motor Current Lo** setpoints, along with their associated protection setup - number of allowed auto restarts, auto restart delay, and bypass time during startup. By default, for overload, the number of auto restart attempts should be set to zero.
7. Go into the **Controller Settings/Info** screen (Menu > Controller > Settings/Info), set the **Supply Voltage Hi** alarm and **Supply Voltage Lo** protection set points associated with **Supply Volt level**, along with their associated protection setup - number of allowed auto restarts, auto restart delay, and bypass time during startup. This only applies to the controller supply voltage.

6.3 STARTUP PROCEDURES

To start up the controller, perform the following procedures:

1. Ensure that all the steps in **5.1 Basic VSD Configuration** have been carried out and no problems are encountered.
2. Verify that no alarm(s) are active and/or latched and the unit is not locked out. If any of these condition(s) are active, unlock the unit, unlatch the active latched alarm(s), and clear all other active alarm(s) by rectifying their cause(s).
   a. Select **HAND/AUTO** operation mode, then press **START**. If the unit is locked out or any alarm is still latched, the **START** button will not appear in the display when **HAND/AUTO** mode is selected.
   b. Calibrate the **VSD Motor Amps** reading by adjusting **Transformer Ratio**. Do this by comparing the displayed initial VSD Motor Amps value to the average of three-phase measured motor current obtained using a multimeter.
   c. Reset the **Underload** and **Overload Current** settings of the VSD. The settings should be a percentage of the stable **VSD Motor Amps** on the final set **Target Speed**.

- Underload = 85%
- Overload = 110%

d. 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 ensure that no faults or shutdowns occur.

e. Download the configuration/history/data for future reference.

Appendix A: **Warning Messages**

The following list contains all of the possible warning alarms, causes and troubleshooting suggestions. Warning alarms will not trip the drive unless the warning escalates to a trip level.

Display	**Description**	**Possible Causes/ Troubleshooting**
Communication Error (scan error)	Internal communications error.	• Improperly programmed VSD. • Improper communications settings. • Improperly connected cables.
Communication Alarm 2 (RS232/RS485/TTL error)	External communications error.	
Earth Fault	Active ground fault.	• Ground fault at the motor. • Ground fault at the output of the VSD. • Current leakage to **Earth Ground**.
DC Fuse Open	Incorrect current reading at DC fuse circuit.	• Open circuit at DC bus circuit.
Point Setting Error	Incorrect setup at an analog input (e.g., VI/II, RR, etc.).	• Gain and bias settings for an analog input are either the same or too close to each other (e.g., F201 and F203 are equal).
PID Low Output Disable	LOD function enabled and the output frequency is less than the F732 setting.	• Disable the **LOD** function at F731 or increase the **Low Output Disable Start Level** at F732.
Main Power Under Voltage	Under-voltage condition at the 3-phase AC input to the VSD.	• Low 3-phase commercial voltage.
Over-Current	VSD output current greater than F601 setting.	• Defective IGBT (U, V, or W). • VSD output to the motor is connected incorrectly. • VSD output phase-to-phase short. • The VSD is starting into a spinning motor. • Motor/machine jammed. • Mechanical brake engaged while the VSD is starting or while running. • Accel/Decel time is too short. • Voltage Boost setting is too high. • Load fluctuations. • VSD operating at an elevated temperature.
*Over-Heat	VSD ambient temperature excessive.	• VSD is operating at an elevated temperature. • VSD is too close to heat-generating equipment. • Cooling fan vent is obstructed • Cooling fan is inoperative. • Internal thermistor is disconnected.
Cumulative Run Timer	Run-time counter exceeded.	• **Type Reset** required; select **Clear run timer**. Refer to **5.3 Alarms and VSD Warning**

Display	Description	Possible Causes/ Troubleshooting
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.
*VSD Overload	Load requirement in excess of the capability of the VSD.	• 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 VSD is improperly matched to the application.
*Braking Resistor Overload	Excessive current at the **Dynamic Braking Resistor**.	• Decel time is too short. • DBR configuration improperly set.
*Over-Voltage	DC bus voltage exceeds specifications.	• VSD 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).
Excessive Torque	Torque requirement is in excess of the setting of F616 or F617 for a time longer than the setting of F618.	• VSD is not correctly matched to the application. • F616 or F617 setting is too low. • Obstructed load.
*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.
Retry	After a trip has occurred, for a number of user-set times an automatic system restart is attempted for a qualified trip.	• The **Retry** function is active.
Low-Current Operation	With the Low-Current Trip (F610) parameter enabled, the output current of the VSD is below the level defined at F611 and remains there for a time longer than the setting of F612.	• Output current too low.
Virtual Linear Pump No Flow	A Low suction/No-flow cut off condition has been active for a duration longer than the setting of F936.	• Pump prime required. • Feed water loss. • Output valve is closed. • System may be set to Trip or Alarm for this condition at F935.

***** Reset ignored if active.

Appendix B: **Fault Messages**

The following list contains all of the possible trips, causes and troubleshooting suggestions.

Display	**Possible Causes/Troubleshooting**
Virtual Linear Pump Abnormal Flow	• Loss of suction pressure or closed pump output valve. • Activated discrete input terminal set to **Low Suction/No Flow Protection**. • VSD Upper-Limit Frequency run-time is equal to F936 time setting.
Emergency Off	• Output signal from the VSD is terminated and a brake may be applied if so configured. • Emergency Off command received via EOI or remotely.
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 VSD). • **Sink/Source** configuration is incorrect.
Brake Sequence Response Error	• F630 is set to a non-zero value. • Braking sequence discrete input and output terminals are not set up properly.
Encoder Signal-Loss Error	• VSD 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. • VSD is not configured properly.
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.
Key Failure	• Same key input for 20 seconds or more.
Analog (Terminal) Input Loss	• VI/II signal loss. • Terminal Board failure. • P24 over-current condition.
CPU Communication Error	• CPU data Transmit/Receive error.
V/f Control Error	• Torque processing error. • Make service call.
CPU Processing Error	• Software processed incorrectly. • Make service call.
Logic Input Voltage Error	• Incorrect voltage applied to the discrete input terminals.
Optional Expansion Input Terminal Board 1 Error	• Optional Expansion Input Terminal Board 1 is defective.
Optional Expansion Input Terminal Board 2 Error	• Optional Expansion Input Terminal Board 2 is defective.
EEPROM Fault	• EEPROM write malfunction. • Make a service call.

Display	Possible Causes/Troubleshooting
EEPROM Read Error	• Control EEPROM read malfunction. • Make a service call.
EEPROM Read Error	• Main Circuit EEPROM read malfunction. • Make a service call.
(Earth) Ground Fault - Software or Hardware	• Ground fault at the motor. • Ground fault at the output of the VSD. • Current leakage to **Earth Ground**. • Ground fault detected by the software.
Input Phase Failure	• 3-phase input to the VSD is low or missing at the R, S, or T input terminals.
Output Phase Failure	• 3-phase output from the VSD is low or missing at the U, V, or W output terminals or at the input to the motor.
VSD RAM Fault	• Internal RAM malfunction. • Make a service call.
VSD ROM Fault	• Internal ROM malfunction. • Make a service call.
CPU Fault	• CPU malfunction. • **Control Board** malfunction. • Make a service call.
Communication Error Interruption	• Communication time out error. • Communication malfunction. • Improper or loose connection. • Improper system settings.
Gate Array Fault	• Main Gate Array is defective.
Low -Current Detector Error	• Improper Low- Current detection level settings at F609 – F612.
Option (Device) Fault	• Check installation, connections, and option device manual.
Flash Memory Error	• Flash memory malfunction. • Make a service call.
Autotune Error	• **Autotune** readings that are significantly inconsistent with the configuration information. • A non-3-phase motor is being used. • Incorrect settings at F400 or F413. • Using a motor that has a significantly smaller rating than the VSD. • VSD output cabling is too small, too long, or is being housed in a cable tray with other cables that are producing an interfering EMF. • Motor is running during the **Autotune** function.
	• F402 adjustment required (Motor temperature is too high).
	• F410 adjustment required (Motor Constant 1 improperly set).
	• F412 adjustment required (Motor Constant 3 improperly set).
	• Autotune setting F400 is set to Auto Calculation and there is a problem with the Motor Constant readings.
VSD 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.

Display	Possible Causes/Troubleshooting
No Error	• No active faults.
Over-Current During Acceleration	• Improper V/f setting. • Restart from a momentary power outage. • The VSD is starting into a rotating motor. • VSD/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 VSD is running. • VSD current exceeds 340% of the rated FLA on VSDs that are 100 HP or less during acceleration. On VSDs that are greater than 100 HP, this fault occurs when the VSD current exceeds 320% of the rated FLA during acceleration.
Over-Heat During Acceleration	• Cooling fan inoperative. • Ventilation openings are obstructed. • Internal thermistor is disconnected. • Acceleration time is too short. • Improper V/f setting. • VSD or the motor is improperly matched to the application.
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 VSD is running. • VSD current exceeds 340% of the rated FLA on VSDs that are 100 HP or less during deceleration. On VSDs that are greater than 100 HP, this fault occurs when the VSD current exceeds 320% of the rated FLA during deceleration.
Over-Heat During Deceleration	• Cooling fan inoperative. • Ventilation openings are obstructed. • Internal thermistor is disconnected. • Deceleration time is too short. • DC Injection current is too high. • VSD or the motor is improperly matched to the application.
Over-Current During Fixed Speed	• Load fluctuations. • VSD is operating at an elevated temperature. • VSD current exceeds 340% of the rated FLA on VSDs that are 100 HP or less during a fixed-speed run or if during a fixed-speed run the VSD overheats. On VSDs that are greater than 100 HP, this fault occurs when the VSD current exceeds 320% of the rated FLA on a fixed-speed run.
Over-Heat During Run	• Cooling fan inoperative. • Ventilation openings are obstructed. • Internal thermistor is disconnected. • Improper V/f setting. • VSD or the motor is improperly matched to the application.
U-Phase Over-Current	• Low impedance at the U lead of the VSD output.
V-Phase Over-Current	• Low impedance at the V lead of the VSD output.
W-Phase Over-Current	• Low impedance at the W lead of the VSD output.

Display	Possible Causes/Troubleshooting
Dynamic Braking Resistor Over-Current	• VSD 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 ckt.). • 3-phase input voltage is above specification.
Over-Heat	• Cooling fan inoperative. • Ventilation openings are obstructed. • Internal thermistor is disconnected.
VSD Overload	• Acceleration time is too short. • DC Injection current is too high. • Improper V/f setting. • Motor running during restart. • VSD or the motor is improperly matched to the application.
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.
Dynamic Braking Resistor Overload	• Deceleration time is too short. • DBR setting adjustment required. • Over-Voltage Stall setting adjustment required.
Over-Voltage During Acceleration	• Motor running during restart.
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.
Over-Voltage During Fixed Speed	• Load fluctuations. • 3-Phase input voltage out of specification. • DBR required (DBR setup required).
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 VSD is improperly matched to the application. • The load is obstructed.
Virtual Linear Pump Sealing Water Error	• Inadequate pump seal water. • Loss of pump seal water.
Main Power Under-Voltage	• Input 3-phase voltage is too low. • Momentary power failure longer than the time setting of F628.
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.

Appendix C: **VSD and Controller Support Resources**

PRODUCT DOCUMENTATION

This manual describes using the ESP Controller to configure the ES7 Drive. For the individual product manuals:

- LCS-ENG-M0012 ES7 Drive Installation, Operation & Maintenance Manual
- LCS-ENG-M0013 INSTRUCT ESP Intelligent Controller Installation, Operation & Maintenance Manual

GUIDES AND RELEASE NOTES

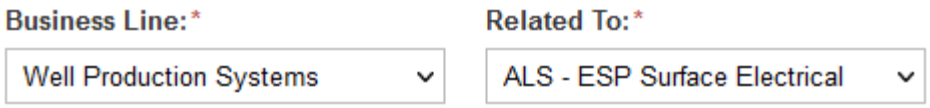
- General guides, best practices, technical alerts and software release notes for the ES7 Drive are available at InTouch 3250348 Reference Page.
- General guides, best practices, technical alerts and software release notes for the INSTRUCT ESP Intelligent Controller are available at InTouch 6023027 Reference Page.

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.



HOW TO REACH US

You can find more information about Sensia, ES7 Drive and the ESP Controller here:

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