User's Guide

Magnetic Bearing Controller

MB4160g5-PC™

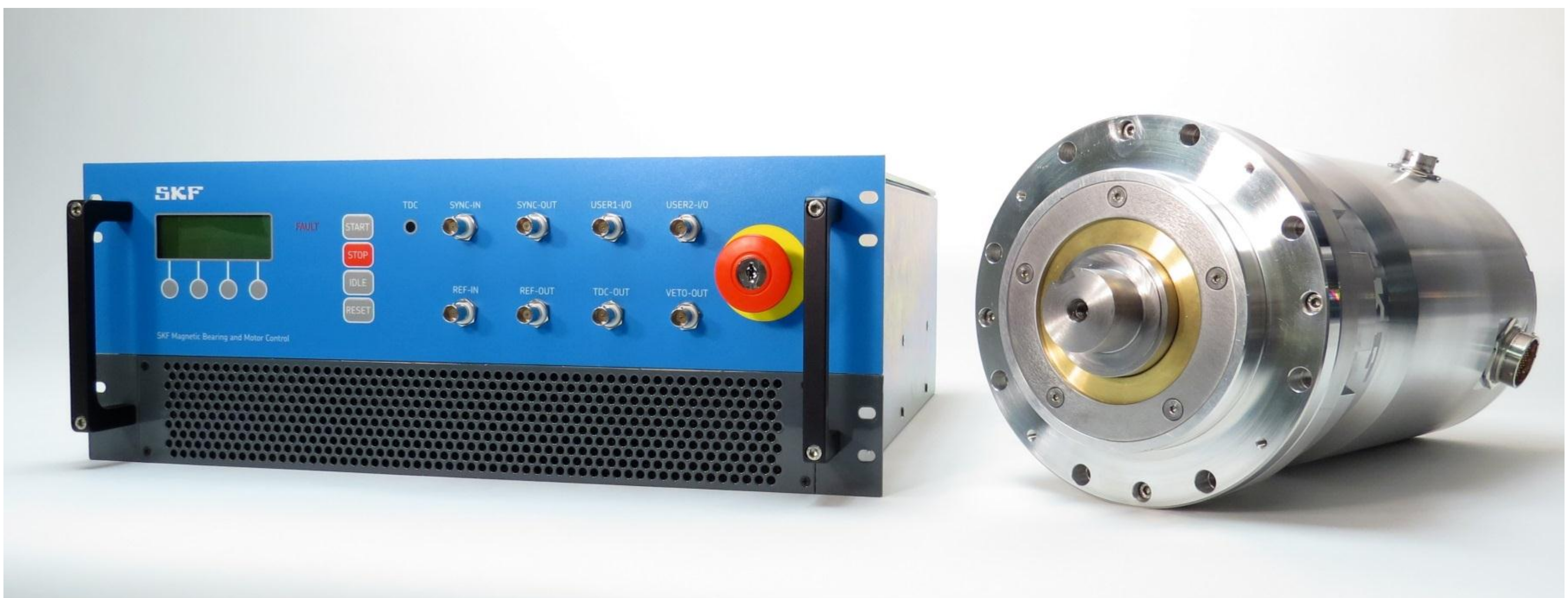


TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 GENERAL

This guide contains basic information on the installation, use, and maintenance of the SKF G5 Magnetic Bearing Control (MBC) System, utilizing the MB4150g5-PC controller.

The MB4150g5-PC is a fully digital, magnetic bearing controller. This controller works with SKF G3 and G5 neutron chopper spindle units. It has been specifically designed for flexibility and ease of use, and to provide optimal performance. Features of the base control system include:

- Motor Phasing
- Five position sensor channels
- Five axis levitation control
- Ten bearing amplifier channels
- Front panel with LCD display for local control
- Discrete I/O for customer logic interface
- Modbus/TCP for remote control
- Shutdown messages and log
- Ethernet MBScope™ control

The MB4150g5-PC contains a five channel 4A, 150V Bearing Amplifier for use with a Magnetic Bearing spindle, handles all shutdown events, and has an internal motor drive.

WARNING

Warning: Installation or operation of this controller contrary to the instructions in this User's Guide could result in damage to the controller or a shock or fire hazard.

1.2 SUPPORTING DOCUMENTS

CSD-930-XXXX-XXX	System Specific User Manual (project specific)
892-0096-006	G3 Fermi Chopper Spindle User Manual
(not yet complete)	*G3 Disk Chopper Spindle User Manual*
892-0114-001	G5 Disk Chopper Spindle User Manual
(not yet complete)	*G5 Fermi Chopper Spindle User Manual*
892-0110	MBScope™ User's Guide – MBG5
892-0112	MBResearch™ User's Guide – MBG5
912-0101	Interconnection Diagram
982-0086-002	Balancing Sheet

1.3 COMPONENTS OF THE CHOPPER SYSTEM

The following components make up the Chopper system.

Controller	**Controller Name**: MB4150g5-PC **Model**: 816-0055-001 **Description**: Magnetic Bearing and Motor Control **Certification**: *[TBD]* **Sensor Type**: Inductive **Resolver and TDC**: Inductive **Position Channels**: 5 **Bearing Amplifiers Channels**: 10Ch – 150V – 4A **Motor Drive**: Internal – 150V- 20A - 1000W **Power Supply**: 150VDC – 2 Parallel 750W
Spindle	Houses the magnetic bearing stators, motor and sensors.
Shaft	The shaft is designed to be magnetically levitated. Disk choppers are an overhung payload design. Fermi Choppers incorporate two stub shafts to support a mid-span payload. The shaft surface is very delicate and care must be taken to avoid surface scratches.
Payload	Customer or vendor supplied.
Coupling	Connects a disk to the shaft. The coupling may be flexible or rigid depending on the application. Fermi payloads are directly bolted to the stub shafts without a coupling.
Cables	A 55-Pin Machine Cable and 4-Pin Motor Cable are needed to connect the controller to the spindle unit.
Firmware	The control software for the magnetic bearing system.
PVF	Parameter Value File This file provides the parameters used by the controller to control the Neutron Chopper. The PVF supplied with your systems contains the necessary operational parameters for the as-shipped system configuration including bearing tuning, motor tuning, sensor calibration, interlocks settings, etc. This file is specific to a spindle, shaft, payload and firmware combination. Use of an incorrect PVF file may result in damage to the machine or unsafe rotation.

1.4 ADDITIONAL FEATURES

For access to additional features including system parameter adjustment (tuning), performance analysis, and detailed troubleshooting, the following two optional peripherals are available:

- MBScope™ software package
- MBResearch™ hardware module

1.4.1 MBSCOPE™

MBScope™ software is used for parameter adjustment (tuning), code loading, balancing, and detailed alarm analysis.

MBScope™ is a software package that provides access to the functional capabilities of the MB4150g5-PC controller. System parameters including position, current, force and speed can be monitored by an external computer connected to the MB4150g5-PC controller via an Ethernet cable. MBScope™ provides a rich graphical user interface for viewing machine operation, as is only possible with magnetic bearings.

Please refer to the MBScope™ User's Guide (SKF Document 892-0110) for more information.

1.4.2 MBRESEARCH™

MBResearch™ is a BNC connector-based breakout module that provides access to signals from the SKF line of magnetic bearing controllers. The signals available include analog currents, positions and a Top Dead Center (TDC) pulse signal for monitoring speed and phase. In addition, *MBResearch™* provides the ability to inject signals on all control axes, making the controller an excellent research tool in the areas of control theory and rotor dynamics.

Please refer to the MBResearch™ User's Guide (SKF Document 892-0112) for more information.

1.5 POWER

The controller is powered via an external single phase connection.

Nominal operating conditions:

- 110VAC, 60Hz, Single Phase (15$A_{rms,max}$)
- 220VAC, 60Hz, Single Phase (8.0$A_{rms,max}$)
- 230VAC, 50Hz, Single Phase (7.5$A_{rms,max}$)

All operating conditions:

- Input Voltage: 95-264Vac, 47-63Hz, Single Phase
- Input Current: 18$A_{rms,max}$ / 10$A_{rms,max}$ (100VAC / 200VAC)

1.6 UPS REQUIREMENTS

To avoid a failure upon loss of power, a UPS system is highly recommended. The UPS must be able to supply 1800W when grid power is available. When off grid power, the UPS must supply about 500W for the duration of an entire coast down. An on-line type UPS is recommended if the power quality is not good, and the UPS should include a dry contact to indicate a failure.

An example of a suitable Line Interactive UPS system is the SMT2200RMI2U from APC. An extra battery may be required for spindles with large rotational energies (the coast down time will increase). To get a dry contact interlock, the "APC Network Management Card (AP9631)" and the corresponding "Dry Contact I/O Accessory (AP9810)" are also needed.

1.7 ENVIRONMENTAL

Temperature	Operating	0ºC to 40ºC (32ºF to 104ºF)
	Storage	-40ºC to 60ºC (-40ºF to 140ºF)
Elevation	Operating	3,000m (10,000ft)
	Storage	15,000m (50,000ft)
Humidity	0% to 95% relative humidity, non-condensing	

2. CONNECTING THE SYSTEM

WARNING

Warning: Before connecting or disconnecting cables to the controller, always turn the power switch to the OFF position.

These connections are made using several connectors on the back of the controller; refer to Figure 15 – Controller Back Panel Layout. In addition, several connectors are provided for diagnostics, research and troubleshooting purposes.

2.1 CONNECTING TO THE SPINDLE

The MB4150g5-PC connects to the spindle using a 55-pin Machine Cable (used for sensors and levitation currents) and a 4-pin Motor Cable.

2.2 CONNECTING TO INTERLOCKS

The controller should be interlocked to external equipment to protect against failure. Cooling, vacuum and UPS interlocks are available as well as a remote motor inhibit and analog input. Acceptable levels for these interlocks are listed in the CSD. Refer to Section 6 of this manual for details on proper connections of interlocks.

2.3 CONNECTING TO DIAGNOSTIC TOOLS

There are several connectors on the back of the controller to allow connection to external diagnostics tools (such as MBReasearch and MBScope). Refer to Section 6 of this manual for details on proper connection to diagnostic tools.

2.4 CONNECTING THE CONTROLLER TO POWER

The controller must be connected to an AC power supply (See Section 1.5).

It may be desirable to install a power locking clip onto the power cord so that it may not get accidently unplugged from the back of the controller. An example of such a clip is the Qualtek PN 730-20/01 (SKF PN 300-0121-001).

2.5 OTHER CONNECTIONS

OSCILLATOR SETTINGS

The G5 controller has a configurable oscillator. This should be set up as shown in Figure 1: Oscillator Dip Switch Settings. If your system needs different settings it will be described in the CSD for that system.

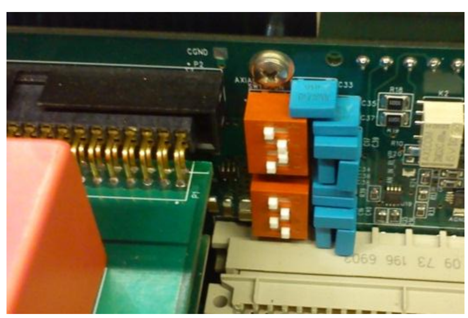


FIGURE 1: OSCILLATOR DIP SWITCH SETTINGS

3. CONTROLLER OPERATION

3.1 FRONT PANEL COMPONENTS

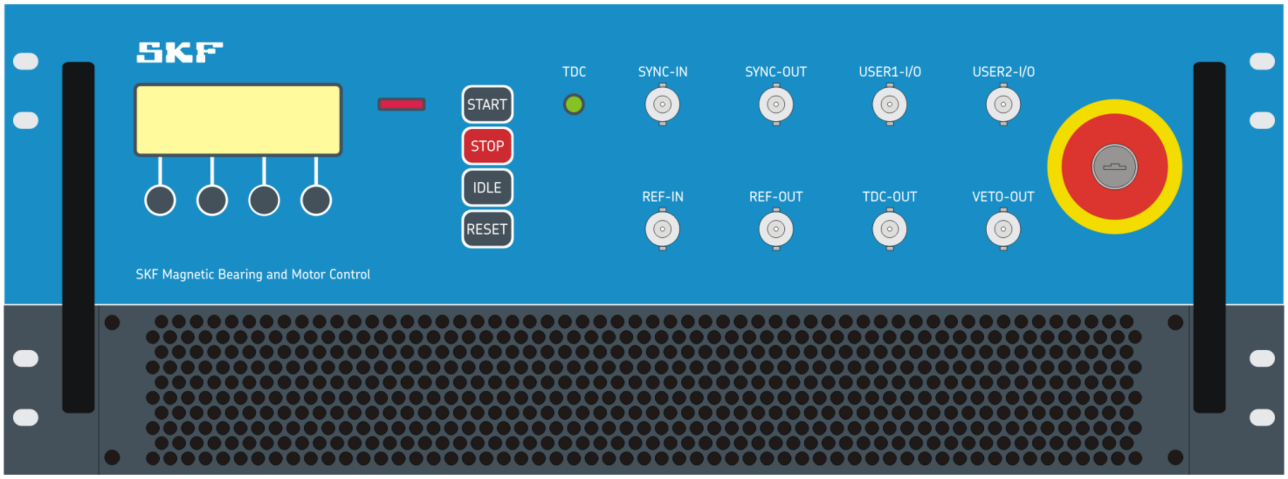


FIGURE 2 – FRONT OF THE CONTROLLER

3.1.1 CONTROL BUTTONS

The four buttons located on the front panel provide local controller operation. The controller can be set to limit the use of these buttons when operating remotely, see section 3.5. The function of each button for the MB4150g5-PC is summarized below:

START – Levitates the shaft, and enables rotation if requested

STOP – Sets rotational speed to zero, and de-levitates the shaft once rotation has stopped

IDLE – (No Action)

RESET – Clears shutdowns messages from the LCD and the Alarm Indicator.

START BUTTON

The *Start Button* is used to initiate levitation and rotation.

When the *Start Button* is pressed, the word *Ready* in the top left corner of the LCD will change to *Levitated*, indicating the shaft is levitated. The Run Relay contact closes when the shaft is levitated.

If the red Alarm Indicator specifies a trip event, the *Start Button* will be ignored. Pressing the *Reset Button* will attempt to clear the event. If the event does not clear, the trip event is still present. For further information, see Section 7.

STOP BUTTON

The *Stop Button* is used to stop and de-levitate the shaft.

When the *Stop Button* is pressed, the word *Levitated* in the top left corner of the LCD will change to *Stopping*, indicating that the system is braking and/or de-levitating and the RUN Relay contact opens. The MB4150g5-PC de-levitates the shaft once the shaft is rotating at a speed below the factory or OEM set de-levitation speed and time out parameters. When the system is fully stopped and de-levitated, the word *Ready* will appear in the top left corner of the LCD.

The controller requires a functioning speed sensor to prevent de-levitation while the shaft is rotating.

IDLE BUTTON

The *Idle Button* is not used in the standard MB4150g5-PC.

RESET BUTTON

The *Reset Button* is used to clear the Alarm Indicator, clear the shutdown message on the LCD Main Display and reset the Shutdown relay.

The cause of the event must be removed before the Alarm Indicator can be cleared. See Section 7 for further details.

3.1.2 ALARM INDICATOR

The Alarm Indicator represents the alarm state of system.

- Solid Red: Represents that a 'Warning' event occurred, the system will continue to run. "Ref loss" warnings are a special case that will self-clear if the event is no longer present.

- Fast (200ns) Flashing Red: indicates that a 'Trip' event is present, the system will shut down.
- Slow (600ns) Flashing Red: represents a Watch Dog failure. To fix this condition a full system restart is required once the system has come to a stop. The TDC light will continue to function.

3.1.3 TDC INDICATOR

The *TDC Indicator* provides information about the rotational status of the machine. It is derived directly from the machine.

- Off: The shaft is parked *without* the TDC Notch aligned with the machine connector
- Solid Orange: The shaft is parked *with* the TDC Notch aligned with the machine connector
- Blinking Bright Green – The shaft is rotating at slow speed (< 10Hz); and if in phase mode the phase ok is above 90%
- Solid Dim Green – The shaft is rotating at high speed (> 15Hz); and if in phase mode the phase ok is above 90%
- Blinking Bright Orange – In phase mode, the shaft is rotating at slow speed (< 10Hz) and the phase ok is below 90%
- Solid Dim Orange – In phase mode, the shaft is rotating at high speed (> 15Hz) and the phase ok is below 90%

3.1.4 MOTOR INHIBIT BUTTON

The large red button on the right side of the controller will inhibit the motor and ensure that the chopper will eventually come to a stop. Depressing this button removes power from the motor and will cause the system to coast down. The system will not actively break while in this condition. SKF sets this situation to a 'Warning' condition in order to keep the shaft levitated once it has coasted down; this protects the shaft from external vibration.

3.1.5 LCD DISPLAY

The front panel LCD display is a four row, 20 character display used to monitor and update system variables, and to perform basic troubleshooting.

Four soft keys, located directly beneath the display, control the LCD. The function of each of the soft keys changes depending upon which menu is active.

3.1.6 BNCS

The Front panel BNCs are described in section 4.

3.2 LCD MENU STRUCTURE

The LCD Menu Structure is divided into the following types of screens:

SETUP – used to set system parameters.

DISPLAY - used to monitor system parameters. This is a read-only menu.

LOG – used to view the most recent system events. This is a read-only menu

The entire LCD Menu Structure is shown in Figure 3 – LCD Menu Structure.

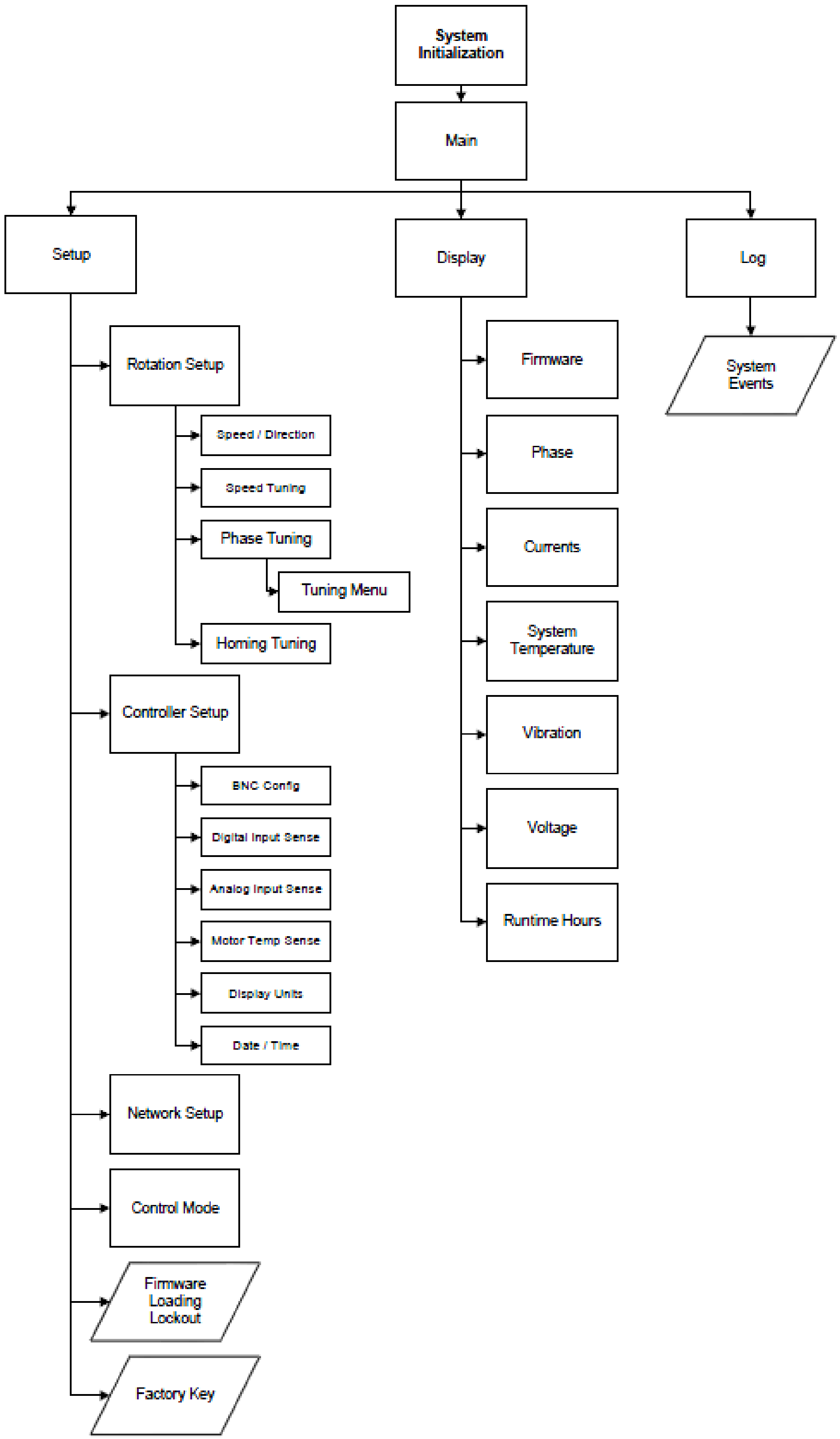


FIGURE 3 – LCD MENU STRUCTURE

3.3 SOFT KEYS

The four buttons located directly below the LCD Display are soft keys. They are used to scroll through the LCD menus, and to input parameter settings. The function of each of these soft keys changes depending on the menu or parameter that is chosen, and is indicated by the text directly above each key on the bottom row of the LCD displays. The soft keys and their associated actions are shown in Table 1.

TABLE 1 – SOFT KEY FUNCTION

SOFT KEY	Function
SETUP	Go to *Setup* Menu
DSPLY	Go to *Display* Menu
LOG	Go to *Shutdown Log* Display
EXIT	Go up one menu, or to previous selection
ENTER	Select menu item beside the cursor Or Accept parameter
NEXT	Moves curser right
BACK	Moves curser left
CNCL	Cancel editing parameter and restore previous value
↑	Scroll up through menu or parameter values OR Increase parameter value, or previous enumerated parameter value.
↓	Scroll down through menu or parameter values OR Decrease parameter value, or next enumerated parameter value.

FIGURE 4 - SOFT KEY FUNCTIONS

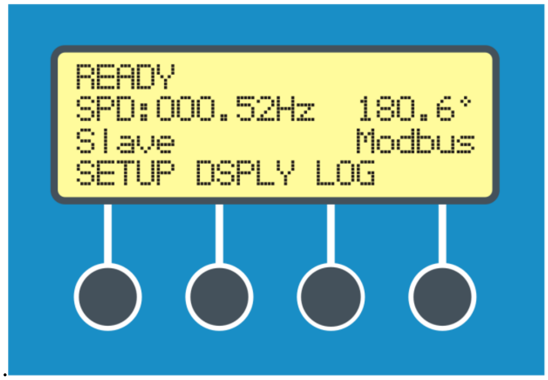
3.4 LCD MENU SCREENS

Note, future development improvements include:

- New menu items, also indicated in ***(blue)*** text.

3.4.1 MAIN DISPLAY

Once the power up sequence is complete, the Main Display is shown. Examples are shown below in the figures below.



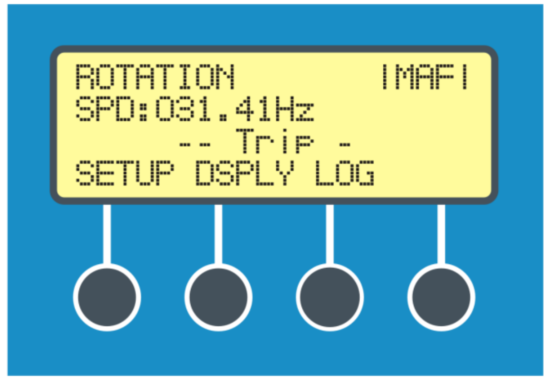


FIGURE 5 - MAIN DISPLAY

Line 1: Information on the left is the System State. Valid displays are: READY, DELEV-ING, LEVITATED, STARTING, STOPPING, COAST, ROTATION. If the system is in 'Test Mode' it is indicated by appending 'TM-' to the beginning of the system state.

> *Note: If the system is in the COAST state and a coast down time is currently being enforced, the remaining time that the system must remain in the COAST state will be shown on this line.*

Information on the right is the Motor State. Valid displays are: SRTUP (Startup), READY, RUNNG (Running), BRKNG (Braking), HOMNG (Homing) and ORNT (Orientating). If the motor is inhibited an IHN- is appended to the front of the state.

Line 2: Information on the left is rotor speed. This value is always shown.

Information on the right is the rotor angle. This value is only shown when the rotor has a rotation speed below 2Hz and the machine has a resolver.

Line 3: Information on the left shows if the system is slaved to another chopper (via the SEEP signal – refer to section 4-2). If this is the case, the word 'Slave' is shown.

Information on the right shows the control mode of the system. Valid displays are: Modbus, MBScope, Hardwire, Local, Free (Free for All) and No Reqst (Request Mode but no requests have been made).

Information on Line 3 may be obscured if a warning or trip event is present. If so, the words "-- Warning -- " or "-- Trip --" will be shown.

Line 4: This line always contains navigation information, as described in section 3-6.

3.4.2 SETUP MENU

The *Setup Menu* allows the selection of parameter menus for system control and operation.

Menu Item	Description	Values	Units
Rotation Setup	Enters the Rotation Setup menu (refer to section 3.4.3)	N/A	N/A
Controller Setup	Enters the Controller Setup menu (refer to section 3.4.9)	N/A	N/A
Network Setup	Enters the Communication Setup menu (refer to section 3.4.15)	N/A	N/A
Control Mode	Enters the Control Mode Setup menu (refer to section 3.4.16)	N/A	N/A
FW Load	Provides a method of locking out a firmware upgrades. The default is ON, selecting a time will provide a countdown and turn this setting ON when the time expires.	WR Protect/ Allow / Allow-30m	N/A
Factory Key	Set the password to enable factory menus for SKF.	XXXXXX	N/A

3.4.3 ROTATION SETUP MENU

The *Rotation Setup Menu* allows the selection of additional rotation related menus.

Menu Item	Description	Values	Units
Speed / Direction	Enters the Speed Direction menu (refer to section 3.4.4)	N/A	N/A
Speed Tuning	Enters the Speed Tuning menu, only displayed when in Speed mode (refer to section 3.4.5)	N/A	N/A
Phase Tuning	Enters the Phase Tuning menu, only displayed when in Phase mode (refer to section 3.4.6)	N/A	N/A
Homing Tuning	Enters the Homing Tuning menu (refer to section 3.4.8)	N/A	N/A

3.4.4 ROTATION SETUP > SPEED / DIRECTION MENU

The *Speed / Direction Menu* allows the setup of the speed control, direction, and set points.

Menu Item	Description	Values	Units
Motor Ctrl	Specifies the motor control method. The corresponding menu will be displayed on the rotation setup menu.	SPEED / PHASE	N/A
Direction	Specifies the direction of rotation	CW / CCW	N/A
*Speed (read only)	Displays the current rotational speed of the spindle	000.00 – 999.99 (00000 – 99999)	Hz (RPM)
RunStPt	Specifies the desired run speed. Note that if in phase control the actual setpoint will be the nearest multiplier/divisor.	000.00 – MaxSpd (00000 – MaxSpd)	Hz (RPM)
Max Spd	The maximum rotational speed allowed	000.00 – (Overspeed/1.05) (00000 – Overspeed/1.05)	Hz (RPM)
Min Spd	The minimum rotational speed allowed	000.00 – MaxSpd (00000 – MaxSpd)	Hz (RPM)
*Ovrspeed (read only)	Specifies the rotational speed at which point the system generates an overspeed condition.	000.00 – 999.99 (00000 – 99999)	Hz (RPM)

3.4.5 ROTATION SETUP > SPEED TUNING MENU

The *Speed Tuning Menu* allows the setup of the speed control parameters.

Menu Item	Description	Values	Units
*Speed (read only)	Displays the current rotational speed of the spindle	000.00 – 999.99 (00000 – 99999)	Hz (RPM)
RunStPt	Specifies the desired run speed. Note, if in phase control, the actual setpoint will be the nearest multiplier/divisor.	MinSpd – MaxSpd	Hz (RPM)
Kp Speed	The proportional gain of the RPM motor control	00.000 – 99.999	N/A

Ki Speed	The integral gain of the RPM motor control	00.000 – 99.999	N/A

3.4.6 ROTATION SETUP > PHASE TUNING MENU

The *Phase Tuning Menu* allows the setup of the phase control parameters.

Menu Item	Description	Values	Units
Tuning Menu	Parameters to change phase control (refer to section 3.4.7)	N/A	N/A
*Speed (read only)	Displays the current rotational speed of the spindle	000.00 – 999.99 (00000 – 99999)	Hz (RPM)
RunStPt	Specifies the desired run speed. Note that if in phase control the actual setpoint will be the nearest multiplier/divisor.	000.00 – MaxSpd (00000 – MaxSpd)	Hz (RPM)
VetoWin	This menu item is used to control the Veto-Out signal located on the front panel of the controller. The Veto-Out signal is a pulse which is generated on the rising edge of a TDC pulse when the previous TDC pulse occurred outside a veto window around a Reference-In pulse or a phantom Reference-In mark. A Veto-Out signal is generated every TDC when the <VetoWin> is set to 00.0 us.	000.000 – 999.999 (000.00 – 359.99)	µs (deg)
*Phase OK (read only)	The percentage of TDC pulses that fall in a time window centered on the Reference-In pulse adjusted for < RefDelay>. The width of time window is defined by <VetoWin>. For the last 1000 Ref-in counts.	000 – 100	%
*Efficiency (read only)	The percentage of TDC pulses that fall inside the veto window since the veto count was last reset.	000 – 100	%
*Veto (read only)	The number of TDC pulses that have fallen outside the veto window or occurred when a Reference Loss alarm was present since the veto count was last reset.	0000000000 – 9999999999	counts
*Non-Veto (read only)	The number of TDC pulses that fall inside the veto window without Reference Loss alarm being present since the veto count was last reset.	0000000000 – 9999999999	counts
Clear Veto Count	Executing this menu item will clear the 'Veto' and 'Non-Veto' counts	N/A	N/A
*Phase Acc (read only)	Phase accuracy, the calculated mean TDC position with respect to Ref-in for the last 1000 Ref-in counts.	0000.00 – 9999.99 (000.00 – 359.99)	µs (deg)
*Phase Rep (read only)	Phase repeatability, the calculated standard deviation of TDC position with respect to Ref-in for the last 1000 Ref-in counts.	0000.00 – 9999.99 (000.00 – 359.99)	µs (deg)
(*Phase Mn) (read only)	The calculated mean TDC position with respect to Ref-in since Veto Count was cleared.	0000.00 – 9999.99 ***(000.00 – 359.99)***	µs ***(deg)***
(*Phase Dev) (read only)	The standard deviation of the TDC from Ref-in since Veto Count was cleared.	0000.00 – 9999.99 ***(000.00 – 359.99)***	µs ***(deg)***
(*Win Max) (read only)	The positive deviation of the TDC from Ref-in since Veto Count was cleared.	0000.00 – 9999.99 ***(000.00 – 359.99)***	µs ***(deg)***
(*Win Min) (read only)	The negative deviation of the TDC from Ref-in since Veto Count was cleared.	0000.00 – 9999.99 ***(000.00 – 359.99)***	µs ***(deg)***

3.4.7 ROTATION SETUP > PHASE TUNING MENU > TUNING

The *Tuning Menu* allows the setup of control parameters for motor tuning in phasing.

Menu Item	Description	Values	Units
*Speed (read only)	Displays the current rotational speed of the spindle	000.00 – 999.99 (00000 – 99999)	Hz (RPM)
RunStPt	Specifies the desired run speed. Note: if in phase control, the actual setpoint will be the nearest multiplier/divisor.	000.00 – MaxSpd (00000 – MaxSpd)	Hz (RPM)
RefDelay	This parameter is used when the motor control is in PHASE mode to set a time offset to the desired rotor position with respect to the reference signal.	000.0000 – 999.9999 (000.00 – 359.99)	ms (deg)

Kp Phase	Sets the gain of the motor phase control loop when the motor is in the PHASE motor control mode.	00.00 - 99.99	N/A
Kp Speed	The proportional gain of the RPM motor control	00.000 – 99.999	N/A
Ki Speed	The integral gain of the RPM motor control	00.000 – 99.999	N/A
REF-IN Freq	This parameter is used to select the incoming REF-IN BNC Signal. The Loss of Reference Signal alarm is based on this setting.	0-999	Hz
REF-OUT Freq	Generates a timing signal on the REF-OUT BNC.	5 / 10 / 14 / 50 / 60 / 100	Hz

3.4.8 ROTATION SETUP > HOMING TUNING MENU

The *Homing Tuning Menu* allows the setup of the homing control parameters.

Menu Item	Description	Values	Units
*Speed (read only)	Displays the current rotational speed of the spindle	000.0 – 999.99 (00000 - 99999)	Hz (RPM)
*Angle (read only)	Displays the current rotational angle of the rotor	000.0 – 359.9	Deg
Park Angle	Specifies the parking / homing angle of the rotor	000.0 – 359.9	Deg
Zero Angle	Zeros the angle measurement to the current position of the disk. The park angle is updated accordingly as to not rotate the disk. Must enter this menu and then select the option to zero angle.	N/A	N/A
Kp Home	The proportional gain of the homing control	000.000 – 999.999	N/A
Ki Home	The integral gain of the homing control	0.000000 – 9.999999	N/A
Kd Home	The derivative gain of the homing control	000.000 – 999.999	N/A

3.4.9 CONTROLLER SETUP MENU

The *Controller Setup Menu* shows the selection of additional controller configuration related menus.

Menu Item	Description	Values	Units
BNC Config	Enters the BNC Configuration menu (refer to section 3.4.10)	N/A	N/A
Digital Input Sense	Enters the Digital Input Sense menu (refer to section 3.4.11)	N/A	N/A
Analog Input Sense	Enters the Analog Input Sense menu (refer to section 3.4.12)	N/A	N/A
Motor Temp Setup	Enters the Motor Warning Setup menu (refer to section 3.4.13)	N/A	N/A
Display Units	Allows the changing of display units	N/A	N/A
Date / Time	Enters the Time and Date menu (refer to section 3.4.14)	N/A	N/A

3.4.10 CONTROLLER SETUP > BNC CONFIG MENU

The *BNC Config Menu* allows the setup of the BNC hardware available on the front panel. See section 4.2.

Menu Item	Description	Values	Units
SYNC-IN 50ohm	Enables or disables the connection of the 50 ohm termination resistor on the SYNC-IN BNC	ON / OFF	N/A
REF-IN 50ohm	Enables or disables the connection of the 50 ohm termination resistor on the REF-IN BNC	ON / OFF	N/A
REF-IN Freq	This parameter is used to select the incoming REF-IN BNC Signal. The Loss of Reference Signal trip is based on this setting.	0-999	Hz
REF-OUT Freq	Generates a timing signal on the REF-OUT BNC.	5 / 10 / 50 / 60 / 100	Hz
VETO-OUT	Configures the VETO-OUT BNC to be either a driven or an open drain source.	OPEN DRN / DRIVEN	N/A
USER1	Chooses the function for the USER1-IO BNC (refer to section	OFF / DSMP-OUT	N/A

	4.2.7)		
USER2	Chooses the function for the USER2-IO BNC (refer to section 4.2.8)	OFF / SMP-OUT	N/A

3.4.11 CONTROLLER SETUP > DIGITAL INPUT SENSE MENU

The *Digital Input Sense Menu* allows the configuration of the back panel interlock connections.

Menu Item	Description	Values	Units
Cooling	Cooling Loss Interlock configuration. Triggers a 'trip' when input matches selection. See section 6.2.4	FLT OPEN / FLT CLSD	N/A
UPS Loss	UPS Loss Interlock configuration. Triggers a 'trip' when input matches selection. See section 6.2.4	FLT OPEN / FLT CLSD	N/A
Vacuum	Vacuum Loss Interlock configuration. Triggers a 'trip' when input matches selection. See section 6.2.4	FLT OPEN / FLT CLSD	N/A
Ext Fault	Fault Interlock configuration. Triggers a 'trip' when input matches selection. See section 6.2.3	FLT OPEN / FLT CLSD	N/A
Fault Rst	Fault Reset Interlock configuration. Triggers a 'trip' when input matches selection. See section 6.2.3	ACT OPEN / ACT CLSD	N/A
Remote Rn	Remote Run Interlock configuration. Triggers a 'trip' when input matches selection. See section 6.2.3	ACT OPEN / ACT CLSD	N/A

3.4.12 CONTROLLER SETUP > ANALOG INPUT SENSE MENU

The *Analog Input Sense Menu* allows the configuration of the analog input modes.

Menu Item	Description	Values	Units
Warn/Trip	Enables the interlocks to generate warnings and trips.	ENABLE / DISABLE	N/A
Sense Mode	Configures the analog mode of the Analog Interlock connection.	0-10V / 4-20mA	N/A
*Analog Val (read only)	Displays the current value of the Analog Interlock.	00.00 – 10.00 00.0 – 20.0	V mA
Over Trip	Set the high alarm trip level.	00.00 – 10.00 00.0 – 20.0	V mA
Under Trip	Set the low alarm trip level.	00.00 – 10.00 00.0 – 20.0	V mA
Over Warn	Set the high warning level.	00.00 – 10.00 00.0 – 20.0	V mA
Under Warn	Set the low warning level.	00.00 – 10.00 00.0 – 20.0	V mA

3.4.13 CONTROLLER SETUP > MOTOR TEMP SETUP MENU

The *Motor Temp Setup Menu* allows the configuration of the motor warning levels.

Menu Item	Description	Values	Units
Warning Lvl	Set the motor stator temperature warning level	000.0 – 999.9	°C

3.4.14 CONTROLLER SETUP > TIME AND DATE MENU

The *Time and Date Menu* allows the setting of time for the internal real time clock. Time is set using a 24hr clock, no operation is provided for time zone or daylight savings.

Menu Item	Description	Values	Units
Year	Sets the controller year value for the RTC	1991 – 2100	N/A
Month	Sets the controller month value for the RTC	01 – 12	N/A
Day	Sets the controller day value for the RTC	01 – 31	N/A
Hour	Sets the controller hour value for the RTC	00 – 23	N/A

Min	Sets the controller minute value for the RTC	00 – 59	N/A
*Sec (read only)	Displays the controller seconds value for the RTC. It is reset to zero whenever the minute or hour values are changed.	00 – 59	N/A

3.4.15 NETWORK SETUP MENU

The *Network Setup Menu* allows the setup of the controller's IP and network settings.

Menu Item	Description	Values	Units
IP1	Sets the IP of the controller	000-255	N/A
IP2		000-255	N/A
IP3		000-255	N/A
IP4		000-255	N/A
Mask1	Sets the Subnet Mask of the controller	000-255	N/A
Mask2		000-255	N/A
Mask3		000-255	N/A
Mask4		000-255	N/A
Gtwy1	Sets the Gateway of the controller	000-255	N/A
Gtwy2		000-255	N/A
Gtwy3		000-255	N/A
Gtwy4		000-255	N/A

3.4.16 CONTROL MODE MENU

The *Control Mode Menu* allows the selection of input control for the system.

Menu Item	Description	Values	Units
*Cur Mode (read only)	Displays the current control mode.	Local/Hardwire/MBScope/Modbus/Free	N/A
Sel Mode	Select between the control mode groups.	Hardwire/Request/Free	N/A
Request Local Mode	Request local control. Only shown when control group is set to request and local does not already have control.	N/A	N/A
Release Local Rqst	Releases local control so another request can take control.	N/A	N/A

	Start	Stop	Reset	Parameters
Local	Front Panel Only	All except Hardwire	Front Panel Only	Front Panel Only
Hardwire	Hardwire Only	Hardwire Only	Hardwire Only	Unrestricted
Modbus	Modbus Only	All except Hardwire	Modbus Only	Modbus Only
MBScope	MBScope Only	All except Hardwire	MBScope Only	MBScope Only
Free for All	All except Hardwire	All except Hardwire	Unrestricted	Unrestricted
Not Requested*	Completely Restricted	All except Hardwire	Completely Restricted	Completely Restricted

*Can occur when the control mode group is set to Request, but nothing has yet requested control.

3.4.17 DISPLAY MENU

The *Display Menu* shows the selection of additional display related menus.

Menu Item	Description	Values	Units
Firmware	Enters the Firmware Display menu (refer to section 3.4.18)	N/A	N/A
Currents	Enters the Current Display menu (refer to section 3.4.19)	N/A	N/A
Temperature	Enters the Temperature Display menu (refer to section 3.4.20)	N/A	N/A

Vibration	Enters the Vibration Display menu (refer to section XXXX)	N/A	N/A
Phase	Enters the Phase Display menu (refer to section XXXX)	N/A	N/A
Voltage	Enters the Voltage Display menu (refer to section XXXX)	N/A	N/A
Runtime Hours	Enters the Runtime Hours Display menu (refer to section XXXX)	N/A	N/A

3.4.18 CONTROLLER DISPLAY > FIRMWARE MENU

The *Firmware Menu* displays data listed in the following table.

Menu Item	Description	Values	Units
Ver	Lists the SKF part number of the currently installed firmware version	784-XXXX-XXX	N/A

3.4.19 CONTROLLER DISPLAY > CURRENTS MENU

The *Currents Menu* displays data listed in the following table.

Menu Item	Description	Values	Units
V1 0.00 V3 0.00	Displays the V1 and V3 peak currents	0.00 – 9.99	A
W1 0.00 W3 0.00	Displays the W1 and W3 peak currents	0.00 – 9.99	A
V2 0.00 V4 0.00	Displays the V2 and V4 peak currents	0.00 – 9.99	A
W2 0.00 W4 0.00	Displays the W2 and W4 peak currents	0.00 – 9.99	A
Z1 0.00 Z2 0.00	Displays the Z1 and Z2 peak currents	0.00 – 9.99	A

3.4.20 CONTROLLER DISPLAY > TEMPERATURE MENU

The *Temperature Sense Menu* displays data listed in the following table.

Menu Item	Description	Values	Units
*Mot Temp (read only)	Displays the motor temperature.	000.0 - 999.9	°C
*Mot Trip (read only)	Displays the alarm level for the motor temperature.	000.0 - 999.9	°C
*Cntl Temp (read only)	Displays the controller temperature measured at the heat sink.	000.0 - 999.9	°C
*Cntl Trip (read only)	Displays the alarm level for the controller temperature.	000.0 - 999.9	°C

3.4.21 CONTROLLER DISPLAY > VIBRATION MENU

The *Vibration Menu* displays data listed in the following table.

Menu Item	Description	Values	Units
V13 000 W13 000	Displays the V13 and W13 peak vibrations	000 – 999	µm
V24 000 W24 000	Displays the V24 and W24 peak vibrations	000 – 999	µm
Z12 000	Displays the Z12 peak vibrations	000.0 - 999.9	µm

3.4.22 CONTROLLER DISPLAY > PHASE MENU

The *Phase Menu* displays data listed in the following table.

Menu Item	Description	Values	Units
*Speed (read only)	Displays the current rotational speed of the spindle	000.00 – 999.99 (00000 - 99999)	Hz (RPM)

*Phase OK (read only)	The percentage of TDC pulses that fall in a time window centered on the Reference-In pulse adjusted for < RefDelay>. The width of time window is defined by <VetoWin>. For the last 1000 Ref-in counts.	000 – 100	%
*Efficiency (read only)	The percentage of TDC pulses that fall inside the veto window since the veto count was last reset.	000 – 100	%
*Veto (read only)	The number of TDC pulses that have fallen outside the veto window or occurred when a Reference Loss alarm was present since the veto count was last reset.	0000000000 – 9999999999	counts
*Non-Veto (read only)	The number of TDC pulses that fall inside the veto window without Reference Loss alarm being present since the veto count was last reset.	0000000000 – 9999999999	counts
*Phase Acc (read only)	Phase accuracy, the calculated mean TDC position with respect to Ref-in for the last 1000 Ref-in counts.	0000.00 – 9999.99 (000.00 – 359.99)	µs (deg)
*Phase Rep (read only)	Phase repeatability, the calculated standard deviation of TDC position with respect to Ref-in for the last 1000 Ref-in counts.	0000.00 – 9999.99 (000.00 – 359.99)	µs (deg)
(*Phase Mn) (read only)	The calculated mean TDC position with respect to Ref-in since Veto Count was cleared.	0000.00 – 9999.99 (000.00 – 359.99)	µs (deg)
(*Phase Dev) (read only)	The standard deviation of the TDC from Ref-in since Veto Count was cleared.	0000.00 – 9999.99 (000.00 – 359.99)	µs (deg)
(*Win Max) (read only)	The positive deviation of the TDC from Ref-in since Veto Count was cleared.	0000.00 – 9999.99 (000.00 – 359.99)	µs (deg)
(*Win Min) (read only)	The negative deviation of the TDC from Ref-in since Veto Count was cleared.	0000.00 – 9999.99 (000.00 – 359.99)	µs (deg)

3.4.23 Controller Display > Voltage Menu

The *Voltage Menu* displays data listed in the following table.

Menu Item	Description	Values	Units
+15V Bus (read only)	The measured voltage of the +15V bus.	00.0 - 99.9	V
Bearing Amp (read only)	The bus voltage measured at the bearing amplifier.	000.0 - 999.9	V
Motor Bus (read only)	The bus voltage measured by the motor processor.	000.0 - 999.9	V
System Bus (read only)	The bus voltage measured by the system.	000.0 - 999.9	V
Interlock (read only)	The analog interlock voltage.	00.00 – 99.99	V

3.4.24 Controller Display > Runtime Hours Menu

The *Runtime Hours Menu* displays data listed in the following table.

Menu Item	Description	Values	Units
Cntlr (read only)	Displays the amount of hours the controller has been powered on.	0000000.0 – 9999999.9	Hr
Levit (read only)	Displays the amount of hours the controller has been levitating for.	0000000.0 – 9999999.9	Hr
Rotate (read only)	Displays the amount of hours the controller has been rotating for.	0000000.0 – 9999999.9	Hr

3.4.25 Log Menu

The *Log Menu displays* an event log for control and alarm events.

Special case for hardwire commands: Since run on/off hardwire are continuously issued the event log will not record duplicate consecutive events for these two commands in order to prevent filling up the event log

3.5 USING THE CONTROLLER

3.5.1 CONTROL MODES

Note: After a firmware load, the control mode group will be set to free for all

The controller can accept commands via 5 different methods:

- Local (Front Panel) – No parameter changes allowed from any other interface, except that the Stop signal will be accepted from all.
- Hardwire – Is Free For All with the hard wired dry contacts. Hardwire will override all other inputs to the stop and start buttons. (parameter changes and reset from all other inputs accepted)
- Modbus over Ethernet – Only Modbus can write parameters
- MBScope over Ethernet– Only MBScope can write parameters
- Free For All- (Hardwire off) any input except hardwire can write parameters

The current control interface is listed in Current Control Mode. To Set your control interface, change the control mode selection. If in request mode: request control from the preferred interface. To move control to another interface you must release control. (each type of communication can request itself and must release control for another to take over) To override a request mode switch the Control Mode, this will clear the request.

The Stop button always works. (except for hardwire)
All parameters are readable by other interfaces in all control modes.
These changes can be made at any point, rotating or not.

- Modbus can only request control and release.
- Local and MBScope can set the control mode to hardwire, Request or Free for All. This overrides the current control mode. (If Modbus crashes, you would set the controller to free for all then put it back into Request so another interface could request control.)
- Local can request Local. (must wait for control to be given up)
- MBScope can request MBScope. (must wait for control to be given up)

3.5.2 OPERATING THE CONTROLLER LOCALLY

The following procedures describe how to operate the MB4150g5-PC controller

1. Apply power to the controller**.** When the word *READY* appears in the top left corner of the LCD, the controller is initialized and ready to operate.
2. Enable local control via the Front Panel menu (refer to Section 3.4.16).
3. Press the *Start* button to initiate levitation. The word *READY* on the LCD will change to *LEVITATED* and the *Run* contact will close. Rotation of the motor can be started. (Note: If a run speed is set the chopper will accelerate to that speed).
4. Press the *Stop* button to de-levitate. The 1st line of the *Main* Display will show *STOPPING* while breaking.

Once the shaft has stopped rotating and is de-levitated, the 1st line of the *Main* Display will show *READY*.

3.5.3 OPERATING THE CONTROLLER REMOTELY VIA MBSCOPE™

The controller can also be operated remotely via the MBScope™ software suite. Refer to SKF Documentation 892-0110 (User's Guide, MBScope.NET, MBG5) for how to connect to the controller, and how to use these features.

3.5.4 OPERATING THE CONTROLLER REMOTELY VIA MODBUS/TCP

The controller can also be operated remotely via the Modbus/TCP protocol. Refer to Section 7 on using this control.

3.6 CHOPPER SETUP

3.6.1 HEALTH CHECK

A Health Check is to be done on the system during install, after moving the system to a new mounting and for install of a new shaft assembly.

- Calibrations – See section 3.6.8
- Full speed unbalanced response – See section 3.6.9
- Tuning Validation – Currently SKF personal are required, on site, to take the measurements for this check. Data gathered is checked against models and stability criteria to ensure robustness throughout the running range.

If the Health Check does not pass SKF support should be requested.

Quick Health Check

A Clearance Check can be performed as a quick check of system health. For a Clearance Check run Calibrations of all axis as described in section 3.6.8. Quick checks should be performed after a shaft replacement (for a proven shaft assembly), after a crash, after a period of inactivity and as an aux bearing maintenance check. If results do not match FAT data a full Health Check should be completed.

Movement on a translation table does not require any checks to be performed on a validated system.

3.6.2 RESOLVER AND TDC CALIBRATION

The resolver and TDC set up is done using snapshots and the Calibrations-system tab. This will be setup by SKF for any full system delivered. If a Shaft is changed this setup should be done to ensure peak performance.

The gain and offset must be changed in calibrations so that when viewing the proper signal in snapshots the signals will be maximized without clipping. The chopper will have to be run at around 5 or 10 Hz to view and compare the signals. Ensure that all resolver signals are the same amplitude and offset. It is suggested to bottom out the offset, and then increase the gain adjusting offset as you go. The offset and gain have an effect on each other, due to how the circuit is designed.

3.6.3 PARKING ANGLE

Disk parking angle can be zeroed to align the desired disk position with the controller display. Disk parking position is not related to phasing position.

To do this change the parking angle to align the disk to the desired position. Select <Zero Angle> on the front panel. The <Angle> and <Park Angle> will now read zero and the disk will be in the desired position. Changes to <Park Angle> will now be in reference to this position. This has no effect on rotation and phasing.

3.6.4 PHASING

For operation in Phase mode, provide a signal to the Ref-IN BNC. Set the <Ref-In Freq> to match the provided signal. The chopper will now phase to the provided signal at the requested <Set Speed>. Veto counts are recorded according to the specified <VetoWin>. The Phase OK read out will give a percentage for acceptable measurements; this is based on the Phase OK setting of TDC or Ref-in.

Ref-in uses the last 1000 Ref-in counts for the display.

TDC uses 5 seconds of TDC pulses with a minimum of 50 pulses and a maximum of 1000.

If phasing is not required set the chopper in Speed Mode. The chopper will run at the set speed, no phasing or veto counts will occur.

3.6.5 PHASE DELAY

The chopper will phase relative to the TDC notch leading edge. The disk window leading edge will be positioned according to its mechanical position relative to the TDC notch. Several settings allow the changing of payload position relative to Ref-In signal. The Speed Adjustment Delay <TDCDelay> allows you to compensate for the difference in electrical timing with speed. This allows you to use the same Phase Advance <RefDelay> when running at different speeds. See MBscope and section 3.4.7 for details.

To set the Speed Adjustment Delay:

Using a strobe measure the shaft position at low speed (5 Hz), this will be your reference position.

Take the system to full speed and measure the offset from the previous low speed measurement.

Enter this value in the Speed Adjustment Delay <TDCDelay> parameter.

3.6.6 SYSTEM BALANCE

The system as shipped is in a suitable balance state where the orbits at the DE and NDE sensors are no greater than the alarm limits set in the PVF file shipped with the system. Of note improved balance with smaller orbits will provide better phasing. The rotor can be balanced externally, once placed in the spindle you may still need to fine balance the rotor at your run speed. After balancing any balance screws should be permanently secured using Loctite or thread deformation.

1. The balancing drawing is listed in 1.2 Supporting Documents. Print off a copy of this document.
2. Fill in the blanks on the sheet, incl. your name, the date, the speed at which the balancing procedure is taking place, and the system name that the balancing is being performed on.
3. Under the Motor Setup menu set the mode to RPM.
4. Set the Run speed to the speed you plan to balance at. Balancing should be done at the highest achievable speed without tripping alarms, room must be provided for changes that make the balance worse.
5. Do Not Start the Unit.
6. Open the "Orbits" function of MBScope.
7. For "Orbits": Turn off the filter
8. Close the unit and run it up to speed (under vacuum).
9. On the "Orbits" screen overlay the cursors with the TDC indicator boxes. Right-Click on the TDC indicator and snap both points to cursors 1 and 2. Be sure to keep straight which one is which measurement.

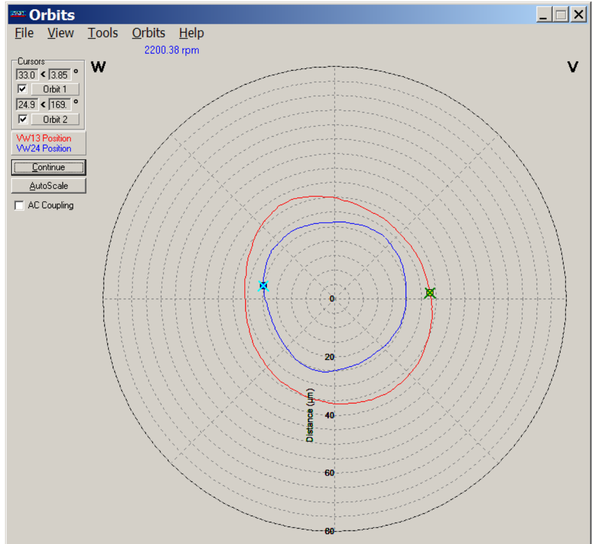
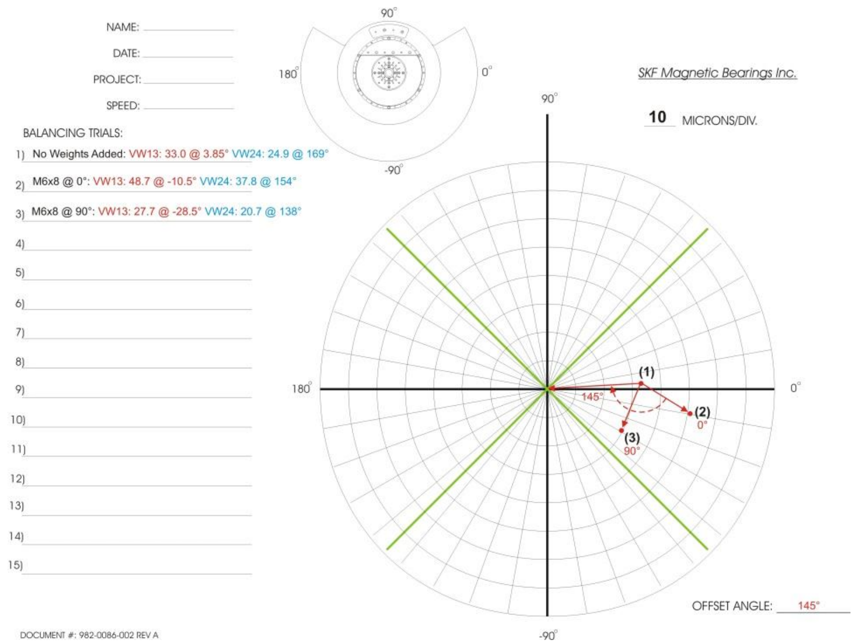


FIGURE 6– ORBITS SCREEN

10. Record the magnitude and phase of the VW13 and VW24 bearings on the Balance Sheet.
11. Stop the unit.
12. If the VW13 orbits were larger, balance the DE plane first. If the VW24 orbits were larger, balance the NDE plane first.
13. Insert a test balance weight into the payload through the window at the 0º point, (any point is fine as long as its position is recorded).
14. Plot the position of the weight on the small picture of the payload. (See example sheet below)
15. Repeat steps 8-11.
16. Remove the test weight and replace it at ±90º from where you had inserted it last. Record on the balance sheet where it has been placed.
17. Repeat steps 8-11.
18. Remove the test weight.
19. Plot the “Orbits” magnitude and phase on the Balance Sheet for all three trials, be as accurate as possible. Indicate the trial number. See the example balance sheet below.
20. Overlay the 90º angle of the position of the trial weights onto the plots of the Orbits. Trial one (no weight) is the common point. Mark the weight directions (Draw arrows from trial 1 to trial 2 and from trial 1 to trial 3). See the balance sheet below.
21. Draw an arrow from trial 1 to the center of the balancing sheet.
22. Measure the angle from trial 2 to the center of the balancing sheet and record it on the Balance Sheet under ‘Offset Angle’.
23. Note the change in magnitude due to the weight inserted.
24. Insert a weight, sized according to the effect of the test weight (compare vector lengths) at the measured angle (or as close as you

can get).

25. Run the system up to speed and observe orbits.
26. If balance is not achieved repeat steps 25-27. This iterative process should take no more than a few trials.
27. If necessary, move to a higher speed and start a new Balance Sheet for this speed.



3.6.7 MOTOR TUNING

The system shipped comes with a list of motor tuning parameters that will provide best performance at all speeds tested. Those parameters will also perform well at speeds close by.

In case the system has to run at a speed not listed, the following procedure optimizes the motor tuning parameters.

NOTE:
Experience shows that low speeds require different motor tuning than high speeds.

1. Start by tuning the Speed-Control loop.
2. Set the controller to RPM control
3. Adjust proportional and integral gain in order to reach the speed set point with no or little overshoot.
4. Once a good speed control is achieved, set the controller to PHASE mode
5. Change the Phase gain until the phase performance at a given speed improves.

NOTE:
A very low integral gain will cause the system to take a long time to achieve

phase lock.

3.6.8 CALIBRATIONS

3.6.8.1 CALIBRATION TOOL

Calibration must be performed while the shaft is levitated.

The MBScope Calibration Tool is used to calibrate the sensors and center the shaft in the touchdown bearings. It is used following a configuration change and to perform the following functions:

- Calibrate the shaft position measurement from the radial sensors
- Calibrate the sensor offset
- Check machine internal clearances, and
- Check alarm levels and alarm functions

The G5 Controller does not use the calibration sensitivities in the control loop for the amplifiers.

Note: When the Calibration tool is loaded, it will give the option to switch the controller into "test mode". In this mode, the position and current alarm limits will be ignored and motor inhibited. This allows the position of the (non-rotating) shaft to exceed the alarm limits without causing the system to de-levitate. In order to test alarm levels and functions, the user should allow the screen to continue in "normal mode".

3.6.8.2 FINDING INFLECTION POINTS

The inflection point is the point where the shaft of the system first touches the touchdown bearing. The inflection points can be found for a specific axis by using the buttons at the top of the graph.

FIGURE 7 CALIBRATION BUTTONS

The << button will search for the left inflection point and the >> button will search for the right inflection point by slowly changing the set point in small steps. Center the shaft on all axes before searching for inflection points, use the '0' button to center the shaft. The shaft must be centered between each search.

Clicking the < button will move towards the left inflection point and the > button will move towards the right inflection point one step at a time.

The step size can be selected from the View – Options menu. Setting the step size too large may cause the search process to miss an inflection point and the rotor to go unstable. If a search fails, the shaft should be immediately centered using the '0' button.

3.6.8.3 SELECTING AXIS TO CALIBRATE

The axis drop down box is used to select the axis to be calibrated. Once the axis has been selected, its specific data will be displayed in the boxes on the left-hand side of the screen. All the axis should be at centered before checking the calibration.

3.6.8.4 MEASUREMENT AND PARAMETER DISPLAY BOX

This box displays various measurements taken from the controller in real time. The values shown are displayed for monitoring the calibration only and cannot be edited.

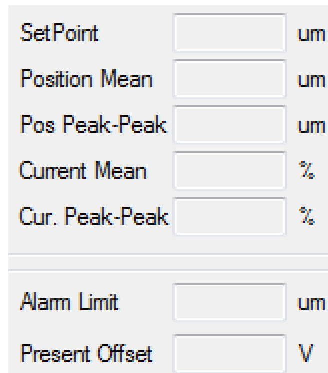


FIGURE 8 CALIBRATION DISPLAY BOX

The Setpoint value is the requested position of the shaft.
Position Mean value is the actual position of the shaft.
Pos Peak – Peak value is the variation in the position of the shaft.
Current Mean value is the average current of the actuator.
Cur. Peak – Peak value is the variation in the current from the actuator.

Alarm Limit displays the maximum displacement that can be reached before an alarm occurs.
Present Offset displays the value of the present offset being used by the controller for the chosen axis.

3.6.8.5 MEASUREMENT AND PARAMETER EDIT BOX

This box displays specific parameters and their values for the chosen axis. These values can be altered and will change if the system configuration is altered.

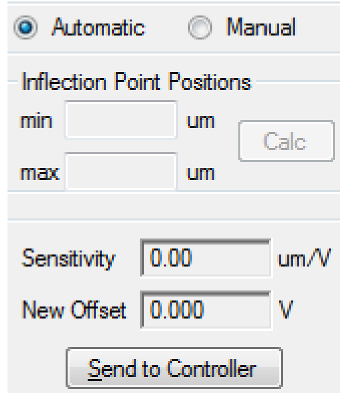


FIGURE 9 MEASUREMENT AND PARAMETER EDIT BOX

The following values can change:

To enter values manually, [Manual] must be selected, see Figure 9.

Sensitivity – This value is the relationship of um/Volts from the sensors and electronic circuitry. It is specific for the system.

New Offset – The new offset is automatically chosen if you are in Automatic mode, or manually chosen when in Manual mode. When in manual mode, the offset can be directly entered, or the points of inflection can be entered, and the new offset will be calculated after pressing the Calculate button.

After the desired measurement and parameter values are entered, the Send to Controller button must be clicked to transfer the new values for the selected axis to the controller RAM. This does not save the changes permanently see 3.6.11.

3.6.8.6 COMMON PROBLEMS

ERRATIC DATA POINTS

SOMETIMES NEAR THE END OF A SEARCH FOR THE INFLECTION POINTS THE DATA WILL BECOME ERRATIC, BOUNCING UP AND DOWN. THIS CAN BE CAUSED BY ONE OF THE AXES NOT BEING ZEROED AND THE SHAFT GETTING JAMMED UP AGAINST THE BEARING. TO FIX THIS ZERO ALL AXIS. THIS CAN ALSO BE CAUSED BY STIFF TUNING. A SMALLER STEP SIZE CAN BE USED, SETTING THE STEP SIZE TO 1 UNDER VIEW>OPTIONS CAN HELP SMOOTHEN THE RESPONSE. ANOTHER SOLUTION IS THAT THE TOTAL GAIN CAN BE LOWERED FOR DOING CALIBRATIONS BUT MUST BE RETURNED TO THE CORRECT VALUE AFTER, CHANGE THIS ON THE SYSTEM TAB. THE LAST OPTION IS TO USE THE MANUAL ENTRY TO SELECT THE INFLECTION POINT WHERE YOU SEE THE CONTACT TO START TO OCCUR.

3.6.9 UNBALANCED RESPONSE

The unbalanced response is a trend of positions during acceleration and deceleration that shows the peak to peak vibration of the system at all run speeds. Use MBScope Trending to capture this data. This can be compared to previous results to see if changes to the system balance have occurred. If differences are observed SKF should be contacted for direction on how to proceed.

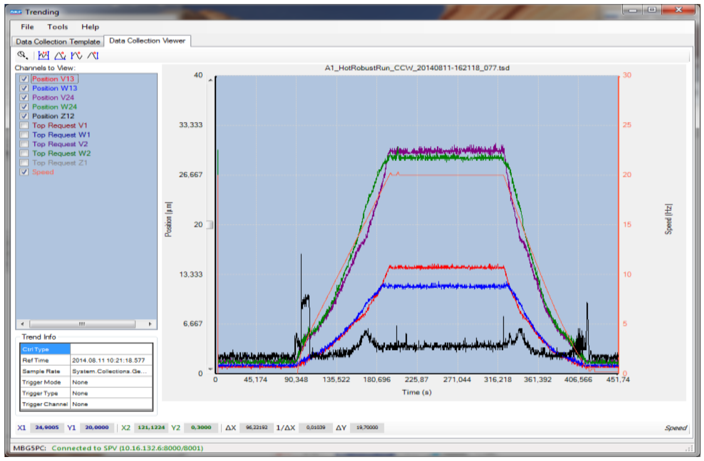


FIGURE 10 UNBALANCED TREND

3.6.10 TUNING VALIDATION

Currently SKF must make measurements of the system with special hardware in order to validate the tuning. SKF has tools in development to allow the customer to make these measurements.

3.6.11 SAVING DATA TO PERMANENT MEMORY

Parameters accessed from the front panel are daily use parameters and are automatically saved on power down. When changing parameters through MBScope the user should manually save to permanent memory to ensure all parameters are remembered after a power cycle. To do this use Control Panel > Control Tab and execute the store parameters to permanent memory button. You may also want to make a copy of the PVF using parameter loader.

4. FRONT PANEL CONNECTIONS

4.1 FRONT PANEL LAYOUT

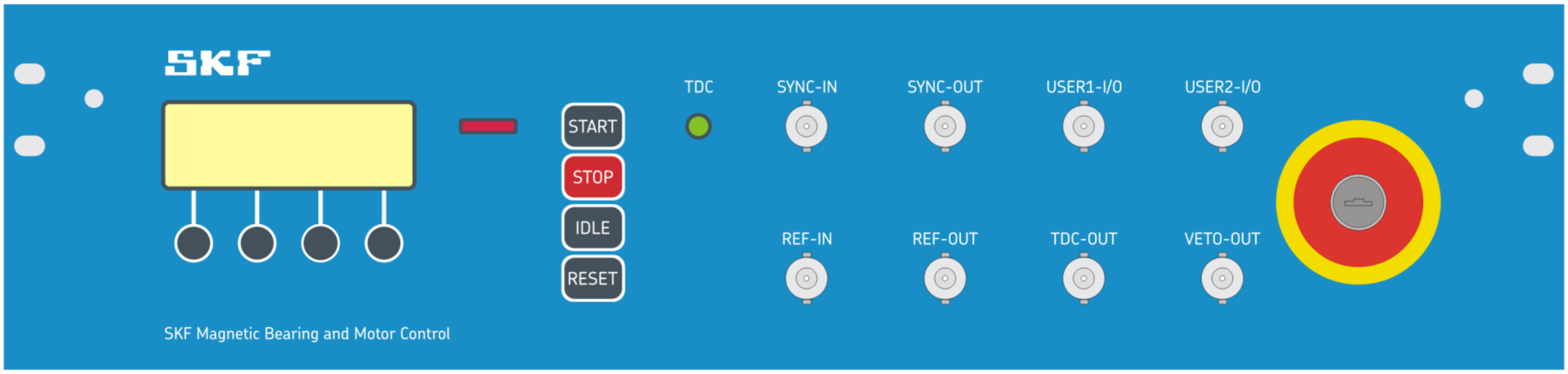


FIGURE 11 – CONTROLLER FRONT PANEL LAYOUT

4.2 BNC SIGNALS

The output signals are all capable of driving 50 ohm load. The input signals can be user configurable with jumper to have 50 ohm input impedance or high impedance (See Section 3.4.10).

4.2.1 REF-IN

Motor phase control uses REF-IN as the input signal for phase reference. REF-IN is a TTL pulse train with a frequency determined by the <REF-IN Freq>. Phase timing is referenced to the rising edge of the signal.

The system will generate a 'Ref Loss' warning if the provided frequency is outside of the range specified by this alarm. (See section 8.3.4).

4.2.2 REF-OUT

Reference out is a signal generator that outputs <REF-OUT Freq>. This can be used to synchronize multiple choppers. This signal is generated separately from any of the controllers other activities. This signal should be connected from one of the choppers to the REF-IN BNC of each chopper in the beam line.

4.2.3 TDC-OUT

This signal represents the 'Top Dead Center' of the system. The first edge of the TDC-OUT BNC is triggered by the first edge of the TDC signal from the machine. The Speed Adjustment Delay <TDCDelay> is available to keep the rotation angle between the TDC notch and the TDC-OUT pulse constant with speed (to compensate for electrical delay in the sensor).

4.2.4 VETO-OUT

Dependent on the Veto setting of Pulsed or Latched.

Pulsed

This signal indicates that the time interval between the TDC of the rotor and the REF pulse has exceeded the programmable <VetoWin>. It is generated on the first edge of a TDC-OUT pulse when the *previous* TDC occurred outside its veto window, or when a *Reference Loss* alarm was active.

Latched

The veto window is the maximum absolute time difference between the DSMP and the TDC. If the absolute time difference between the two signals is greater than the veto window, but less than 999µs, a veto is latched immediately at the time the second signal arrives. If the absolute time difference between the two signals is greater than 999µs, a veto is latched at ½-SMP period (1/2 run speed setpoint period) after the arrival of the first signal.

The VETO-OUT signal can be set to Driven or Drain in MBScope.

A VETO-OUT signal allows data resulting from 'bad' TDC pulses to be identified. The veto window can be set via the Front Panel (Section 3.4.6) MBScope and Modbus.

4.2.5 SYNC-IN

This signal is used to determine which REF pulse to use when the system is operating sub-synchronously.

4.2.6 SYNC-OUT

This signal is generated so that all systems are using the same REF pulse when operating sub-synchronously. It is usually tied to the SYNC-IN of another unit.

4.2.7 USER1-I/O

This USER BNC can be selected to output customer specific signals.

DSMP - Delayed Secondary Master Pulse

The first edge of this signal is synchronized to the primary edge of the REF pulse, but delayed by the customer supplied 'REF Delay' parameter, and the 'TDC Delay' parameter. The delay represents where you want the Rotor Pulse (RP) or TDC to occur. The frequency is the run speed of the chopper.

4.2.8 USER2-I/O

This USER BNC can be selected to output customer specific signals.

SMP - Secondary Master Pulse

The first edge of this signal is synchronized to the primary edge of the REF pulse, and is not delayed by any parameter. The frequency is the run speed of the chopper.

4.3 TIMING DIAGRAM (EXTERNAL REFERENCE)

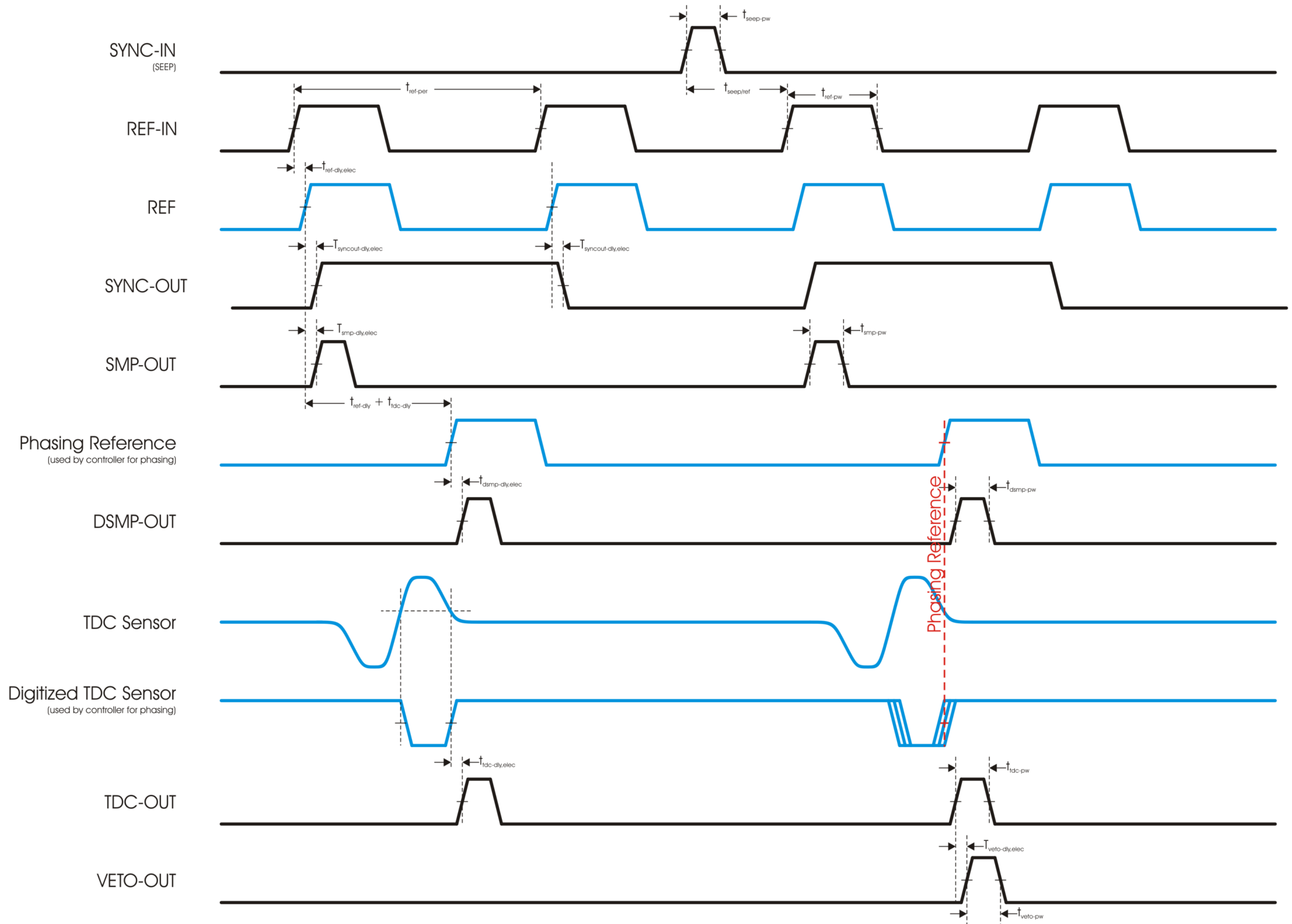


FIGURE 12 - TIMING DIAGRAM FOR USING AN EXTERNAL REFERENCE

4.4 Electrical Specifications

PARAMETER	DESCRIPTION	MIN	TYP	MAX	UNIT
$t_{ref\text{-}per}$	REF In period	16.667		100.000	ms
$t_{ref\text{-}pw}$	REF In pulse width	1		tref-per-1	µs
$t_{ref\text{-}dly,elec}$	REF In electrical delay			*(TBD)*	ns
$t_{smp\text{-}pw}$	SMP Out pulse width		6		µs
$t_{smp\text{-}dly,elec}$	SMP Out electrical delay			*(TBD)*	ns
$t_{ref\text{-}dly}$	REF delay (‘RefDelay’ - Section 3.4.6)			tref-per	ms
$t_{tdc\text{-}dly}$	TDC delay (Section3.6.5)			tref-per	ms
$t_{dsmp\text{-}pw}$	DSMP Out pulse width		128		µs
$t_{dsmp\text{-}dly,elec}$	DSMP Out electrical delay			500	ns
$t_{tdc\text{-}pw}$	TDC Out pulse width		100		µs
$t_{tdc\text{-}dly,elec}$	TDC Out electrical delay			100	ns
$t_{syncin\text{-}pw}$	SYNC In pulse width	1			µs
$t_{seep/ref}$	SYNC In setup to REF In	1			µs
$t_{syncout\text{-}pw}$	SYNC Out pulse width		tref-per		ms
$t_{syncout\text{-}dly,elec}$	SYNC Out electrical delay			50	ns
$t_{veto\text{-}pw}$	VETO Out pulse width		20		µs
$t_{veto\text{-}dly,elec}$	VETO Out electrical delay			25	ns

Voltage specifications for all inputs and outputs are as per the following:

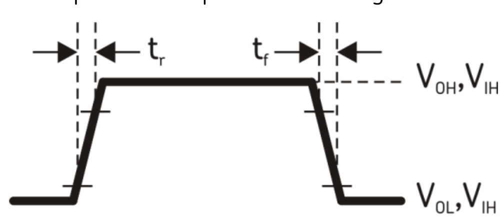


Figure 13 - General BNC Timing / Voltage

PARAMETER	DESCRIPTION	MIN	TYP	MAX	UNIT
V_{IH}	High-level input voltage	2.0		5.0	V
V_{IL}	Low-level input voltage	0.0		0.8	V
V_{OH}	High-level output voltage (no load)	2.4			V
	High-level input voltage (50Ω load)	2.0			V
V_{OL}	Low-level output voltage			0.4	V
t_r	Rise Time (50Ω load)			10	ns
t_f	Fall Time (50Ω load)			10	ns

5. CUSTOMER INPUT / OUTPUT SIGNAL DESCRIPTIONS

5.1 GENERAL

This section provides a description of the digital control signals available via the REMOTE CONTROL OUTPUT, REMOTE CONTROL INPUT, and AUX EQUIPMENT INTERLOCK terminal blocks.

5.2 REMOTE CONTROL OUTPUT

The REMOTE CONTROL OUTPUT terminal block is used to obtain status information from the controller. The provided outputs can be used as required for shutdown annunciation, motor interlock, or part of external hardware control. All outputs are discrete dry relay contacts. Electrical specifications can be found in Section 5.6.

Note: if inductive loads such as relays or solenoids are driven by the contacts, a fly back diode must be used to limit back EMF when the contact opens. The voltage-limiting device should be located as closely as possibly to the inductive load. The back EMF can interfere with the operation of the controller causing false shutdowns. The diode needs to be rated for the voltage and the current though the inductive load. A general purpose silicon diode such as the 1N4001 from Fairchild semiconductor is suitable.

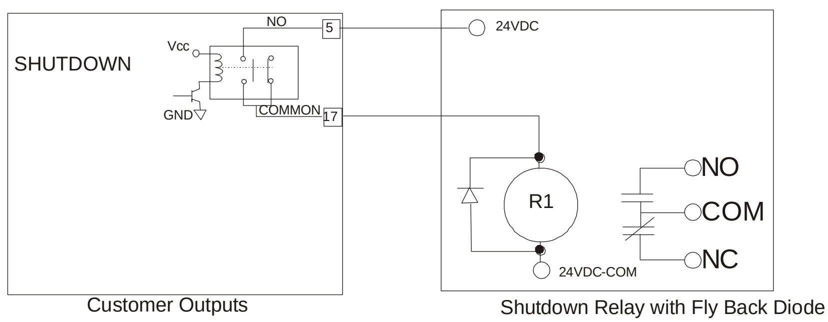


FIGURE 14 – FLY BACK DIODE ACROSS A RELAY COIL.

5.2.1 SHUTDOWN/TRIP – NORMALLY OPEN

The *Shutdown/Trip* contact is open when the controller detects a Trip event. A shutdown indicates that a condition exists that could result in mechanical damage to the machine if the shaft is allowed to continue to rotate.

The *Shutdown/Trip* relay is de-energized (open) whenever the *Alarm Indicator* is red. The relay is energized (closed) when the *Alarm Indicator* is off. The relay is de-energized through hardware if a *Watchdog Fault* occurs.

5.2.2 WARNING – NORMALLY OPEN

The *Warning* contact is open when the controller detects a Warning event. A warning indicates that the system can still operate normally, but corrective action should take place when convenient.

5.2.3 READY TO ROTATE – NORMALLY OPEN

The *Ready to Rotate* contact is closed whenever the bearing controller is in a state that permits rotation (such as '*Levitated*'). The contact is used to interlock with an external drive controller, it does not report on the internal drive readiness. The contact indicates when rotation of the shaft is permissible. The *Ready to Rotate* contact state is indeterminate if a *Watchdog Fault* occurs and should therefore be wired in series with the *Shutdown/Trip* contact when interlocking a drive. The motor inhibit button and remote motor inhibit interlock will affect this contact.

5.2.4 LEVITATED – NORMALLY OPEN

The *Levitated* contact is closed when the system has detected levitation of the machine. This contact may be closed even if levitation is not requested.

5.2.5 ROTATING – NORMALLY OPEN

The *Rotating* contact is closed when the system has detected rotation of the machine. This contact may be closed even if rotation is not requested.

5.2.6 PHASE LOCKED / SPEED LOCKED – NORMALLY OPEN

The function of the *Phase Locked/Speed Locked* contact depends on the mode of the motor control that has been selected.

Speed Mode: The relay is activated when the shaft speed is:

- within 2% of the set point, rotating below 100Hz.
- within 2 Hz of the set point, above 100Hz.

Phase Mode: The relay is energized when the machine is phase locked to the synchronization pulse. It is considered phase locked when the PHASE OK parameter is above 90%, which is based on the Phase OK setting. See 3.6.4

5.2.7 SPARE OUT – NORMALLY OPEN OR NORMALLY CLOSED

This output is currently unused.

5.3 REMOTE CONTROL INPUT

The REMOTE CONTROL INPUT terminal block is used to control the operation of the system. The inputs can be used for remote digital control, and are designed to interface to a discrete dry contact that closes to request the specified action. Electrical specifications can be found in Section 5.6.

The inputs can be either asserted as active high or active low. The input sense is set from the front panel (refer to Section 3.4.11).

5.3.1 REMOTE RUN

The *Remote Run* input can be used to connect the controller to a run switch. Asserting the input will levitate the shaft and close the *Ready To Rotate* output relay (and likewise, de-asserting the input will open the *Ready To Rotate* output relay). Once the shaft has stopped rotating it will de-levitate. This method of stopping the controller is only active if the *Control* parameter is set to *Hardware* (refer to Section 3.4.16)

5.3.2 EXTERNAL FAULT

The *External Fault* input is used to produce an *External Fault* shutdown. This will result in stopping the rotation of the shaft and de-levitating. In addition, an *External Fault* message will be displayed on the front panel LCD, the red *Alarm Indicator* will light up and the *Shutdown/Trip* and *Ready to Rotate* contacts will open.

See Section 8 for shutdown actions.

5.3.3 WARNING / TRIP RESET

The *Warning / Trip Reset* input is used to clear warning and trip events. It provokes the same action as the Reset button on the front panel (see section 3.1.1), and is triggered on a transition edge (close or open).

5.3.4 SPARE IN

This input is currently unused.

5.4 Aux Equipment Interlocks

The *Aux (Auxiliary) Equipment Interlock* terminal block is used to give status information about other equipment that may be used in conjunction with the magnetic bearing to cause a trip alarm. Each input is designed to interface to a discrete dry contact that closes to request the specified action. Electrical specifications can be found in Section 5.6.

The inputs can be either asserted as active high or active low. The input sense is set from the front panel (refer to Section 3.4.11).

See Section 8 for shutdown actions.

5.4.1 Cooling Loss

The *Cooling Loss* input can be connected to a temperature switch that monitors the cooling fluid for the machine. For failsafe operation, the connection should be open when the coolant temperature is out of spec and the input should be configured to Fault Open. If multiple sensors are required then the sensors should be connected in series.

5.4.2 Vacuum Loss

The *Vacuum Loss* input should be connected to a pressure switch or vacuum monitoring equipment. For failsafe operation, the connection should be open when the pressure is out of spec and the input should be configured to Fault Open. If multiple sensors are required then the sensors should be connected in series.

5.4.3 UPS Failure

The *UPS Failure* input should be connected to the UPS module that is powering the controller. For failsafe operation, the connection should be open when the UPS has a problem and the input should be configured to Fault Open.

5.4.4 Remote Motor Inhibit

The *Remote Motor Inhibit* input is used to generate a *Motor Inhibit* event. This will result in inhibiting the motor drive and bring the system to a full stop. In addition, a -- *Warning* -- message will be displayed on the front panel LCD, the red *Alarm Indicator* will light up and the *Warning* and *Ready to Rotate* contacts will open.

See Section 8 for shutdown actions.

5.5 ANALOG SIGNALS

The *Analog Signals* terminal block contains non-isolated analog inputs and outputs for monitoring and control. Electrical specifications can be found in Section 5.6.

The Analog Input connections can be either 4-20mA or 0-10V, and can be selected via the Front Panel Menu (refer to Section 3.4.12).

5.5.1 ANALOG INTERLOCK INPUT

The *Analog Interlock Input* allows a connection to an external analog device (i.e., an external temperature sensor). A warning and/or trip level can be set on the input, which can be used to trigger warning or trip events in the controller.

5.5.2 ANALOG INPUT

The *Analog Input* is currently not used.

5.5.3 ANALOG OUTPUT

The *Analog Output* is currently not used.

5.6 ELECTRICAL SPECIFICATIONS

5.6.1 DISCRETE INPUT CONNECTIONS

The inputs are electrically isolated from the controller by via opto-couplers. Each pair of input +ve and –ve terminals are designed to be shorted together to assert the input. External voltage should not be applied to these terminals.

TABLE 2 - ELECTRICAL SPECIFICATIONS FOR DISCRETE INPUTS

Specification	Value	Units
Absolute maximum input voltage (-ve to +ve terminal)	26	V
Absolute minimum input voltage (-ve to +ve terminal)	0	V

5.6.2 DISCRETE OUTPUT CONNECTIONS

These outputs are electrically isolated from the controller by relays. The outputs are all normally open dry contacts.

TABLE 3 - ELECTRICAL SPECIFICATIONS FOR DISCRETE OUTPUTS

Specification	Value	Units
Maximum Operating Voltage (DC)	220	V
Maximum Operating Voltage (AC)	250	V
Maximum Operating Current	2	A
Maximum Switching Capacity (DC)	60	W
Maximum Switching Capacity (AC)	62.5	VA

5.6.3 ANALOG INPUT CONNECTIONS

The analog inputs are not electrically isolated and care should be taken to avoid ground loops – the '-ve' terminal of the analog input should be 0V when referenced to chassis ground. The Analog Input connections can be either 4-20mA or 0-10V, and is selected via the Front Panel Menu (refer to Section 3.4.12).

TABLE 4 - ELECTRICAL SPECIFICATIONS FOR ANALOG INPUTS

Specification	Value	Units
Maximum Voltage (+ve with respect to -ve terminal)	10	V
Minimum Voltage (+ve with respect to -ve terminal)	0	V
Maximum Current Draw	20	mA

5.6.4 ANALOG OUTPUT CONNECTIONS

The analog outputs are not electrically isolated and care should be taken to avoid ground loops – the '-ve' terminal of the analog input should be 0V when referenced to chassis ground.

TABLE 5 - ELECTRICAL SPECIFICATIONS FOR ANALOG OUTPUTS

Specification	Value	Units
Maximum Voltage	5	V
Minimum Voltage	0	V
Output Impedance	100	Ω

6. BACK PANEL CONNECTIONS

6.1 BACK PANEL LAYOUT

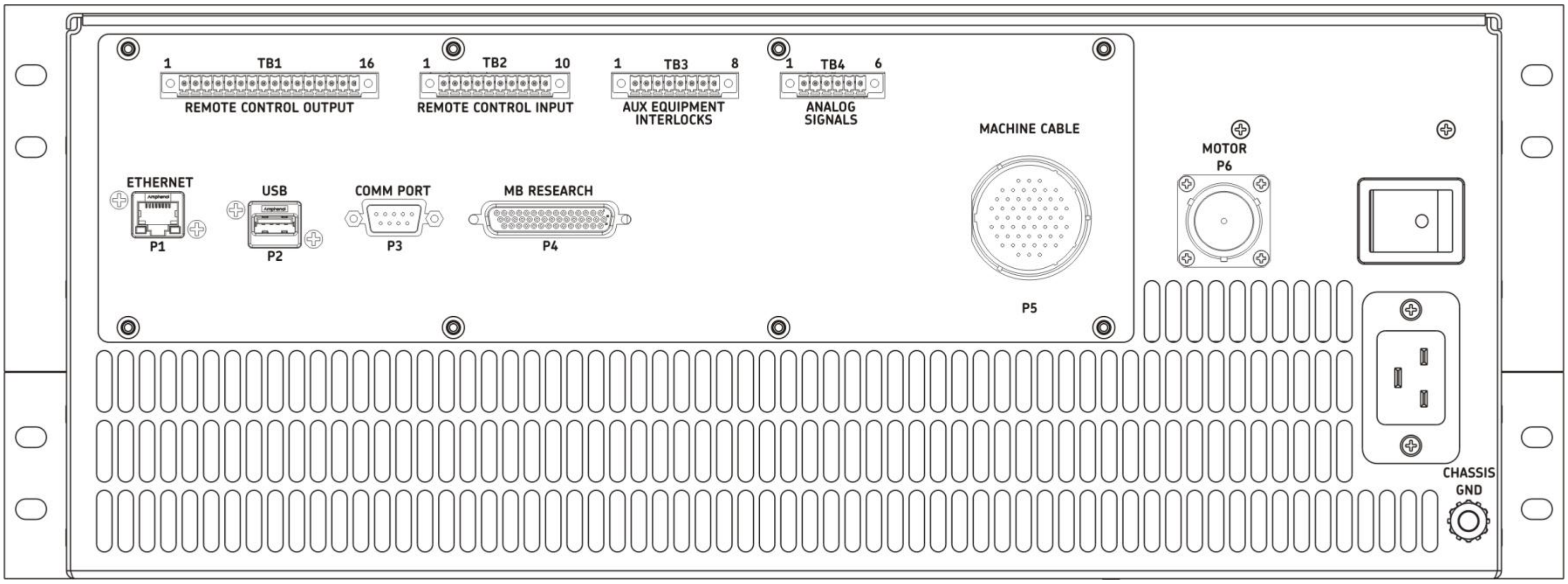


FIGURE 15 – CONTROLLER BACK PANEL LAYOUT

6.2 TERMINAL BLOCK DESCRIPTIONS

6.2.1 TERMINAL BLOCK REPLACEMENT PNS

If replacement terminal blocks are required, they are provided by connector company Phoenix Contact (https://www.phoenixcontact.com).

6 Pole – Manuf PN: 1847097

8 Pole – Manuf PN: 1847181

10 Pole – Manuf PN: 1847204

16 Pole – Manuf PN: 1847262

6.2.2 TB1 – Remote Control Output

The *Remote Control Output* terminal block is used to interlock the controller to a motor drive or to connect it to customer control logic. See Section 5.2 for a detailed description of the signals.

Table 6 – Remote Control Output Terminal Block: Pinout

Pin	Signal Description	Signal Type
1	SHUTDOW/TRIP_NO	Isolated Digital Output
2	SHUTDOW/TRIP_COM	Isolated Digital Output
3	WARNING_NO	Isolated Digital Output
4	WARNING_COM	Isolated Digital Output
5	READY_TO_ROTATE_NO	Isolated Digital Output
6	READY_TO_ROTATE_COM	Isolated Digital Output
7	LEVITATED_NO	Isolated Digital Output
8	LEVITATED_COM	Isolated Digital Output
9	ROTATING_NO	Isolated Digital Output
10	ROTATING_COM	Isolated Digital Output
11	PHASE_LOCKED_NO	Isolated Digital Output
12	PHASE_LOCKED_COM	Isolated Digital Output
13	SPARE_OUT_NO	Isolated Digital Output
14	SPARE_OUT_COM	Isolated Digital Output
15	SPARE_OUT_NC	Isolated Digital Output
16	(not connected)	

6.2.3 TB2 – Remote Control Input

The *Remote Control Input* terminal block is used to interlock the controller to a motor drive or to connect it to customer control logic. See Section 5.3 for a detailed description of the signals.

Table 7 – Remote Control Input Terminal Block: Pinout

Pin	Signal Description	Signal Type
1	(not connected)	
2	REMOTE_RUN	Isolated Digital Input
3	REMOTE_RUN_GND	Isolated Digital GND
4	EXTERNAL_FAULT	Isolated Digital Input
5	EXTERNAL_FAULT_GND	Isolated Digital GND
6	TRIP/WARN_RESET	Isolated Digital Input
7	TRIP/WARN_RESET_GND	Isolated Digital GND
8	SPARE_IN	Isolated Digital Input
9	SPARE_IN_GND	Isolated Digital GND
10	(not connected)	

6.2.4 TB3 – AUX EQUIPMENT INTERLOCKS

The *Aux Equipment Interlocks* terminal block is used to interlock the controller to external equipment for fault monitoring. See Section 5.4 for a detailed description of the signals.

TABLE 8 – AUX EQUIPMENT INTERLOCK TERMINAL BLOCK: PINOUT

Pin	Signal Description	Signal Type
1	COOLING_LOSS	Isolated Digital Input
2	COOLING_LOSS_GND	Isolated Digital GND
3	VACUUM_LOSS	Isolated Digital Input
4	VACUUM_LOSS_GND	Isolated Digital GND
5	UPS_FAILURE	Isolated Digital Input
6	UPS_FAILURE_GND	Isolated Digital GND
7	REMOTE_MOTOR_INHIBIT	Isolated Digital Input
8	REMOTE_MOTOR_INHIBIT_GND	Isolated Digital GND

6.2.5 TB4 – ANALOG SIGNALS

The *Analog Signals* terminal block is used to interlock the controller to external equipment for fault monitoring. See Section 5.5 for a detailed description of the signals.

TABLE 9 – ANALOG SIGNALS TERMINAL BLOCK: PINOUT

Pin	Signal Description	Signal Type
1	ANALOG_INTERLOCK_IN	Analog Input
2	ANALOG_INTERLOCK_GND	Analog Input GND
3	ANALOG_IN	Analog Input
4	ANALOG_IN_GND	Analog Input GND
5	ANALOG_OUT	Analog Output
6	ANALOG_OUT_GND	Analog Output GND

6.3 CONNECTOR DESCRIPTIONS

6.3.1 P1 - ETHERNET CONNECTOR

The *Ethernet* connector is used for communicating with the controller via the MBScope™ Software Suite. It is also used for the MODBUS TCP connection.

6.3.2 P2 – USB

The USB connector allows provisions to supply the controller with PVFs, new Firmware, and to capture alarm snapshots. This functionality has not yet been implemented.

6.3.3 P3 – MBRESEARCH™

The *MBReserach™* connector is used to interface with a digital G5 MBResearch™ module.

6.3.4 P5 – MACHINE CABLE

The *Machine Cable* connector is the main interface to the magnetic bearing. It contains sensor information and provides power to the magnetic bearings in the spindle.

6.3.5 P6 – MOTOR

The *Motor* connector is used to provide power to the spindle motor.

6.3.6 P3 – COMM PORT

The *Comm Port* connector is currently not used.

6.3.7 POWER CONNECTOR

The *Power* connector supplies power to the controller. The power requirements are described in Section 0.

6.3.8 CHASSIS GROUND

The *Chassis Ground* lug provides a connection point to securely ground the controller. The lug requires a 1/4" UNC nut.

7. MODBUS/TCP

7.1 OVERVIEW

7.1.1 PURPOSE

A Modbus/TCP interface over the network connection provides the following remote capabilities:

- Run and stop functions
- Clearing of latched shutdowns
- Monitoring of status information
- Modification of select parameters

7.1.2 SPECIFICATION

This document does not define the Modbus specification; however, some factual information related to the Modbus protocol is repeated in this manual. For more complete information on the Modbus protocol, refer to the following documents:

[1] *Modbus Protocol Reference Guide (PI-MBUS-300).*

[2] *Open Modbus/TCP specification; Release 1.0 29 March 1999*

[3] *Modbus Application Protocol Specification V1.1a*

7.1.3 SUPPORTED MODBUS FUNCTIONS

The magnetic bearing controller supports the Modbus functions below.

Function Code	Function Name	Description
03	Read Holding Registers	Modbus standard command
16	Preset Multiple Registers	Modbus standard command

7.1.4 HOLDING REGISTERS

Refer to Section 7.2 for a complete list of holding registers defined for the controller.

VALUES WIDER THAN 16 BIT

Data elements wider than 16 bits are accessed through successive consecutive registers. Values 32 bits wide are stored in a big endian format. For example, the 32bit value 0x12345678L would be transmitted and received in the Modbus packet as 0x12 0x34 0x56 0x78. Floating point values are stored in IEEE-754 format.

An address error will result if only a 16 bit portion of a 32 bit value is read or written.

VALUES SMALLER THAN 16 BIT

Data elements smaller than 16 bits will have the data stored in the lower 8 bits of the response (the upper 8 bits are to be ignored). When writing the register, only the lower 8 bits will be used.

READ AND WRITE ACCESS

Some registers reflect process data, and naturally cannot be written.

7.2 HOLDING REGISTER MAPPING MODBUS_V8

Address	Description	Length [bytes]	Type	Units	Access	Category	Purpose
40077	Global Image Version	32	char		R	Information	This parameter is used to indicate the collective firmware version of the entire system.
40111	Command - Store to Flash SPV	1	uint8		RW	Control	Used to request the command [0=Not Requested, 1=Requested]
40112	Command - Store to Flash DSP	1	uint8		RW	Control	Used to request the command [0=Not Requested, 1=Requested]
40113	Command - Store to Flash AMP	1	uint8		RW	Control	Used to request the command [0=Not Requested, 1=Requested]
40114	Command - Store to Flash MCP	1	uint8		RW	Control	Used to request the command [0=Not Requested, 1=Requested]
40121	Status - Store to Flash SPV	1	uint8		R	Control	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40122	Status - Store to Flash DSP	1	uint8		R	Control	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40123	Status - Store to Flash AMP	1	uint8		R	Control	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40124	Status - Store to Flash MCP	1	uint8		R	Control	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40129	Alarm – DSP HW Watchdog	1	uint8		R	Control	Indicates if there is a DSP HW Watchdog Alarm
40130	Alarm – AMP HW Watchdog	1	uint8		R	Control	Indicates if there is a AMP HW Watchdog Alarm
40131	Alarm – MCP HW Watchdog	1	uint8		R	Control	Indicates if there is a MCP HW Watchdog Alarm
40132	Alarm – SPV SW Watchdog	1	uint8		R	Control	Indicates if there is a SPV SW Watchdog Alarm
40133	Alarm – DSP SW Watchdog	1	uint8		R	Control	Indicates if there is a DSP SW Watchdog Alarm
40134	Alarm – AMP SW Watchdog	1	uint8		R	Control	Indicates if there is a AMP SW Watchdog Alarm
40135	Alarm – MCP SW Watchdog	1	uint8		R	Control	Indicates if there is a MCP SW Watchdog Alarm
40136	Alarm – Radial Oscillator Over Voltage	1	uint8		R	Control	Indicates if there is a Radial Oscillator Over Voltage Alarm
40137	Alarm – Radial Oscillator Under Voltage	1	uint8		R	Control	Indicates if there is a Radial Oscillator Under Voltage Alarm
40138	Alarm – Axial Oscillator Over Voltage	1	uint8		R	Control	Indicates if there is a Axial Oscillator Over Voltage Alarm
40139	Alarm – Axial Oscillator Under Voltage	1	uint8		R	Control	Indicates if there is a Axial Oscillator Under Voltage Alarm
40140	Alarm – Position V13	1	uint8		R	Control	Indicates if there is a Position V13 Alarm
40141	Alarm – Position W13	1	uint8		R	Control	Indicates if there is a Position W13 Alarm
40142	Alarm – Position V24	1	uint8		R	Control	Indicates if there is a Position V24 Alarm
40143	Alarm – Position W24	1	uint8		R	Control	Indicates if there is a Position W24 Alarm
40144	Alarm – Position Z12	1	uint8		R	Control	Indicates if there is a Position Z12 Alarm
40155	Alarm – External Fault	1	uint8		R	Control	Indicates if there is an External Trip Event
40156	Alarm – Controller Temperature	1	uint8		R	Control	Indicates if there is a Controller Temperature Alarm
40160	Alarm – Machine Temperature	1	uint8		R	Control	Indicates if there is a Machine Temperature Alarm
40161	Alarm – Digital Bus Over Voltage	1	uint8		R	Control	Indicates if the controller has detected an over voltage on the internal digital bus
40162	Alarm – Digital Bus Under Voltage	1	uint8		R	Control	Indicates if the controller has detected an under voltage on the internal digital bus
40163	Alarm – Analog Bus Over Voltage	1	uint8		R	Control	Indicates if the controller has detected an over voltage on the internal analog bus
40164	Alarm – Analog Bus Under Voltage	1	uint8		R	Control	Indicates if the controller has detected an under voltage on the internal analog bus
40165	Alarm – Bearing Amplifier Bus Over Voltage	1	uint8		R	Control	Indicates if the controller has detected an over voltage on the internal bearing amplifier bus
40166	Alarm – Bearing Amplifier Bus Under Voltage	1	uint8		R	Control	Indicates if the controller has detected an under voltage on the internal bearing amplifier bus
40167	Alarm – Motor Bus Over Voltage	1	uint8		R	Control	Indicates if the controller has detected an over voltage on the internal motor bus
40168	Alarm – Motor Bus Under Voltage	1	uint8		R	Control	Indicates if the controller has detected an under voltage on the internal motor bus
40169	Alarm – Motor Bus Over Current	1	uint8		R	Control	Indicates if the controller has detected an over voltage on the internal motor bus
40171	Alarm – Overspeed	1	uint8		R	Control	Indicates if the controller has detected an overspeed event
40172	Alarm – Speed Sensor	1	uint8		R	Control	Indicates if the controller has detected a speed sensor failure event
40173	Alarm – Brake Failure	1	uint8		R	Control	Indicates if the controller has detected a motor braking failure
40174	Alarm – Rotation without Levitation – DSP	1	uint8		R	Control	Indicates if the controller DSP has detected rotation without levitation
40175	Alarm – Rotation without Levitation – SPV	1	uint8		R	Control	Indicates if the controller SPV has detected rotation without levitation
40176	Alarm – Rotation Lockout	1	uint8		R	Control	Indicates if the controller hardware has detected rotation without levitation
40177	Alarm – Interlock: PSU	1	uint8		R	Control	Indicates if an internal interlock with the power supply has tripped
40178	Alarm – Interlock: UPS	1	uint8		R	Control	Indicates if an external UPS interlock has triggered
40179	Alarm – Interlock: Vacuum	1	uint8		R	Control	Indicates if an external Vacuum interlock has triggered
40180	Alarm – Interlock: Cooling	1	uint8		R	Control	Indicates if an external Cooling interlock has triggered
40181	Alarm – Interlock: Analog	1	uint8		R	Control	Indicates if an external Analog interlock has triggered
40182	Alarm – Short Circuit V13	1	uint8		R	Control	Indicates if a short circuit was detected on the V1 or V3 amplifier
40183	Alarm – Short Circuit W13	1	uint8		R	Control	Indicates if a short circuit was detected on the W1 or W3 amplifier
40184	Alarm – Short Circuit V24	1	uint8		R	Control	Indicates if a short circuit was detected on the V2 or V4 amplifier

40185	Alarm – Short Circuit W24	1	uint8		R	Control	Indicates if a short circuit was detected on the W2 or W4 amplifier
40186	Alarm – Short Circuit Z12	1	uint8		R	Control	Indicates if a short circuit was detected on the Z1 or Z2 amplifier
40187	Alarm – Current Over Max Command V1	1	uint8		R	Control	Indicates if the current in the V1 bearing is over the maximum command
40188	Alarm – Current Over Max Command V2	1	uint8		R	Control	Indicates if the current in the V2 bearing is over the maximum command
40189	Alarm – Current Over Max Command V3	1	uint8		R	Control	Indicates if the current in the V3 bearing is over the maximum command
40190	Alarm – Current Over Max Command V4	1	uint8		R	Control	Indicates if the current in the V4 bearing is over the maximum command
40191	Alarm – Current Over Max Command W1	1	uint8		R	Control	Indicates if the current in the W1 bearing is over the maximum command
40192	Alarm – Current Over Max Command W2	1	uint8		R	Control	Indicates if the current in the W2 bearing is over the maximum command
40193	Alarm – Current Over Max Command W3	1	uint8		R	Control	Indicates if the current in the W3 bearing is over the maximum command
40194	Alarm – Current Over Max Command W4	1	uint8		R	Control	Indicates if the current in the W4 bearing is over the maximum command
40195	Alarm – Current Over Max Command Z1	1	uint8		R	Control	Indicates if the current in the Z1 bearing is over the maximum command
40196	Alarm – Current Over Max Command Z2	1	uint8		R	Control	Indicates if the current in the Z2 bearing is over the maximum command
40197	Alarm – Energy Limit V1	1	uint8		R	Control	Indicates if the energy in the V1 bearing is over the limit
40198	Alarm – Energy Limit V2	1	uint8		R	Control	Indicates if the energy in the V2 bearing is over the limit
40199	Alarm – Energy Limit V3	1	uint8		R	Control	Indicates if the energy in the V3 bearing is over the limit
40200	Alarm – Energy Limit V4	1	uint8		R	Control	Indicates if the energy in the V4 bearing is over the limit
40201	Alarm – Energy Limit W1	1	uint8		R	Control	Indicates if the energy in the W1 bearing is over the limit
40202	Alarm – Energy Limit W2	1	uint8		R	Control	Indicates if the energy in the W2 bearing is over the limit
40203	Alarm – Energy Limit W3	1	uint8		R	Control	Indicates if the energy in the W3 bearing is over the limit
40204	Alarm – Energy Limit W4	1	uint8		R	Control	Indicates if the energy in the W4 bearing is over the limit
40205	Alarm – Energy Limit Z1	1	uint8		R	Control	Indicates if the energy in the Z1 bearing is over the limit
40206	Alarm – Energy Limit Z2	1	uint8		R	Control	Indicates if the energy in the Z2 bearing is over the limit
40207	Alarm – Current Limit V1	1	uint8		R	Control	Indicates if the current in the V1 bearing is over the limit
40208	Alarm – Current Limit V2	1	uint8		R	Control	Indicates if the current in the V2 bearing is over the limit
40209	Alarm – Current Limit V3	1	uint8		R	Control	Indicates if the current in the V3 bearing is over the limit
40210	Alarm – Current Limit V4	1	uint8		R	Control	Indicates if the current in the V4 bearing is over the limit
40211	Alarm – Current Limit W1	1	uint8		R	Control	Indicates if the current in the W1 bearing is over the limit
40212	Alarm – Current Limit W2	1	uint8		R	Control	Indicates if the current in the W2 bearing is over the limit
40213	Alarm – Current Limit W3	1	uint8		R	Control	Indicates if the current in the W3 bearing is over the limit
40214	Alarm – Current Limit W4	1	uint8		R	Control	Indicates if the current in the W4 bearing is over the limit
40215	Alarm – Current Limit Z1	1	uint8		R	Control	Indicates if the current in the Z1 bearing is over the limit
40216	Alarm – Current Limit Z2	1	uint8		R	Control	Indicates if the current in the Z2 bearing is over the limit
40217	Alarm – Communication DSP	1	uint8		R	Control	Indicates if there is communication issues to the DSP
40218	Alarm – Communication AMP	1	uint8		R	Control	Indicates if there is communication issues to the AMP
40219	Alarm – Communication MCP	1	uint8		R	Control	Indicates if there is communication issues to the MCP
40220	Alarm – Communication DPRAM	1	uint8		R	Control	Indicates if there is communication issues between the DSP and AMP
40231	Alarm – Ref Loss	1	uint8		R	Control	Indicates if the system has detected a that the reference signal is not available
40232	Alarm – Timebase DSP	1	uint8		R	Control	Indicates if the timebase of the DSP is out of sync
40233	Alarm – Timebase MCP	1	uint8		R	Control	Indicates if the timebase of the MCP is out of sync
40234	Alarm – Timebase AMP	1	uint8		R	Control	Indicates if the timebase of the AMP is out of sync
40240	Alarm Level	1	uint8		R	Control	Indicates the current Alarm Level of the system [0=No Alarm, 1=Warning, 2=Trip, 3=Trip Plus]
40241	Real Time Clock – Year	1	uint16		RW	Setup	The Time/Date of the system
40242	Real Time Clock – Month	1	uint16		RW	Setup	The Time/Date of the system [Valid Values: 1-12]
40243	Real Time Clock – Day	1	uint16		RW	Setup	The Time/Date of the system [Valid Values: 1-31; No check on invalid day/month combo]
40244	Real Time Clock – Time	1	uint32		RW	Setup	The Time/Date of the system (in seconds since midnight) [Valid Values: 0-86399]
40336	Motor Temperature	1	float32	degrees C	R	Status	Motor Temperature
40338	TDC Delay	1	float32	degrees	RW	Motor Control	Gets or sets the TDC Delay parameter
40340	Disk Angular Alignment	1	float32	degrees	RW	Setup	Gets or sets the angular alignment of the disk in relation to the TDC
40342	Max Speed	1	float32	Hz	RW	Setup	Gets or sets the maximum speed of the system
40344	Min Speed	1	float32	Hz	RW	Setup	Gets or sets the minimum speed of the system
40346	Run Speed Setpoint	1	float32	Hz	RW	Motor Control	Gets or sets the run speed setpoint of the system
40348	Rotation Direction	1	int16		RW	Motor Control	Gets or sets the direction of rotation [0=Direction A, 1=Direction B]
40349	Motor Control Mode	1	int16		RW	Motor Control	Gets or sets the motor control mode [0=Speed Control,1=Phase Control]
40350	Motor Kp	1	float32		RW	Motor Control	Gets or sets the motor control proportional gain parameter
40352	Motor Ki	1	float32		RW	Motor Control	Gets or sets the motor control integral gain parameter
40354	Run Speed	1	float32	Hz	R	Status	Gets the current rotational speed of the system

40356	Reference In Period	1	float32	s	RW	Motor Control	Gets or sets the Reference In period
40358	Reference Out Period	1	float32	s	RW	Motor Control	Gets or sets the Reference Out period
40361	Veto Window	1	Uint32	ns	RW	Motor Control	Gets or sets the Veto Window
40363	Reference Delay	1	Uint32	ns	RW	Motor Control	Gets or sets the Reference Delay
40366	Motor Kphase	1	float32		RW	Motor Control	Gets or sets the motor control phase gain parameter
40368	Stats – Phase OK	1	float32	%	R	Status	Gets the Phase OK status
40370	Stats – Phase Efficiency	1	float32	%	R	Status	Gets the Phase Efficiency
40372	Stats – Phase Accuracy	1	float32	s	R	Status	Gets the Phase Accuracy
40374	Stats – Phase Repeatability	1	float32	s	R	Status	Gets the Phase Repeatability
40376	Stats – Veto Counts	1	uint32		R	Status	Gets the Veto Count
40378	Stats – Non-Veto Counts	1	uint32		R	Status	Gets the Non-Veto Count
40380	Home Angle Setpoint	1	float32	Degrees	RW	Motor Control	Gets or sets the parking angle setpoint
40382	Home Kp	1	float32		RW	Motor Control	Gets or sets the Home Kp parameter
40384	Home Ki	1	float32		RW	Motor Control	Gets or sets the Home Ki parameter
40386	Home Kd	1	float32		RW	Motor Control	Gets or sets the Home Kd parameter
40388	Home Angle	1	uint16	1/100 degrees	R	Status	Gets the rotational angle of the shaft
40389	Command - Modbus Run On	1	uint8		RW	Motor Control	Used to request the command [0=Not Requested, 1=Requested]
40390	Command - Modbus Run Off	1	uint8		RW	Motor Control	Used to request the command [0=Not Requested, 1=Requested]
40391	Command - Coast On Command	1	uint8		RW	Motor Control	Used to request the command [0=Not Requested, 1=Requested]
40392	Command - Coast Off Command	1	uint8		RW	Motor Control	Used to request the command [0=Not Requested, 1=Requested]
40393	Command - Modbus Clear Alarms	1	uint8		RW	Control	Used to request the command [0=Not Requested, 1=Requested]
40394	Command – Clear Veto Counts	1	uint8		RW	Control	Used to request the command [0=Not Requested, 1=Requested]
40395	Command - Modbus Control Request	1	uint8		RW	Control	Used to request the control of parameter editing when system is in request mode. Send '0' to allow other systems to take control. [0=Release Modbus control, 1=Requested]
40403	Command Processing Status – Modbus Run On	1	uint8		R	Motor Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40404	Command Processing Status – Modbus Run Off	1	uint8		R	Motor Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40405	Command Processing Status – Hardwire Run On	1	uint8		R	Motor Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40406	Command Processing Status – Hardwire Run Off	1	uint8		R	Motor Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40407	Command Processing Status – MBScope Run On	1	uint8		R	Motor Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40408	Command Processing Status – MBScope Run Off	1	uint8		R	Motor Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40409	Command Processing Status – Local Run On	1	uint8		R	Motor Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40410	Command Processing Status – Local Run Off	1	uint8		R	Motor Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40411	Command Processing Status – Test Mode On	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40412	Command Processing Status – Test Mode Off	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40413	Command Processing Status – Coast On	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40414	Command Processing Status – Coast Off	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40415	Command Processing Status – Modbus Clear Alarms	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40416	Command Processing Status – Hardwire Clear Alarms	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40417	Command Processing Status – MBScope Clear Alarms	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40418	Command Processing Status – Local Clear Alarms	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]

40419	Command Processing Status – Reset Veto Counter	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40420	Command Processing Status – Store to Flash SPV	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40421	Command Processing Status – Store to Flash DSP	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40422	Command Processing Status – Store to Flash AMP	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40423	Command Processing Status – Store to Flash MCP	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40428	Command Processing Status – Modbus Request Control	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40429	Command Processing Status – MBScope Request Control	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40430	Command Processing Status – Hardwire Request Control	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40431	Command Processing Status – Local Request Control	1	uint8		R	Control	Indicates the status of the command [0 = Not Requested, 1 = State Not Ready, 2 = Protection Not Ready, 3 = Device Not Ready, 4 = Processing, 5 = Done, 6 = Failed]
40438	Status – Modbus Run	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40439	Status – Hardwire Run	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40440	Status – MBScope Run	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40441	Status – Local Run	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40442	Status – Test Mode	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40443	Status – Coast	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40444	Status – Modbus Clear Alarms	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40445	Status – Hardwire Clear Alarms	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40446	Status – MBScope Clear Alarms	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40447	Status – Local Clear Alarms	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40448	Status – Clear Veto Counts	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40453	Status – Modbus Request Control	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40454	Status – MBScope Request Control	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40455	Status – Hardwire Request Control	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40456	Status – Local Request Control	1	uint8		R	Status	Indicates the status of the operation [0=Unknown, 1=Not Completed, 2=Completed 3=Off, 4=On]
40457	Time Controller Powered On	4	uint32	s	R	Status	Total seconds that the controller has been powered on.
40459	Time System Levitated	4	uint32	s	R	Status	Total seconds that the controller has been Levitated.
40461	Time System Rotated	4	uint32	s	R	Status	Total seconds that the controller has been Rotating.
40463	System State	2	uint16		R	Status	Current System State. State values: 0 = Invalid 1 = Power Up 2 = Standby 3 = Idle 4 = Deleving 5 = Levitation 6 = Starting 7 = Stopping 8 = Coast 9 = Rotation 10 = Levitated 11 = Rotating

40466	Alarm – Motor Inhibit	1	uint8		R	Control	Indicates if there is a Motor Inhibit Alarm (Red front panel button)
40467	Alarm – Remote Motor Inhibit	1	uint8		R	Control	Indicates if there is a Motor Inhibit Alarm (Digital I/O on back panel)
40468	Alarm - Brake Resistor Failure	1	uint8		R	Control	Gets the brake resistor failure alarm status (active high).
40469	Alarm – MBResearch Communication	1	uint8		R	Control	Gets the MBResearch communication failure alarm status (active high).
40470	Alarm - I2C DSP Communication	1	uint8		R	Control	Gets the I2C DSP communication failure alarm status (active high).
40472	Consolidated Status – Veto Counts	4	uint32		R	Status	Gets the Veto Count (this data is also available at address 40376).
40474	Consolidated Status – Phase Accuracy	4	float32		R	Status	Gets the Phase Accuracy (this data is also available at address 40372).
40476	Consolidated Status –Phase Repeatability	4	float32		R	Status	Gets the Phase Repeatability (this data is also available at address 40374).
40478	Consolidated Status – Speed	2	uint16	1/10th Hz	R	Status	Gets the rotor speed.
40479	Consolidated Status – Status Register	2	register		R	Status	Controller status register with the following mapping: Bit 0 – Warning Detected (Active High) Bit 1 – Trip Detected (Active High) Bit 2 – Levitation Detected (Active High) Bit 3 – Rotation Detected (Active High) Bit 4 – Up To Speed (Active High) Bit 5 – Phase Locked (Active High) Bit 6 – Phase Slave (0 = Master, 1 = Slave) Bit 7 – Phase nRPM (0 = RPM, 1 = Phase) Bit 8 – Direction (0 = CW on Front Panel, 1 = CCW on front panel)
40482	Veto Window	4	float32	degrees	RW	Motor Control	Window of acceptable phase, represented as a +/- margin of error around the target phase
40484	Reference Delay	4	float32	degrees	RW	Motor Control	Parameter for chopper-type machines allowing adjustment of rotational phase delay with respect to the active edge of the reference input pulse measured in degrees
40488	Alarm - Motor Inhibit Warning	1	uint8		R	Control	Gets the warning level motor inhibit alarm status (active high)

8. EVENTS CAUSING WARNING / TRIP

8.1 OVERVIEW

A shutdown occurs when a physical system parameter exceeds preset limits, or when a control system failure occurs.

The control system includes self-protection functions based on the permanent control of the following parameters:

- Position of the shaft in five axes
- Output current from each of the 10 power amplifiers
- Rotor rotation
- Temperature of the motor
- Temperature of the controller
- DSP-microprocessor communication.

When any shutdown occurs, these events occur:

- The *Alarm Indicator* on the front panel illuminates
- An error message is displayed on the main screen of the LCD and is added to the shutdown log.
- The shutdown and run relay contacts open

Other shutdown actions vary based on shutdown source.

8.2 ALARM LEVELS

The MBC system is internally protected. It provides various alarm conditions and controls all the protective measures. In the event of a malfunction, the MBC system generates an alarm signal.

There are two levels of alarm:

- ALARM LEVEL 1 – WARNING (Minor Malfunction):

  If normal operating parameters are exceeded, or if a minor malfunction occurs, the system generates a 'Warning Event'.

  The MBC continues to operate.

  The MBC does not request a machine shut-down.

  This alarm will open the 'WARNING' relay contact (refer to section 5.2.2)

- ALARM LEVEL 2 – TRIP (Major Malfunction):

  If alarm parameters are exceeded, or if a major malfunction occurs, the system generates a 'Trip Event'.

  The system is no longer operating within the design specification. Continued operation may cause damage to the machine, and the MBC begins the shutdown procedure.

  Unless otherwise specified in the following alarm list, the motor will actively brake the system to slow the system as quickly as possible. When the system is no longer rotating, it will delevitate.

  This alarm will open the 'SHUTDOWN/TRIP' relay (refer to section 5.2.1)

8.3 ALARM EVENTS DESCRIPTIONS

The following section describes all of the alarms that may occur.

8.3.1 ROTOR POSITION ALARM

Description:

The rotor position is measured from a set of radial and axial position sensors providing 4 radial position and 1 axial position feedback signals.

Once the levitation is activated (whether the rotor is spinning or at standstill), the MBC supervising system samples the peak value of these 5 rotor positions according to some programmable time window and compares them to predefined alarm thresholds.

5 separate rotor position alarms are defined with respect to the 5 axes being controlled: V13, W13, V24, W24 and Z12.

These alarms fall into a warning or failure category based on the position amplitude level.

Conditions / Actions:

The alarm may occur in the following operation modes:

- Levitation
- Rotation

The alarm may generate either a Warning or Trip alarm.

Criteria:

Warning set criteria: at least 7* out of 10* peak position samples exceed the warning threshold within a 1* sec time window**.**

Trip set criteria: at least 7* out of 10* peak position samples exceed the failure threshold within a 1* sec time window**.**

- Peak positions are synchronously sampled every 0.1 sec,
- * Adjustable/programmable thresholds

Possible causes of the alarm	Recommended course of action
High rotor unbalance	Perform balancing (Section 3.6.6)
1) Unsteady/unstable process conditions causing bearing overload and high rotor excursion 2) Spurious spike on rotor position signal leading to false position alarm 3) EMC perturbation of position feedback signals 4) Tuning of bearing controls not adapted to current process conditions	1) Review process conditions to eliminate high dynamic transient conditions. 2) Verify wiring, cable and connectors for any loose electrical contacts. 3) Verify shielding connections and eliminate ground loop. 4) Contact SKF service to discuss process conditions and possible adaptation of bearing tuning parameters.
Is position alarm still active when machine is stopped and not rotating? 1-Shaft is not free to "float" (due to foreign element jammed in airgap)	1) Check ball bearing clearance → if not OK perform mechanical and visual inspection of the machine internals.

2-Failure or wear of back-up bearing 3-Failure of one position sensor 4-Failure of one bearing coil 5-Wiring failure	2) Check ball bearing clearance → if not OK, replace back-up bearings. 3) Check the impedance and insulation with respect to ground of the position sensor coils. 4) Check the impedance and insulation with respect to ground of the bearing coils. 5) Check cable(s) for loose connection, ground fault, shorted or damaged wires.

8.3.2 SURGE (LOW FREQUENCY POSITION) ALARM

Not Used with Choppers, Due to vacuum operation there are no process loads and the position alarms catch any disturbances.

-

8.3.3 ROTOR UNBALANCE ALARM

Not Used with Choppers, Due to vacuum operation there are no process loads and the position alarms catch any disturbances.

8.3.4 SPEED SENSOR ALARM

Description:

This alarm is based on the information from the TDC sensor, and indicates if there is any fault detected with the sensor, or rotational speed detection.

Conditions / Actions:

The alarm may occur in the following operation modes:

- Rotation

The alarm will generate a Trip alarm. ***NOTE:*** This alarm will cause the system to enter COAST mode.

Criteria:

When rotation mode has been enabled and one of the following conditions exist:

- Rotation startup is requested, but has not been detected within a short time period
- Rotation is occurring, but suddenly is no longer detected
- The levitation controller and the rotation controller do not agree on the rotational speed

Possible causes of the alarm	Recommended course of action
The motor drive started with delay and/or failed to accelerate the shaft above a speed threshold within the programmed time delay	Check the timing of the startup sequence Check that rotation of the shaft is not impeded Check Vhall Settings for resolver and TDC
Speed sensor is disconnected	Check the wiring of the speed signal from the source up to the MBC.

8.3.5 OVERSPEED ALARM

Description:

The MBC requires and uses a one pulse per revolution feedback signal to measure and monitor the rotor speed (without consideration of the direction of rotation).

This speed signal is processed in the MBC to measure the frequency of rotation and is compared to a predefined overspeed threshold.

Conditions / Actions:

The alarm may occur in all operating modes.

The alarm will generate a Trip alarm. ***NOTE:*** This alarm will cause the system to enter COAST mode.

Criteria:

One of the following conditions exist:

- The detected rotational speed is beyond the predefined overspeed threshold

Possible causes of the alarm	Recommended course of action

The unit speed has really exceeded the overspeed threshold.	Check the motor tuning and TDC calibration parameters; reload the parameters if necessary
Corrupted speed signal by pollution and/or disturbance of the speed feedback signal.	Check: – the speed displayed – the speed measurement (speed signal or electronic circuit of speed signal) – the speed setpoint

8.3.1 BRAKE FAILURE ALARM

Description:

The intended purpose of this alarm is to detect if the rotor is accelerating when it has been commanded to decelerate. If this alarm is detected, the motor assumes it is no longer able to control the rotational speed.

Conditions / Actions:

The alarm may occur in the following operation modes:

- Controller Rotation, Motor Stopping

The alarm will generate a Trip alarm. ***NOTE:*** This alarm will cause the motor to be inhibited.

Criteria:

The rotor accelerates when commanded to decelerate

Possible causes of the alarm	Recommended course of action
Motor tuning parameters are incorrect	Check the motor tuning and TDC calibration parameters; reload the parameters if necessary
Corrupted speed signal by pollution and/or disturbance of the speed feedback signal.	Check: – the speed displayed – the speed measurement (speed signal or electronic circuit of speed signal) – the speed setpoint
Motor wiring is incorrect	Check the motor wiring, specifically for swapped phases

8.3.2 AMP, DSP, MCP, DPRAM COMMUNICATION ALARM

Description:

The MBC operation is based on communication over an internal CAN bus between the "supervising" microcontroller and three DSP processors (one bearing amplifier DSP, one levitation control DSP, and one motor control DSP). A built-in logic triggers a failure when the supervising microcontroller receives an accumulated number of non-valid answers from any DSP processors.

Conditions / Actions:

The alarm may occur in all operating modes.

The alarm will generate a Trip alarm.

Criteria:

The event will be triggered if the supervising microcontroller has received more than 20* consecutive non-valid responses from the DSP

- * Adjustable/programmable thresholds

Possible causes of the alarm	Recommended course of action
Corrupted data caused erratic operation of Microcontroller or DSP processor software.	Cycle power off and on to the MBC in order to reinitialize the DSP processor. - Verify that power supply voltages are within proper range, - Verify that all EMC shielding is properly terminated.
Firmware is invalid	Reload last known working firmware version

8.3.3 AMP, DSP, MCP, SPV WATCHDOG ALARM

Description:

The activity of the bearing amplifier, levitation, and motor controllers are supervised thanks to a watchdog circuit that must receive at regular time interval a timer reset pulse from each one of the processor. The absence of reception of such "timer reset pulse" resets the processors and restarts normal activity. This action is monitored and indicates abnormal activity.

Conditions / Actions:

The alarm may occur in all operating modes.

The alarm will generate a Trip alarm.

Criteria:

The control system has failed to pulse the watchdog hardware in due time.

Possible causes of the alarm	Recommended course of action
Corrupted data caused erratic operation of Microcontroller or DSP processor software.	Cycle power off and on to the MBC in order to reinitialize the DSP processor. - Verify that power supply voltages are within proper range, - Verify that all EMC shieldings are properly terminated.
Firmware is invalid	Reload last known working firmware version

8.3.4 OSCILLATOR FAILURE ALARM

Description:

The oscillator is used to drive the position, resolver, and TDC sensors. It is an essential component of the magnetic bearing system, and improper operation (levitation and rotation) can result if this failure is active.

Conditions / Actions:

The alarm may occur in all operating modes.

The alarm will generate a Trip alarm.

Criteria:

There are four alarms that may be triggered:

- Radial oscillator over voltage
- Radial oscillator under voltage
- Axial oscillator over voltage
- Axial oscillator under voltage

The event will be triggered if the voltage has exceeded the predefined threshold value.

Possible causes of the alarm	Recommended course of action
One or several cables between the oscillator and the position sensors are disconnected.	Check the wiring.
Short or open circuit on one position sensor coil.	Check the impedance of sensors.
Dip Switch (internal to the controller) are not set correctly	Contact SKF for proper settings. See Section (2.5)
Oscillator is over heating	Verify that the fans on the front of the controller are operational, and that a Controller Temperature Alarm is not active.

8.3.5 COMMAND LIMIT ALARM

Description:

During normal operation, the command from the rotor position control loop to the amplifier is a signal that will vary between 0% and 100%, but this command is allowed to exceed 100% (typically during dynamic brief transient) to achieve faster bearing response.

The command limit alarm is intended to detect and protect the system against instances where the command would exceed the 100% threshold for quite a long time (that is for time in the 10 to 60 second range), indicative of an abnormal lasting overload condition.

10 different command limit alarms are defined with respect to the 10 amplifier channels (V1-V3-W1-W3-V2-V4-W2-W4-Z1-Z2).

This command limit alarm can typically be followed by a current limit alarm, which is another indication of an abnormal overload situation.

Conditions / Actions:

The alarm may occur in the following operation modes:

- Levitation
- Rotation

The alarm will generate a Warning alarm only.

Criteria:

The amplifier command level on one of the amplifier channel has exceeded the predefined threshold.

Possible causes of the alarm	Recommended course of action
Process excitation (like Surge condition) during levitation or rotation.	Check the shaft unbalance. Clean the rotating component. Check for any unusual dynamic load coming from the process. Check that the failure can be cleared when the machine is stopped.
Short circuit condition.	Check the wiring.

8.3.6 CURRENT LIMIT ALARM

Description:

Each amplifier channel, digitally controlled and allowed to operate from 0 to 150% of its rated range without any limitation, has a built-in active current limitation mode to prevent the current from exceeding this 150% range and to protect the amplifier hardware from uncontrolled over-current situation.

Note: This active limitation scheme will limit (or clamp) the current peak but will not switch off the current.

The current limit alarms are designed to detect and signal when the amplifier has entered into the current limitation mode, indicative of an abnormal overload situation.

10 different command limit alarms are defined with respect to the 10 amplifier

channels (V1-V3-W1-W3-V2-V4-W2-W4-Z1-Z2).

Conditions / Actions:

The alarm may occur in the following operation modes:

- Levitation
- Rotation

The alarm will generate a Warning alarm only.

Criteria:

Instantaneous current has reached the 1st or 2nd threshold where the current limitation is activated.

Possible causes of the alarm	Recommended course of action
Process excitation (i.e surge or stall condition) during rotation.	Check for any unusual dynamic load coming from the process. Check that the failure can be cleared when the machine is stopped.
Short circuit condition.	Check the wiring.

8.3.7 HARD OVERCURRENT ALARM

Description:

The amplifier channels are equipped by pair with a hardware over-current fast acting protection, separate from the digital controls (intended typically as protection against load short-circuits).

When the hardware over-current level is reached, to avoid any hardware damage to the amplifier, the pair of channels is disabled for a very brief moment and the current flowing though the amplifier and to the bearing coil is interrupted. After a short time delay, the pair of amplifier is automatically re-enabled (automatic retry).

5 different hardware over-current limits are defined with respect to the 5 pairs of amplifier channels (V1V3 / W1W3 / V2V4 / W32W4 / Z1Z2).

Conditions / Actions:

The alarm may occur in the following operation modes:

- Levitation
- Rotation

The alarm will generate a Warning alarm only.

Criteria:

Instantaneous current has reached the hardware threshold.

Possible causes of the alarm	Recommended course of action
Short circuit to ground condition or turn to turn short circuit.	Check the wiring.
Reverse polarity of two adjacent or opposite coils.	Check the wiring.

8.3.8 ENERGY LIMITATION ALARM

Description:

This alarm is intended as an internal protection of the power amplifier against lasting overload. It is based on the monitoring of the cumulative summation of the current over time (which is an image of the energy being delivered by the amplifier channel).

When the energy threshold is reached, to avoid any hardware damage to the amplifier, the channel is automatically current limited to 100%. After a short time delay, the amplifier channel is automatically enabled (automatic retry) and the amplifier channel resumes normal operation.

This Energy warning typically does not occur alone and is most of the time accompanied with other amplifier alarms such as Command limit, Current limit, and Hard Overcurrent alarms.

Conditions / Actions:

The alarm may occur in the following operation modes:

- Levitation
- Rotation

The alarm will generate a Warning alarm only.

Criteria:

Energy level on the channel has reached the predefined threshold.

Possible causes of the alarm	Recommended course of action
Process excitation (i.e surge or stall condition) during rotation.	Check for any unusual dynamic load coming from the process. Check that the failure can be cleared when the machine is stopped.

8.3.9 CONTROLLER OVER-TEMP ALARM

Description:

The controller has a temperature sensor that monitors the internal heatsink. The controller temperature must be at an adequate level to avoid damage to the bearing amplifier and the motor drive.

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm may generate a Warning or Trip alarm.

Criteria:

Warning set criteria: controller temperature has exceeded the trip threshold (typically 60°C), set by SKF.

Trip set criteria: controller temperature has exceeded the trip threshold (typically 70°C), set by SKF.

Possible causes of the alarm	Recommended course of action
The controller is overheating; the heatsink is not properly cooled	Check the ambient temperature Check that the middle fan is always on

	Check that all fans are turned on when the temperature is over 40°C
Bearing or motor amplifier failure causes excessive heat loss	Contact SKF for replacement components
Temperature sensor failure.	Contact SKF for replacement components

8.3.10 MOTOR OVER-TEMP ALARM

Description:

The motor has an RTD style temperature sensor to measure the temperature of the spindle. The motor is typically one of the warmest components of the spindle.

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm may generate a Warning or Trip alarm.

Criteria:

Warning set criteria: motor temperature has exceeded the warning threshold*, set by the user (see section 3.4.13).

Trip set criteria: motor temperature has exceeded the trip threshold (typically 80°C), set by SKF.

- * Adjustable/programmable threshold

Possible causes of the alarm	Recommended course of action
The spindle is being incorrectly cooled.	Reduce temperature of spindle
Excessive Acceleration	Lower the Motor current limits, allow time for heat to dissipate between acceleration \ deceleration runs
Bearings generate excessive heat loss (due to current overload).	Balance the process load to reduce bearing current.
Faulty wiring between the motor temperature sensor and controller.	Check the connectors and the wiring of the machine.
Motor temperature sensor failure.	Check the machine temperature sensor.

8.3.11 POWER, ANALOG, NUMERIC, MOTOR BUS VOLTAGE ALARM

Description:

Monitors the internal bus voltages.

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm will generate a Trip alarm.

Criteria:

There are several alarms that may be triggered:

- Bearing amplifier bus over voltage
- Bearing amplifier bus under voltage
- Motor amplifier bus over voltage

- Motor amplifier bus under voltage
- Numeric bus over voltage
- Numeric bus under voltage
- Analog bus over voltage
- Analog bus under voltage

The event will be triggered if the voltage has exceeded the predefined threshold value.

Possible causes of the alarm	Recommended course of action
Open MBScope monitoring panel and verify the value displayed for 'Voltages' for troubleshooting actions	
If the Bearing or Motor bus is out of range and is displayed as red: 1) Bad connection between the external input supply and the internal PSU 2) Internal PSU is out of range (high) 3) Internal PSU is out of range (low) - Bearing transient reactions to severe process transients and/or excitation causes peak of in-rush current.	1) Check the connection to the mains input supply on the rear of the controller. 2) Check that the value is reading high when the machine is stopped and delevitated. Contact SKF for additional steps 3) Correct process conditions to avoid process transient conditions.
If the Bearing or Motor bus is out of range and is displayed as green	Reset and reinitialize the MBC. If unsuccessful, reload the MBC parameter files.
If other voltage are displayed as red or green	Reset and reinitialize the MBC. If unsuccessful, reload the MBC parameter files.

8.3.12 Checksum Alarm

Not Used with Choppers

8.3.1 DSP, MCP, AMP Timebase Alarm

Not Used with Choppers

8.3.1 Motor Bus Overcurrent Alarm

Description:

Monitors the internal motor bus current.

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm will generate a Trip alarm.

Criteria:

Warning set criteria: motor bus current has exceeded the warning threshold.

Trip set criteria: motor bus current has exceeded the trip threshold.

Possible causes of the alarm	Recommended course of action
Open MBScope monitoring panel and verify the value displayed for 'Motor Current' for troubleshooting actions	

The motor bus current is not reading correctly	Reset and reinitialize the MBC. If unsuccessful, reload the MBC parameter files.

8.3.2 INTERLOCK PSU ALARM

Description:

This alarm is triggered by the internal power supply unit (PSU). This failure indicates that there is something wrong with the internal power supply and action should be taken immediately to correct it.

The internal power supply is comprised of two power units. If one unit fails, the system may continue to operate so that it can safely shut down.

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm will generate a Trip alarm.

Criteria:

This alarm can become active because of the following PSU failures:

- PSU Fan Failure
- Line supply under or over voltage
- Single PSU failure (one of the two power units has failed)

Possible causes of the alarm	Recommended course of action
Line supply under or over voltage	Check the line voltage supplied to the controller
PSU Fan Failure Single PSU Failure	The power unit requires replacement

8.3.1 INTERLOCK UPS, VACUUM, COOLING ALARM

Description:

These alarms are triggered by the digital inputs on the back of the controller (refer to section 5.4).

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm will generate a Trip alarm.

Criteria:

Triggers when the digital input has been asserted.

Possible causes of the alarm	Recommended course of action
The digital input is asserted	De-assert the digital input

8.3.1 ANALOG INTERLOCK ALARM

Description:

This alarm is triggered by the analog inputs on the back of the controller (refer to section 5.5.1).

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm may generate a Warning or Trip alarm.

Criteria:

Warning set criteria: motor bus current has exceeded the warning threshold*.

Trip set criteria: motor bus current has exceeded the trip threshold*.

* Adjustable/programmable threshold by the user (refer to section 3.4.12)

Possible causes of the alarm	Recommended course of action
The analog input is beyond the threshold	Correct the action that the analog interlock is detecting

8.3.2 MOTOR INHIBIT, REMOTE MOTOR INHIBIT ALARM

Description:

These alarms are triggered by user action, either by the red Motor Inhibit button on the front panel, or by the digital input on the back of the controller (refer to section 5.4.4).

This alarm will cause the motor drive to inhibit and to put no further rotational energy into the rotor. Drag on the rotor will cause it to slow down. This alarm is latched as a warning, so the system will resume normal operation as soon as it is cleared.

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm will generate a Warning alarm by default, set by SKF.

The Motor is disconnected and the system will coast to a stop.

Criteria:

Triggers when the front panel Motor Inhibit button is pressed, or if the digital input has been asserted.

Possible causes of the alarm	Recommended course of action
Front panel Motor Inhibit button has been pressed	Reset the button
The digital input is asserted	De-assert the digital input

8.3.3 EXTERNAL FAULT ALARM

Description:

This alarm is triggered by the digital input on the back of the controller (refer to section 5.3.2).

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm will generate a Trip alarm.

Criteria:

Triggers when the digital input has been asserted.

Possible causes of the alarm	Recommended course of action
The digital input is asserted	De-assert the digital input

8.3.4 REFERENCE LOSS ALARM

Description:

This alarm will be triggered when the reference signal provided on the REF-IN BNC does not match the frequency that the controller is expecting. This alarm is a special case and will self-clear if the condition corrects itself.

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm will generate a Warning alarm.

Criteria:

Triggers when the frequency of the signal is beyond ±0.25Hz of the expected frequency.

Possible causes of the alarm	Recommended course of action
The signal is missing	Check that the reference signal is connected to the REF-IN BNC
The signal frequency is not matched to the controller parameter	Set the parameter to the correct reference frequency (section 3.4.7 or 3.4.10)

8.3.5 MOTOR IS INHIBITED

Description:

This alarm will be triggered when the Motor Control Card Inhibits the Motor.

Conditions / Actions:

The alarm may occur in any operation mode.

The alarm will generate a Warning alarm.

Criteria:

Triggers when MCP Status is Inhibit.

Possible causes of the alarm	Recommended course of action
Another alarm that causes motor inhibit is or was present.	Select the reset button
The motor is driving over the system maximum speed.	Ensure Vhalls are set properly. Ensure Ref-in is attached if running in phase mode.

8.4 DETERMINING THE CAUSE OF AN ALARM

The red *Alarm Indicator* will illuminate when a warning or Trip has occurred. The Main LCD screen will display the source of the alarm automatically. The Shutdown Log can be viewed on the LCD *Shutdown Log* Display as described in Section 3.4.21.

A slow flashing red *Alarm Indicator* indicates a *SPV Fail alarm* has occurred. Any information stored in the Shutdown Log is suspect in this case.

8.5 SYSTEM LOG

The controller maintains an internal log of the most recent events ~300. Each log entry contains the shutdown log number, the source of the shutdown, and the time when the shutdown occurred. The Shutdown Log is maintained when the controller is powered off. The complete logged information on the shutdowns can be viewed through the MBScope™ software (refer to MBScope™ manual, SKF Document 892-0110).

8.6 RESETTING ALARM EVENTS

To reset an Alarm Event, press the *Reset Button* on the front panel. If the red *Alarm Indicator* turns off, the alarm condition is no longer present and operation may proceed. If the *Alarm Indicator* remains illuminated, the alarm condition is still present and must be removed before the system can be reset.

Shutdown can also be reset through the REMOTE I/O connector, Modbus/TCP or MBScope connections.

8.7 LOSS OF POWER

In the event that the controller loses main power, the following events will occur:

While power is removed the rotor will fall onto the auxiliary bearings and coast down in speed. There is a risk of auxiliary bearing failure!

On power return, the controller status will show as stopping but the motor status is inhibit (the system is coasting down on the bearings).

The start button must be pressed to levitate the system when this occurs, the system will continue to coast. The system does not auto levitate as there are situations that can cause risk to the spindle greater than an aux bearing failure.

The stop button must be hit to brake, when the system gets to zero speed it will de-levitate and park due to the stop button press.

9. MAINTENANCE, STORAGE AND HANDLING

9.1 MAINTENANCE

The MB4150g5-PC is designed for maintenance free operation, except to occasionally replace / clean the fan filter located on the front of the controller. The fan filter cover is easily removable via 4 screws, shown in the figure below.

WARNING

Warning: Only change the filter when the controller power is OFF.

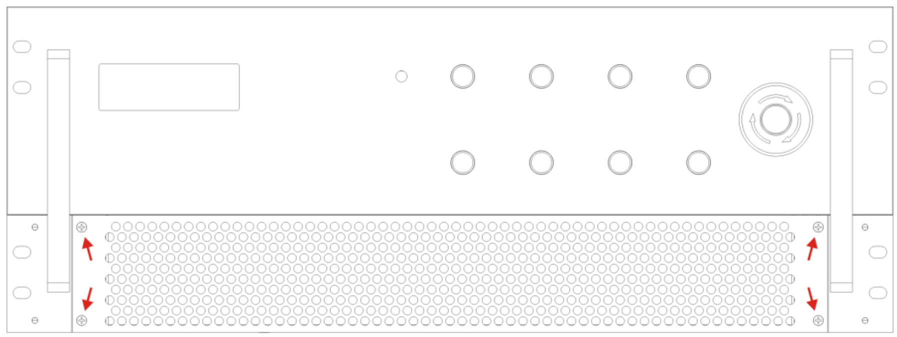


FIGURE 16 - FAN FILTER ACCESS

Clean the controller if necessary by wiping with a soft, dry, lint free cloth.

System Health should be checked according to section 3.6.1.

Spindle maintenance is described in the respective spindle manual. See section 1.2.

9.2 HANDLING

Electronic components within the controller are susceptible to damage from static discharge. There are no user serviceable parts inside the controller.

Contact SKF Magnetic Bearings for assistance.

9.3 STORAGE

Always store the controller in environmental conditions compatible with operating conditions. Exposure to excessive temperature or other environmental conditions may cause damage and/or unreliable operation.

- Storage Temperature Range: -40 to 60 ºC Dry
- Relative Humidity: 0 to 95% (non-condensing)

If the system is not being used but will be left installed, it is best to leave the rotor levitated. This will protect the shaft from external vibration.

10. MOUNTING AND DIMENSIONS

The controller can be mounted in a standard 19' rack. The controller must be supported with mounting rails. The controller should have 6" (150mm) at the front and rear of the controller to allow for airflow and to provide enough room for the bend radius of the machine cables. All dimensions shown below are in inches.

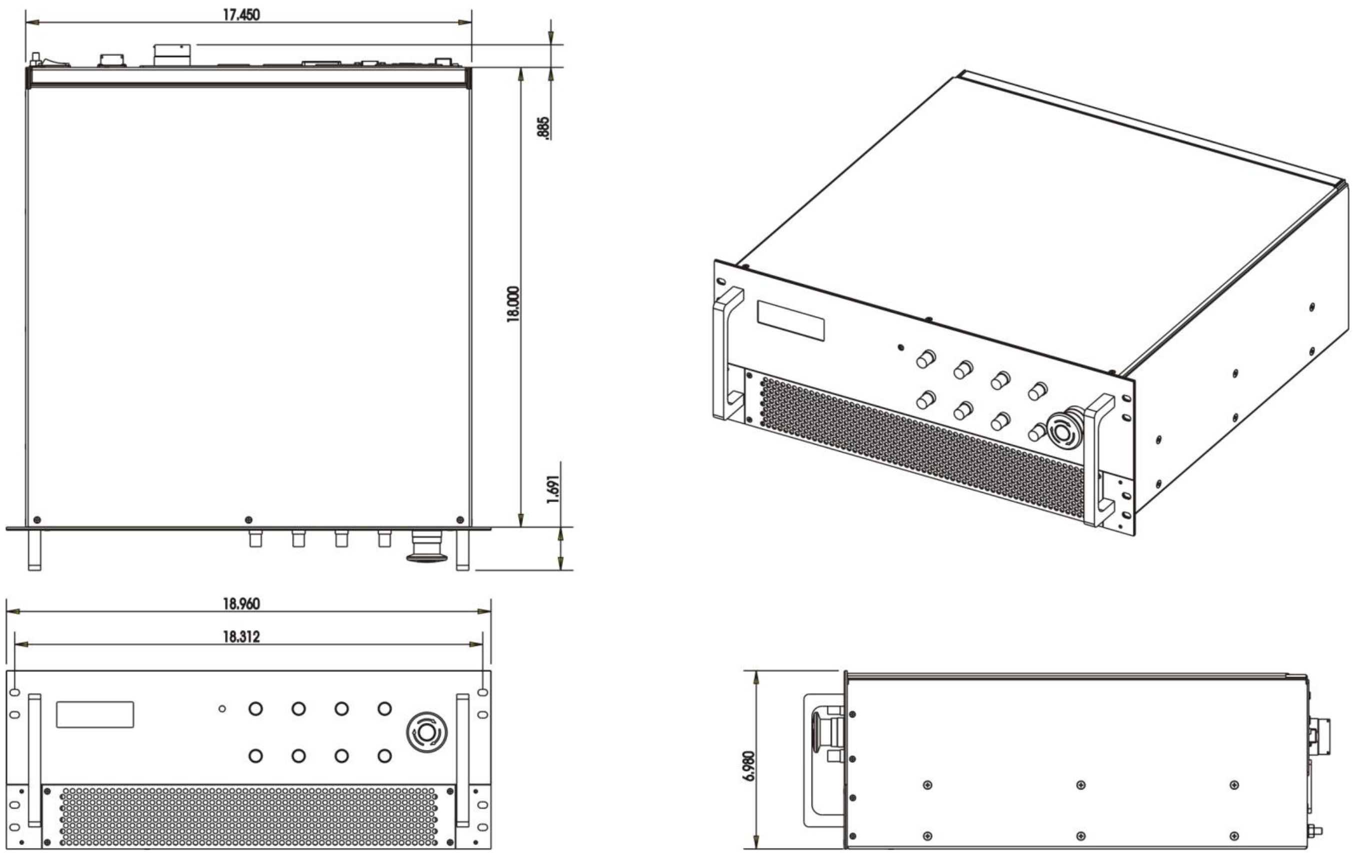


FIGURE 17 – DIMENSIONS OF THE MB4150G5-PC CONTROLLER

11. DIRECTION CONVENTIONS

11.1 AXIS ORIENTATION

The notations V_{13}, W_{13}, V_{24}, W_{24} and Z_{12} are used to refer to the five axes of control in a five-axis system, as shown. On machines with motor between the radial magnetic bearings, the disk or drive end is the end with the driven component. (i.e. disk chopper).

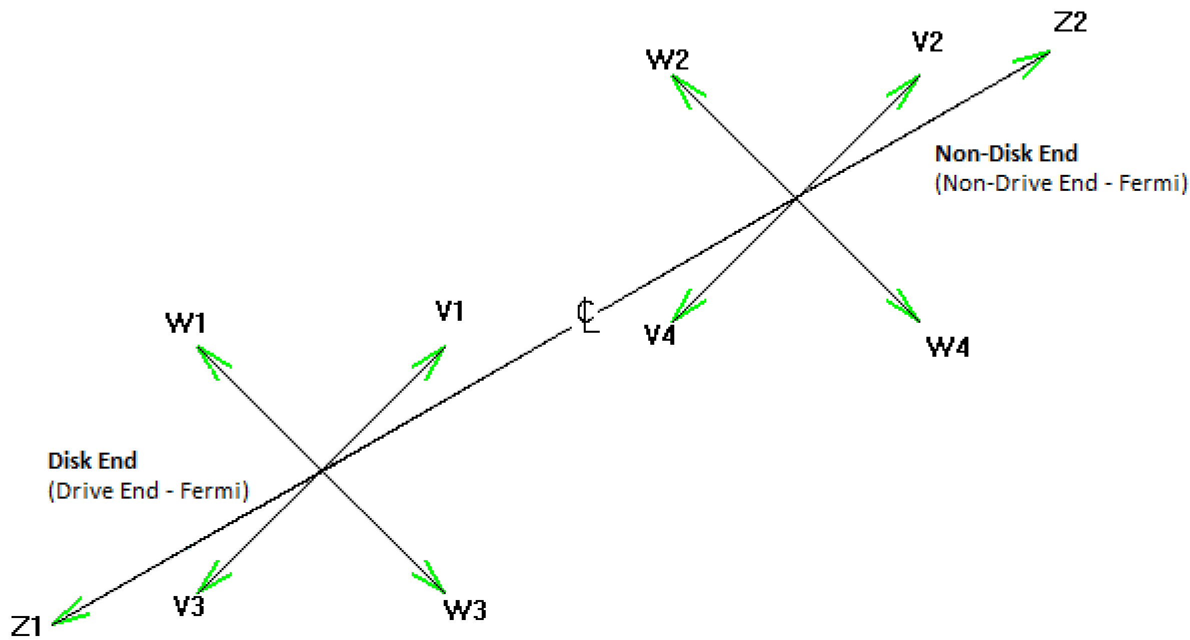


FIGURE 18 – AXIS NAMING CONVENTION

11.2 DISK CHOPPER – ROTATION DIRECTION

The rotation direction of a disk chopper is indicated as shown below. The user can configure if either 'Direction A' or 'Direction B' represents CW rotation by setting the invert direction parameter.

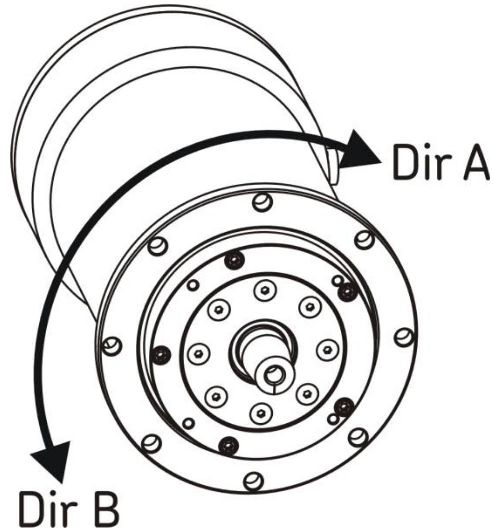


FIGURE 19 - ROTATION CONVENTION FOR DISK CHOPPERSUPDATE PIC FOR WV AND VW

11.3 FERMI CHOPPER – ROTATION DIRECTION

The rotation direction of a Fermi chopper is indicated as shown below. The user can configure if either 'Direction A' or 'Direction B' represents CW rotation by setting the invert direction parameter

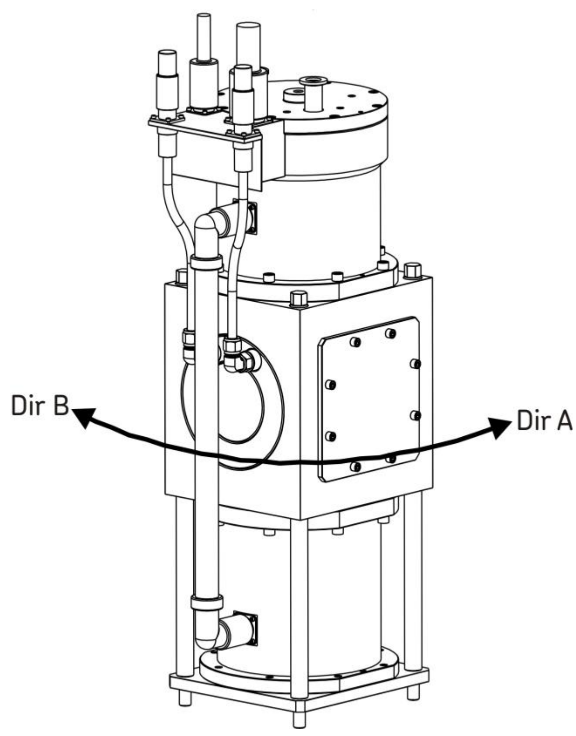
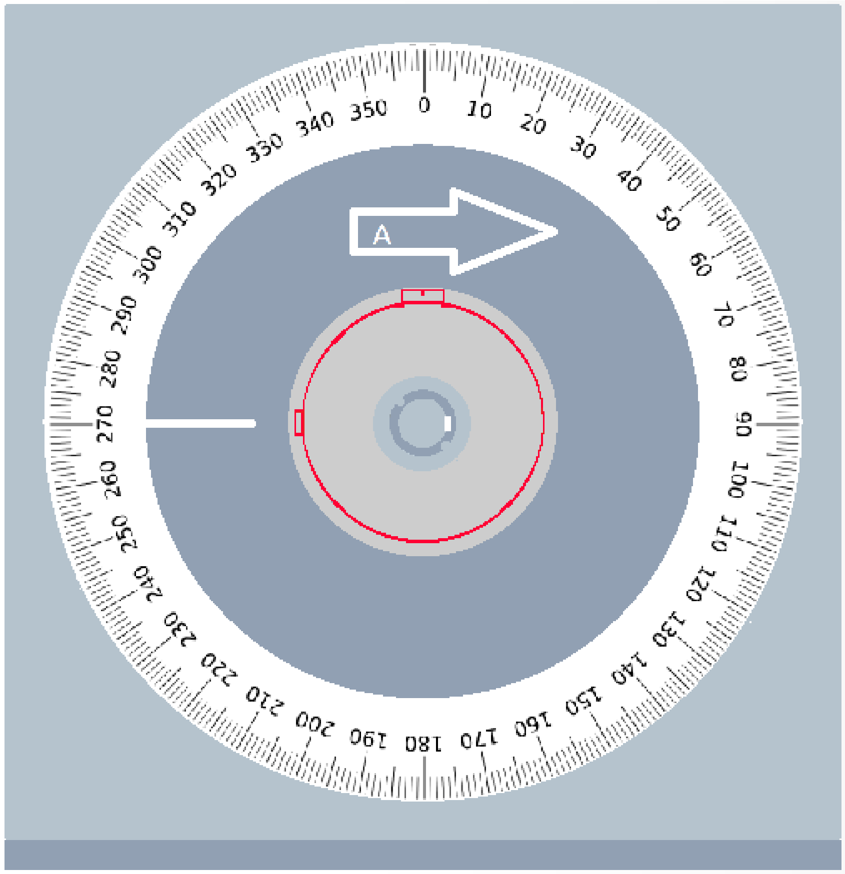


FIGURE 20 - ROTATION CONVENTION FOR FERMI CHOPPERS

11.4 DISK CHOPPER - PARKING

Parking convention assumes a reference of looking at the shaft from the disk end. The direction for positive parking angles are shown below.



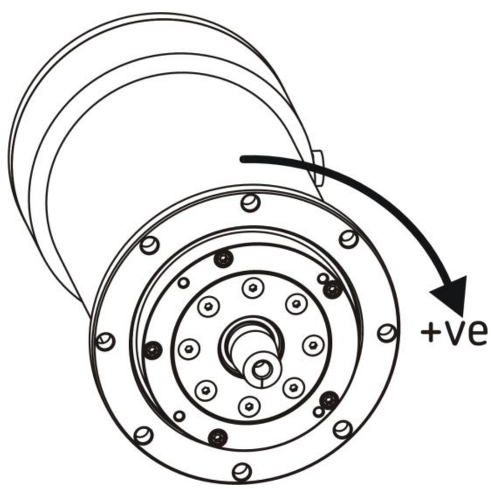


FIGURE 21 - PARKING CONVENTION FOR DISK CHOPPERS. IN THIS FIGURE THE DISK IS PARKED AT 270, WHICH IS OPPOSITE OF THE KEYWAY. LOOKING AT THE SHAFT (DISK END), 55PIN IS UP, 4 PIN TO THE LEFT.