55M3000ENE Rev. C

i3000

LATTICE BOOM CRANES WITH HOIST ROPE LOAD SENSOR(S)

Installation and Calibration Manual

Crane Warning Systems Atlanta
1-877-672-2951 Toll Free
1-678-261-1438 Fax
www.craneindicators.com
sales@craneindicators.com

This page has been intentionally left blank

This page has been intentionally left blank

The purpose of this manual is to provide the customer with the operating procedures essential for the promotion of proper machine operation for its intended purpose. The importance of proper usage cannot be overstressed. All information in this manual should be read and understood before any attempt is made to operate the machine.

Since the manufacturer has no direct control over machine application and operation, conformance with good safety practice in this area is the responsibility of the user and his operating personnel.

All procedures herein are based on the use of the system under proper operating conditions, with no deviations from the original design. Alteration and/or modification of the equipment is strictly forbidden without written approval from Rayco Technology Group.

The i3000 Wylie Systems Rated Capacity Indicator (RCI) is to be regarded only as an aid to the operator . When the parameters are set correctly, the indicator will warn the crane operator of an approaching overload condition that could cause damage to equipment, property, and/or injury to the operator or site workers in the vicinity of the crane and its load.

This system must never be used, under any circumstances, as a substitute for the good judgment of a crane operator when carrying out approved crane-operating procedures. Responsibility for the safe operation of the crane lies with the crane operator. The indicator equipment will not necessarily prevent crane damage due to overloading and related causes if not set properly.

Before operating a crane equipped with a Wylie system RCI, the operator must carefully read the information in both this manual and the crane manufacturer operator’s manual. He must also have read and understood the CIMA safety manual, the latest ASME B30..5 standard and the current OSHA, federal, state and local regulations applicable to his job. Correct functioning of the system depends upon routine daily inspection.

Any suspected faults or apparent damage should be immediately reported to the responsible authority before using the crane.

This page has been intentionally left blank

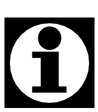
SINCE SAFETY OF PERSONNEL AND PROPER USE OF THE MACHINE IS OF PRIMARY CONCERN, DIFFERENT SYMBOLS ARE USED THROUGHOUT THIS MANUAL TO EMPHASIZE CERTAIN AREAS. THE FOLLOWING DEFINITIONS INDICATE THE LEVEL OF HAZARD WHEN THESE SYMBOLS APPEAR THROUGHOUT THIS MANUAL.

WHENEVER ONE OF THESE SYMBOLS APPEARS IN THIS MANUAL, PERSONNEL SAFETY IS A CONCERN. PLEASE TAKE TIME TO READ AND UNDERSTAND THESE DEFINITIONS!

DANGER: INDICATES A POTENTIALLY HAZARDOUS SITUATION WHICH, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY.

CAUTION: INDICATES A POTENTIALLY HAZARDOUS SITUATION WHICH, IF NOT AVOIDED, MAY RESULT IN MINOR OR MODERATE INJURY. IT MAY ALSO BE USED TO ALERT AGAINST UNSAFE PRACTICES.

IMPORTANT: INDICATES A SITUATION THAT MAY CAUSE MACHINE DAMAGE IF NOT CORRECTLY FOLLOWED.



NOTE: PROVIDES INFORMATION THAT MAY BE OF SPECIAL INTEREST.

TABLE OF CONTENTS

TABLE OF CONTENTS

GENERAL DESCRIPTION

1.1 - Introduction

This manual contains installation, calibration and troubleshooting information for i3000 system. Information in this manual will enable qualified personnel to install, calibrate and troubleshoot the i3000 system efficiently.

1.2 - Personnel qualification and scope of this manual

This manual is intended for use by field engineering and repair personnel, who are fully qualified and trained to perform the procedures described in this manual.

This manual is divided into the following sections:

SECTION 1 - GENERAL DESCRIPTION

SECTION 2 - INSTALLATION

SECTION 3 - CONFIGURATION AND CALIBRATION

1.3 - Brief description of the i3000 system

The i3000 is a computerized crane safety system. It measures load, boom angle and radius, and indicates safe or hazardous conditions. It comprises sensors fitted to the crane, a computer cabinet and a display located in the crane cabin.

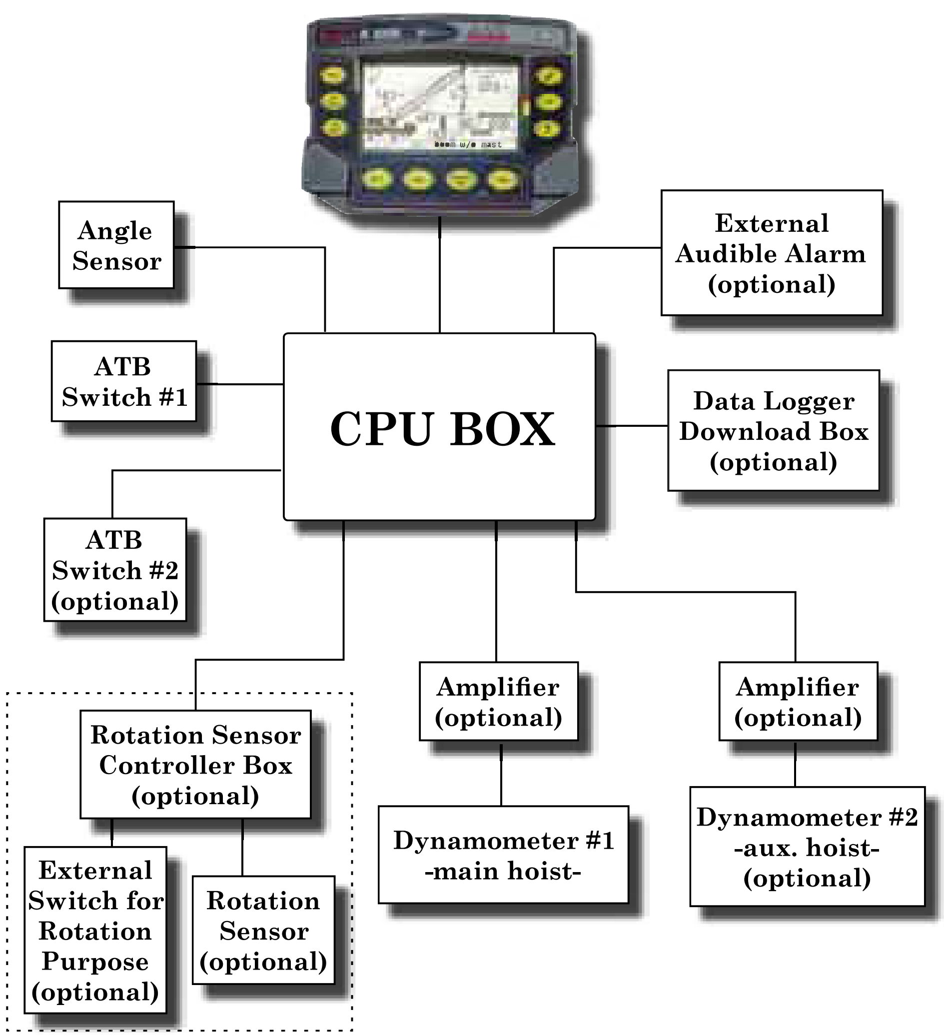
The load sensors provide electrical signals that are proportional to the actual loads in the load hoist rope system of the crane. An inclinometer provides a signal that is proportional to the boom angle. Radius is calculated from boom angle and the boom measurement parameters calculated by the system during the calibration process.

In operation the actual load lifted by the crane is automatically compared with corresponding data related to the maximum permissible crane loading. The actual load is expressed as a percentage of permissible load, if this percentage exceeds a preset value, alarms and safety functions are activated.

The values of hook load, permissible load, boom angle and main radius are displayed in digital form on a graphic liquid crystal display (LCD).

The required load-radius curves are stored in non-volatile memory and cannot be altered except by exchanging a factory programmed 'data eprom'. The calculated crane parameters and calibration data are stored in additional non-volatile memory. The calibration of the crane is performed by using known loads, boom angles, and other pre-determined data.

Figure 1: i3000 Block Diagram



1.4 - i3000 specifications

1.4.1 - Display

- Graphic LCD (240 x 128 pixel)
- Viewing area of 132 mm wide x 76 mm high
- CCFT backlight
- Reverse video mode selectable via front panel
- 3 Color alarm status LED

1.4.2 – Analog inputs

- 6 Analog input available
- 4-20 ma inputs selectable via dip switch
- Temperature drift: 10ppm/C typical (50ppm/C max)
- 2 x AD conversion 12 bits (0-5v)
- 4 x AD conversion 10 bits (0-5v)

1.4.3 – Digital inputs

- 12 digital inputs sourcing opto-isolated
- 5 digital inputs sinking opto-isolated
- 1 dedicated input ATB sinking opto-isolated

1.4.4 – Sensor excitation

- 5V available for each analog input (max 180ma total)
- -5V available for each strain gauge negative input (-DR) (max 180ma total)

1.4.5 – Analog output

- 2 analog outputs, DA conversion 12 bits, 0-5v or 0-20ma dip switch selectable

1.4.6 – Digital output

- 2 Digital output (0-5V)

1.4.7 – Relay output

- 3 NO/NC rated @ 30A
- 2 NO/NC rated @ 5A

1.4.8 – Peripheral communications port

- RS-422 or CAN BUS selectable via dip switch

1.4.9 – Environmental

- Operating: -20 to +55 °C (slow display below –10 °C)
- Storage : -30 to +80 °C

1.4.10 – Input power

- 11 – 30 VDC (10W typical, 20W max)

1.4.11 – Enclosure

- IP65 Display and processing unit

The i3000 display is rated IP-65

2

INSTALLATION

2.1 – Overview

The system consists of a graphical display unit in a heavy duty cast housing, a central processing unit (termination housing), and a number of sensors to monitor boom angle and the load in each hoist rope of the machine. All electrical connections are made via the main termination unit, all operator inputs are made using buttons on the display unit.

This manual does not address sensor mounting. The sensor installation must be done according to the manufacturer's recommendations.

2.2 – Display cable connections

If the display is pre-wired this section is not relevant, proceed to section 2.3. Cable connections to the display are made using the 8 screw terminals on the display processing board. These terminals are shown on figure 2.2.2. Use the following instructions to connect the i3000 display.

1. Unscrew the four back screws to remove the rear cover. Proceed gently in order not to damage the processing board, graphic LCD and keypad.

2. All cable shields should be grounded to the cable gland of the central processing controller box. Therefore the cable shield of the display should not be grounded to the cable gland using the brass ring. The cable gland is assembled as shown in figure 2.2.1.

3. Wire according to the supplied drawing on figure 2.2.2. Connect the wires by stripping off 6 mm of insulation, inserting the wire into the proper terminal and tightening the screw firmly.

4. Make sure all connections are properly made and completed before refitting the rear cover or switching on the power to the display.

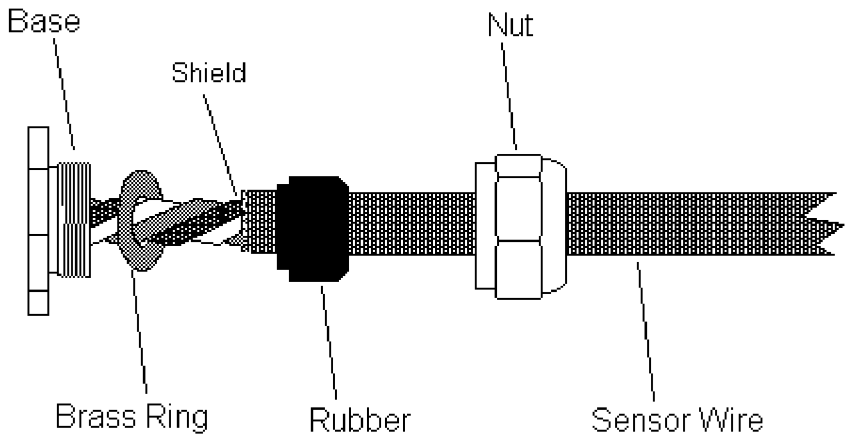


Figure 2.2.1 Cable gland assembly without grounded shield

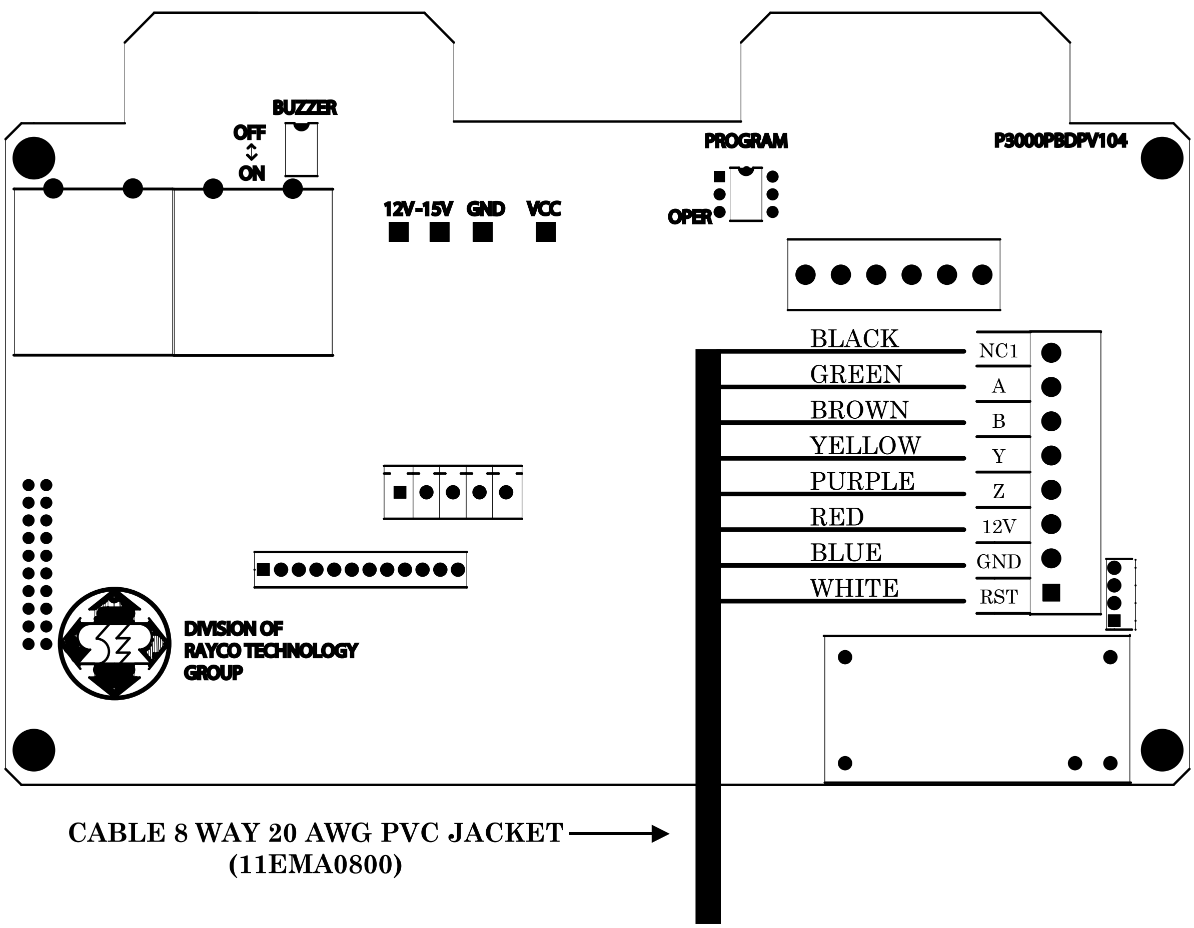


Figure 2.2.2 Display terminal block connection

2.3 – Display mounting

The display is mounted on a bracket assembly that enables the unit to be tilted for optimum viewing angle.

The display should be located at the front of the cab, where it is readily visible from the operator's control position but does not interrupt the external view of the load working area. Take care not to obscure any crane instruments, control levers, or switches etc. Locate the best area and drill 4 x mounting holes to match one of the optional sets of holes in the bracket. Fix the bracket to the console using 4 bolts, do not over-tighten them.

The viewing angle of the display can be adjusted using the two quick release levers on the bracket.

2.4 – I/O board and terminal blocks

The i3000's display, all sensors and options are connected to the i3000 central processing controller box. The terminal blocks are located on the IO board in the bottom of the controller box. The IO board is reached as follows:

1. Unscrew the 14 top screws of the i3000 central processing controller box.

2. Loosen the 10 spring screws of the central processing panel, and carefully lift the panel out of the box to get access to the IO board. This panel is connected to the I/O board via two ribbon cables, these cables may be temporarily disconnected to improve access to the terminations below but take care to protect the loose assembly from damage. The IO board is described on figure 2.4.

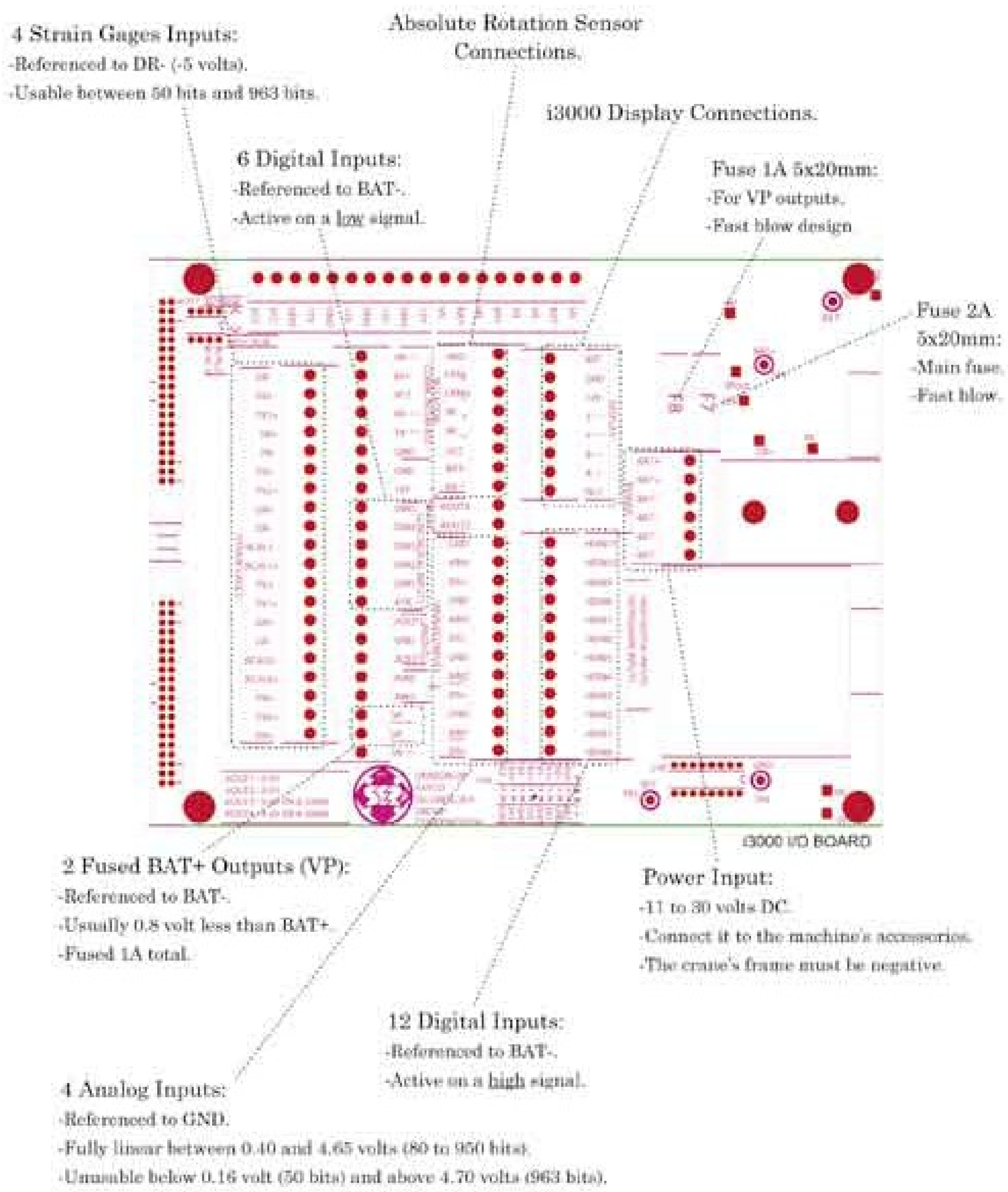


Figure 2.4: IO board and terminal blocks description

2.5 – Central processing controller cable connections

All cable shields must be grounded to the cable gland of the central processing controller box only. Fold the shield over the rubber sleeve in order to get contact with the brass ring as shown in figure 2.5.

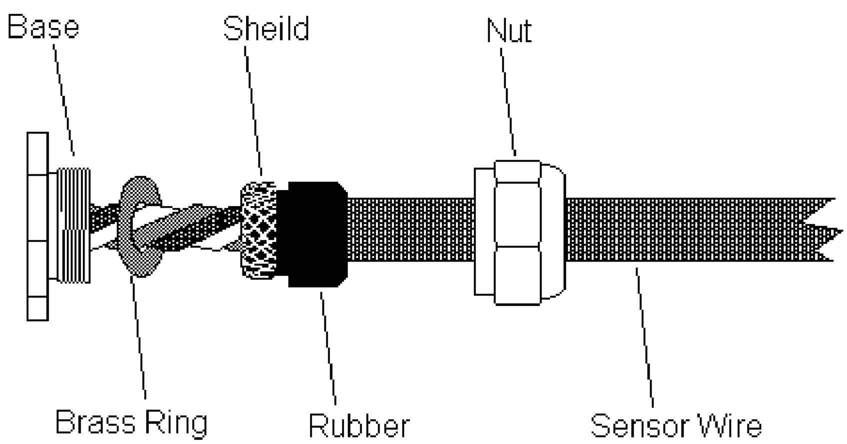


Figure 2.5: Cable gland assembly with grounded shield

2.5.1 – 12/24 VDC Power input

Connect either a +12VDC or +24VDC power source to Power terminal as show in figure 2.5.1. Supply voltage must be a minimum of 11 volts and must not be greater than 30 volts otherwise over-voltage protection will be activated and will blow the protective input fuse F7.

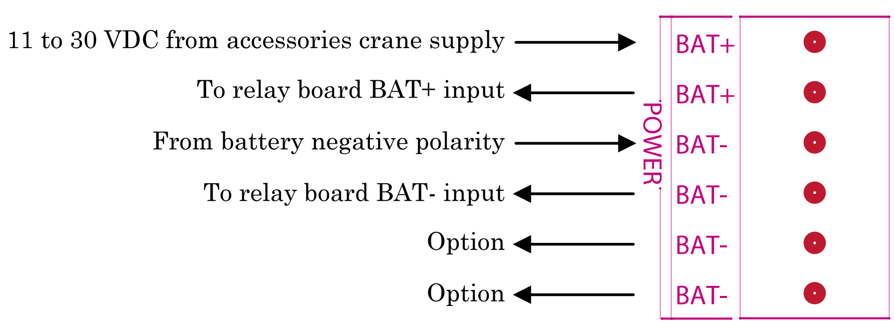


Figure 2.5.1 Input power

2.5.2 – Wire connection of display

Connect the 8 way shielded cable from i3000 display to DISPLAY terminal blocks as shown in Figure 2.5.2

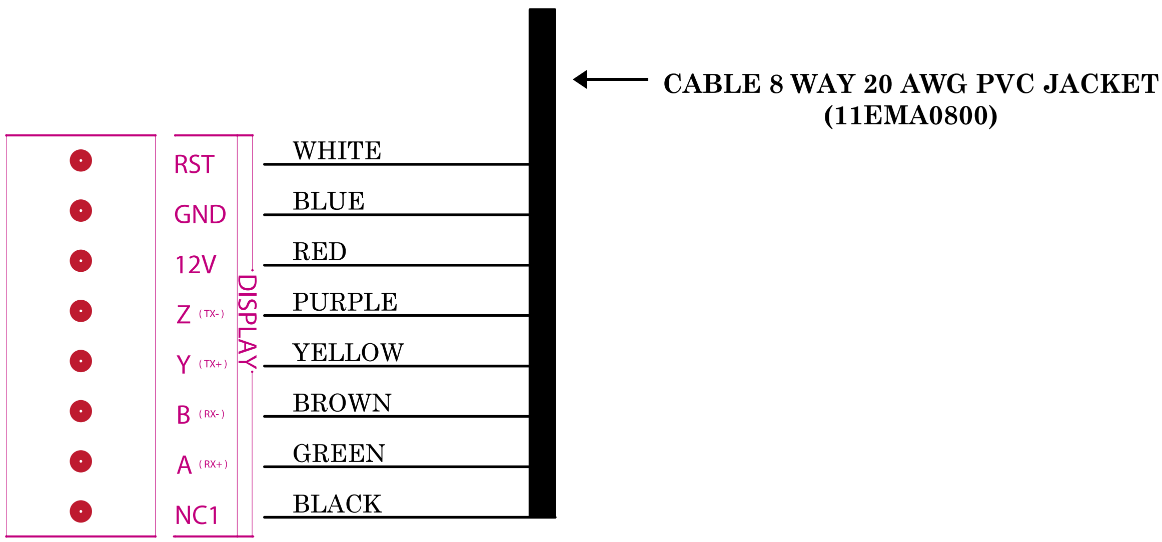


Figure 2.5.2 Display terminal block

2.5.3 – Three wires Analog Input

The 'ANALOG INPUTS' terminals are used to connect 3 wire sensors to the system. 2 Wires are used to supply the sensor and the third gives the sensor's signal. The basic connection is shown in Figure 2.5.3

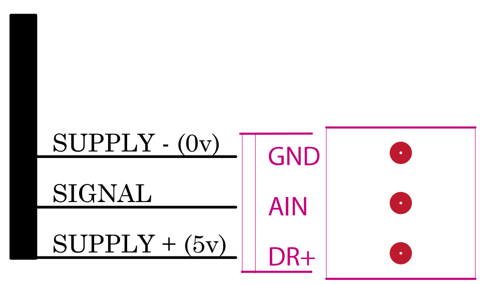


Figure 2.5.3 – Three wire analog input

The analog input description is given in this table.

AIN1	Angle sensor
AIN2	Luffing angle sensor (option)
AIN3	Cant sensor (option)
AIN4	General analog input (option)
AIN5	General analog input (option)
AIN6	General analog input (option)

2.5.3.1 – Boom angle sensor

Connect the boom angle sensor to the terminals as shown in Figure 2.5.3.1

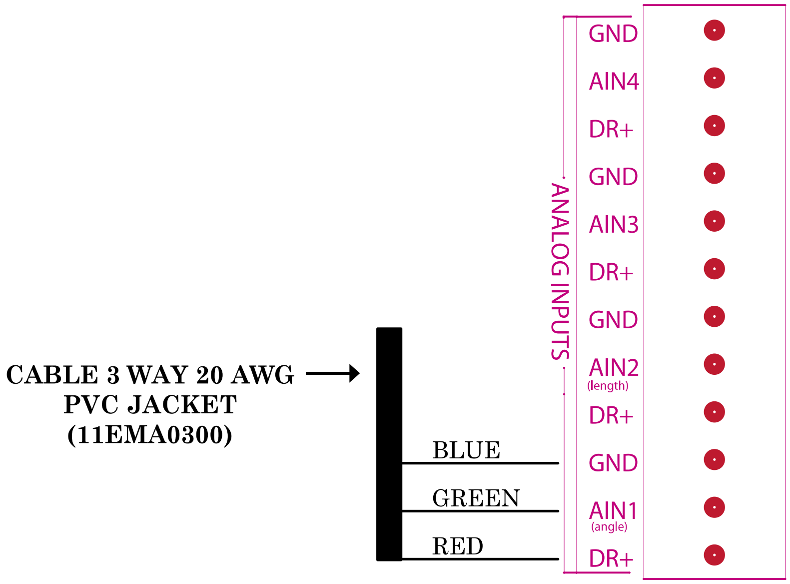


Figure 2.5.3.1 Boom angle sensor connection

2.5.3.2 – Option sensors

If other 3 wire analog sensor options are fitted to your system, connect the option sensors to the terminals as described in section 2.5.3 and refer to table 2.5.3 to determine which analog input to use.

2.5.4 – Four wires Analog Input

The 'STRAIN GAUGE' terminals are used to connect 4 wire sensors to the system. 2 Wires are used to supply the sensor and two to return the sensor signals. The basic connection is shown in Figure 2.5.4

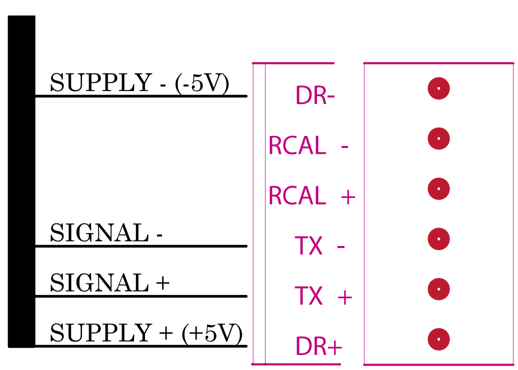


Figure 2.5.4 – Four wire analog input

The strain gauge input description is given in the following table:

TXO+	Main hoist load signal +
TX0-	Main hoist load signal -
TX1+	Aux hoist load signal +
TX1-	Aux hoist load signal -
TX2+	Whip1 hoist load signal +
TX2-	Whip1 hoist load signal -
TX3+	Whip2 hoist load signal +
TX3-	Whip2 hoist load signal -

Table 2.5.4: Strain gauge input description

2.5.4.1 – Main hoist load sensor

Connect the Main hoist load sensor to the terminals shown in Figure 2.5.4.1

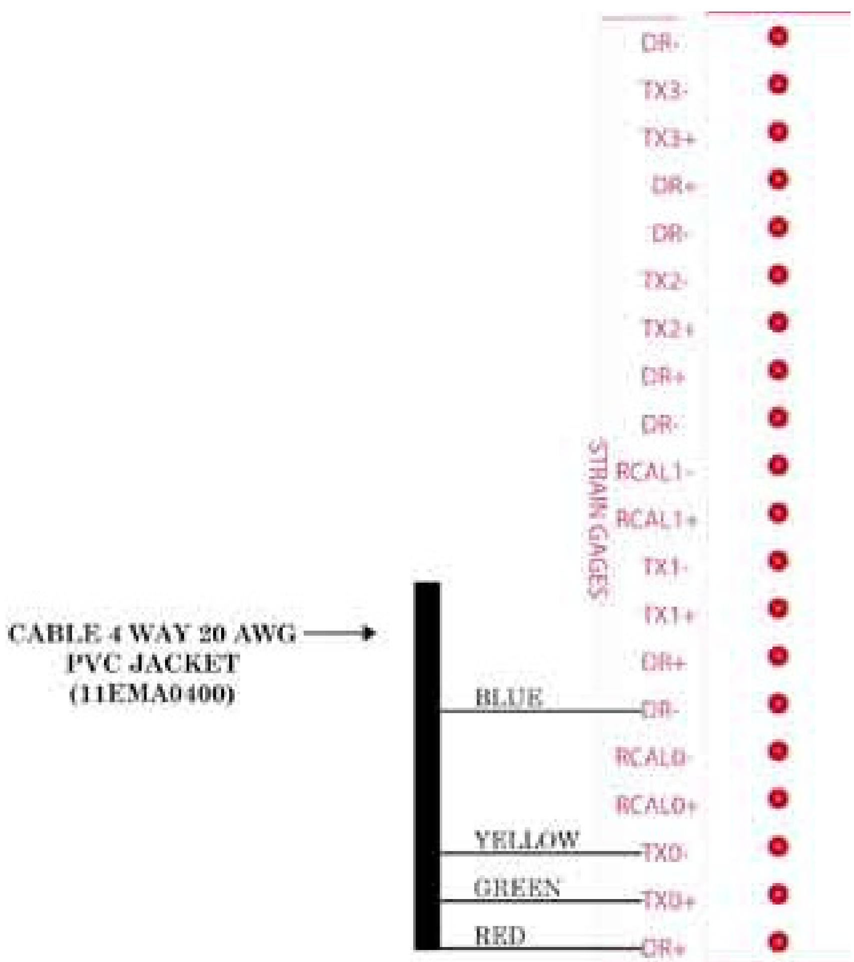


Figure 2.5.4.1 Main Hoist load sensor connection

2.5.4.2 – Auxiliary, whip1 and whip2 sensors

If Auxiliary, Whip1 or Whip2 sensor options are fitted to your system, connect the optional sensors to their respective terminals as described in section 2.5.4 and refer to table 2.5.4 to determine which strain gauge input to use.

2.5.5 – ATB connections

The ATB signal is a pull-up signal, during normal operation the signal must be grounded. When an ATB condition occurs the ground on ATB Signal must be released. If the ATB is not used, you must install a jumper between ATB and GND. Connect the ATB sensor to the terminals described in Figure 2.5.5.

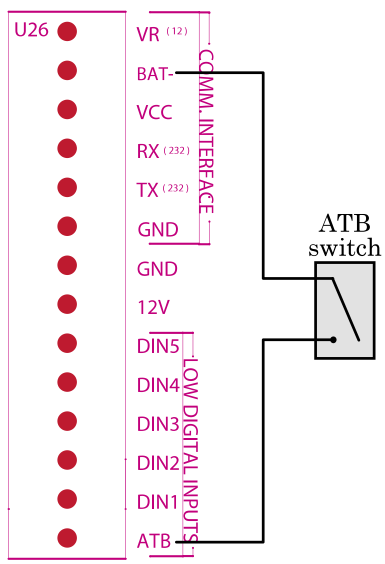


Figure 2.5.5 ATB sensor connection

2.5.6 – Terminal Block for extra options

The terminal blocks in table 2.5.5 are used for extra options. Connections for these options will be described in the individual manuals supplied with the options.

TRANSMISSION
ROTATION
RPM
OUTRIGGERS

Table 2.5.5: Terminal blocks for extra options

2.5.7 – Relay board and Terminal Blocks

The relay board is located just beside the i3000 IO board and is used to control the Lockout system and all alarms. The relay board is described in Figure 2.5.7.

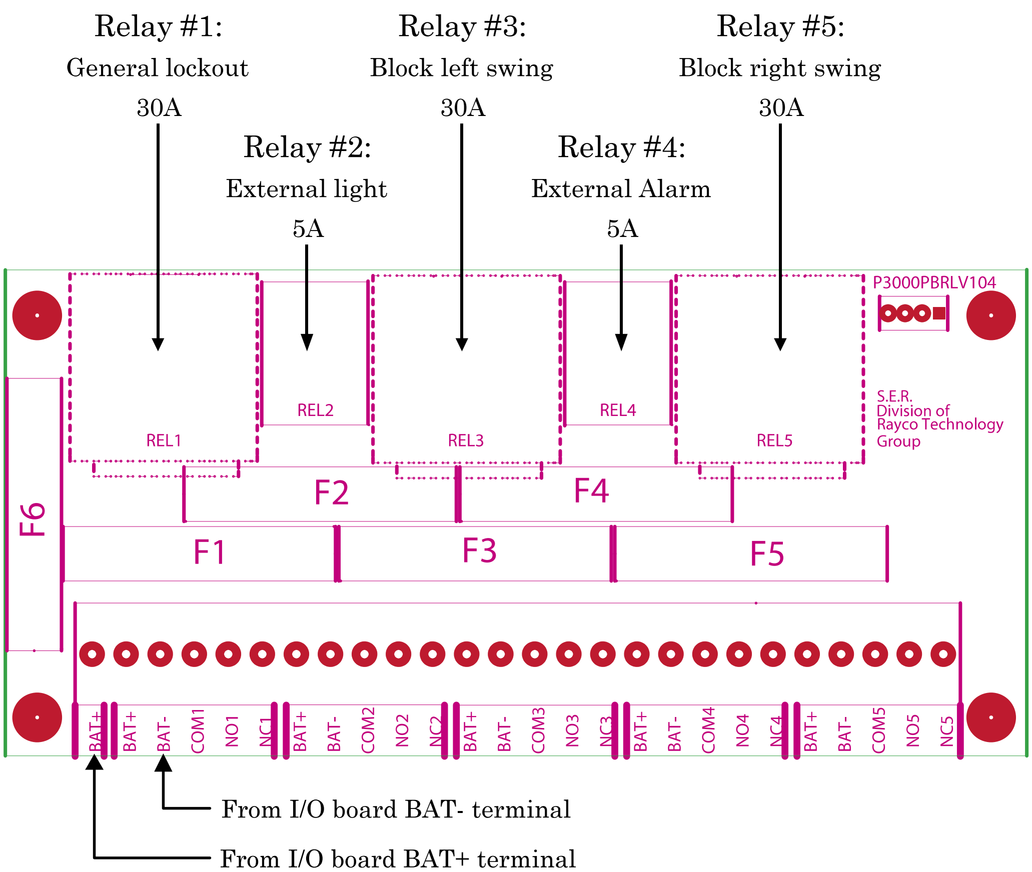


Figure 2.5.7 Relay board and terminals description

2.5.7.1 – Lockout connections

The relay board must be connected to the battery supply voltage from the terminals of the IO board as shown in figure 2.5.7

The lockout connection is according to your specific lockout configuration. The relays are controlled in 'Fail Safe ' mode, that is they will be closed during normal operation, relay status of COM-NO, and open during alarm or power-off, relay status of COM-NC. All terminals of each relay are available for maximum flexibility in configuring and using their outputs.

Fuse F6 is used to protect the input power of the Relay board (BAT+). Fuses F1 to F5 are used to protect the common of each of the corresponding relays.

2.5.7.2 – Typical connection for sourcing external lockout device

The following Figure 2.5.7.2 shows the typical connection of an external lockout device using sourcing configuration.

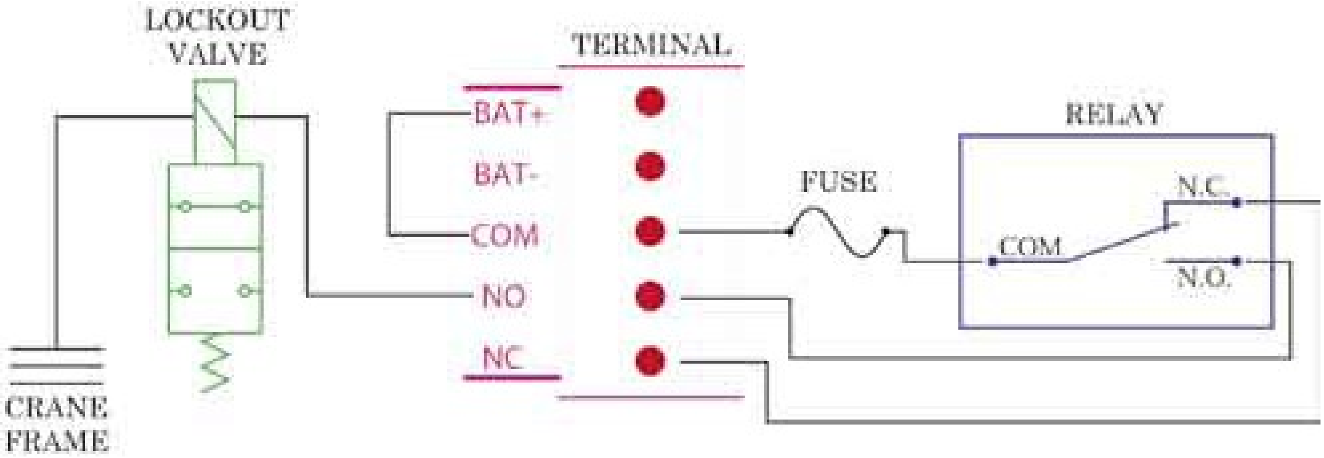


Figure 2.5.7.2 Typical connection for sourcing lockout valve

2.5.7.3 – Typical connection for sinking external lockout device

The following Figure 2.5.7.3 shows the typical connection of an external lockout device using sinking configuration.

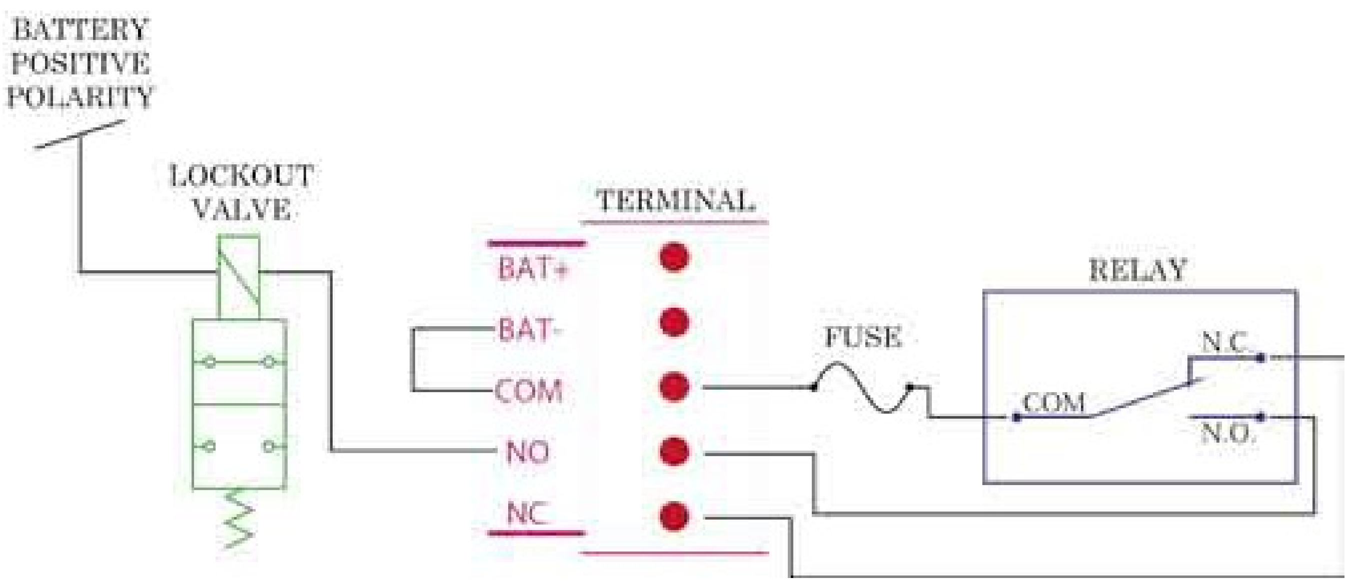


Figure 2.5.7.3 Typical connection for Sinking lockout valve

2.5.7.4 – Typical connection for sourcing external alarm device

The following Figure 2.5.7.4 shows the typical connection of an external alarm device using sourcing configuration.

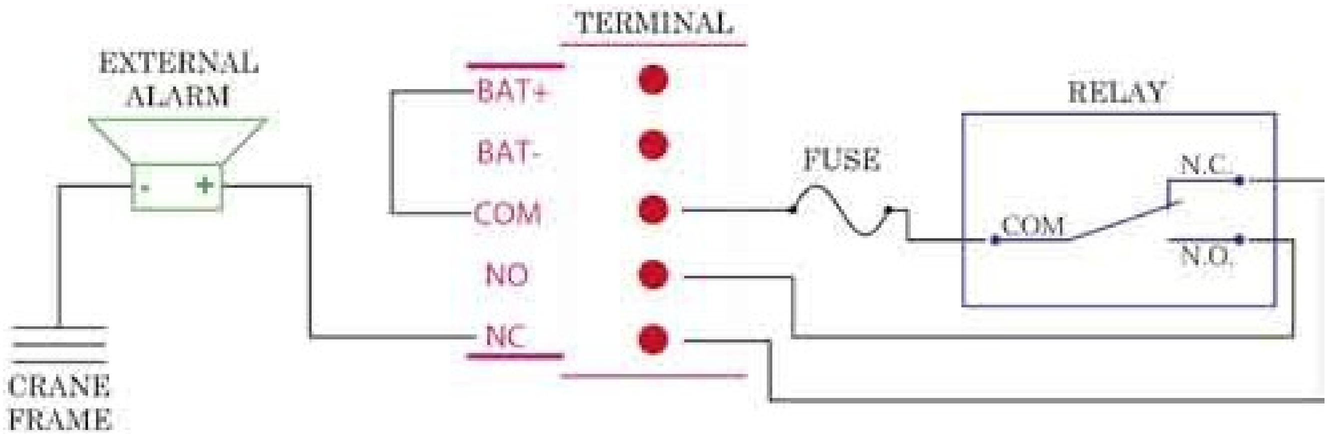


Figure 2.5.7.4 Typical connection for sourcing external alarm

THE FUNCTION OF EACH RELAY GIVEN IN FIGURE 2.5.7 IS FOR STANDARD SOFTWARE VERSIONS ONLY. RELAY FUNCTIONS MAY DIFFER FROM THESE. IF YOUR SYSTEM IS FITTED WITH CUSTOM SOFTWARE, AN ADDENDUM SHEET WILL BE INCLUDED WITH THIS MANUAL IF THIS IS RELEVANT.

3

CONFIGURATION AND CALIBRATION

The calibration section will guide the technician and explain the procedures to follow, in order to calibrate the i3000 system rapidly and efficiently.

The calibration of the sensors is performed using software by entering data using the display's keypad. The only exception is that the amplifier jumpers are set manually.

Necessary Calibrating Tools	• Steel measuring tape of 30m (100 ft) capacity with accuracy of 1cm or better. • Angle indicator with accuracy of 0.5º or better. • Test load that produces a line pull of approximately 90% of line pull.
Necessary Calibration Information	• The rated line pull of each hoist line. • The maximum number of parts of lines. • The weight of each block (within ±1%), slings and attachment used for calibration. • The hoist line weight per meter or feet.

3.1 – Internal amplifier

The i3000 system has an internal amplifier built into the system that is used to amplify the signal coming from load sensors. Some applications where the load sensor is a significant distance away from the termination unit will also be fitted with an external amplifier to ensure a reliable load signal is obtained.

3.1.1 – Internal amplifier gain setting

When no external amplifiers is required, it is necessary to adjust the gain of the internal amplifier. The internal amplifier gain setting is done using the 'MAIN' value in the Diagnostic Mode. While in the diagnostic mode (refer to diagnostic mode section in the i3000 Operator's Manual), go to Diagnostic Mode Screen #3 and check the 'MAIN' value. This value represents the main hoist load input converted into a 10 bits digital signal. This should range between 50 and 950 when functioning correctly.

On the CPU board of the i3000 CPU Box, locate the amplifier jumpers as shown on figure 3.1.

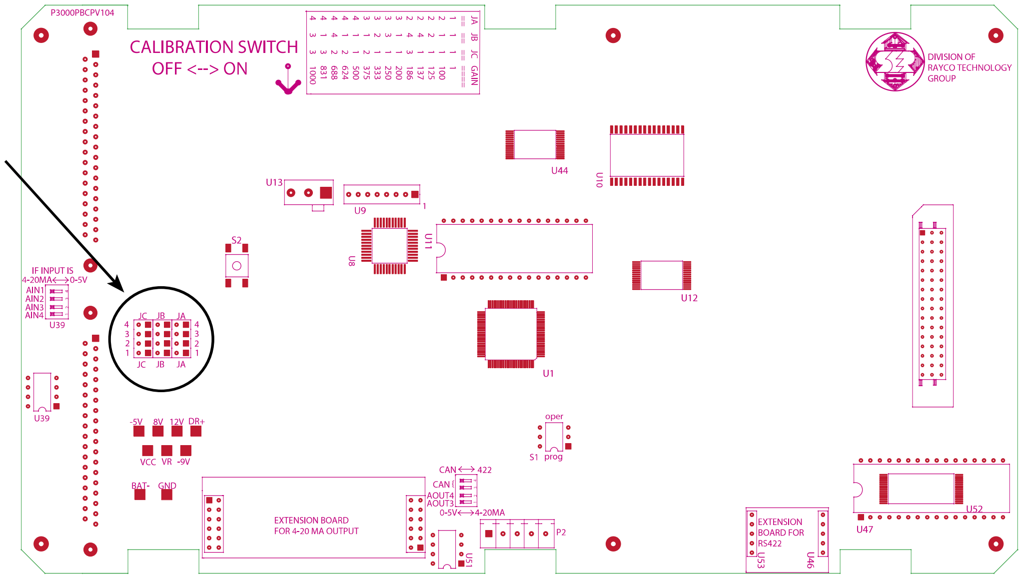


Figure 3.1: The i3000 CPU board

They are noted as JA, JB, JC. Note the arrangement and refer to the table 3.2 below to determine the amplifier gain level.

JA	JB	JC	GAIN Level
1	1	1	1
2	2	2	100
2	2	1	125
2	4	1	137
2	4	3	188
3	1	1	200
3	3	1	250
3	2	1	333
3	1	2	375
4	1	1	500
4	1	2	624
4	4	2	688
4	1	3	831
4	3	3	1000

Table 3.2: Amplifier gain level

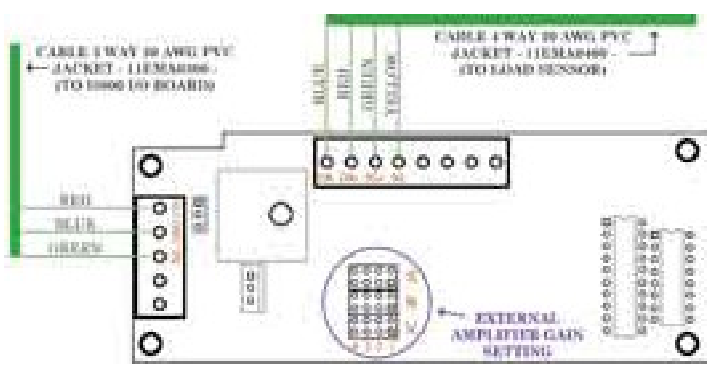
To adjust the internal amplifier, you have to lift the test load on the main hoist, which should provide around 90% of the maximum line pull.

While lifting the test load, if 'main' value of the Diagnostic Mode is lower than 615 bits, set the jumpers to the next higher level until the value is above 615 bits and below 820 bits.

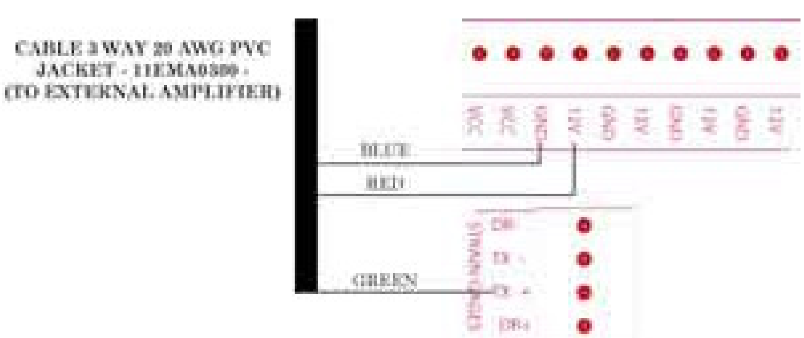
If 'MAIN' value is above 820 bits, set the jumpers to the next lower level until the value is below 820 and above 615 bits.
100% line pull should not exceed 900 bits. The same gain setting is used for main and auxiliary hoist.

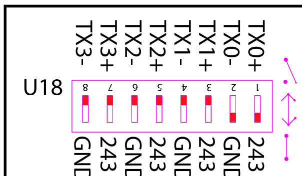
3.1.2 – External amplifier overview

If an external amplifier is required, refer to the manual supplied with the external amplifier for connections and setting. The amplifier gain on the i3000 cpu board must be set to 1 and the gain adjustment is made on the external amplifier board instead. Remember to toggle the appropriate switches (U18 on the i3000 i/o board) according to the analog input used...



external amplifier connection





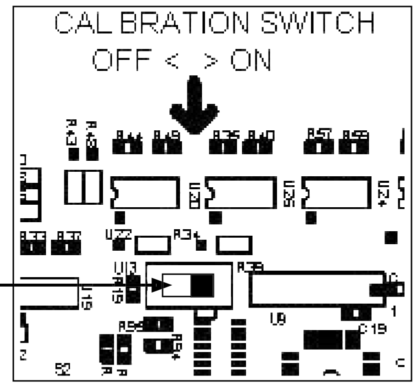
Main hoist: toggle switches 1 and 2.
Aux. hoist: toggle switches 3 and 4.

external amplifier connection on the i3000 i/o board

3.2 - Memory protection

The i3000 system has both a hardware and software key to protect the data calibration. The hardware key protection is implemented by the calibration switch located on the CPU board. When you slide the calibration switch to the ON position, the hardware protection is disabled and you are allowed to enter calibration data in the memory bank.

Close up view of the calibration swich located on the CPU board. When the switch is placed on the ON position, calibration is enabled.

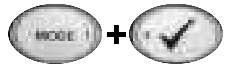
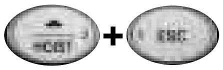
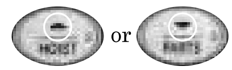


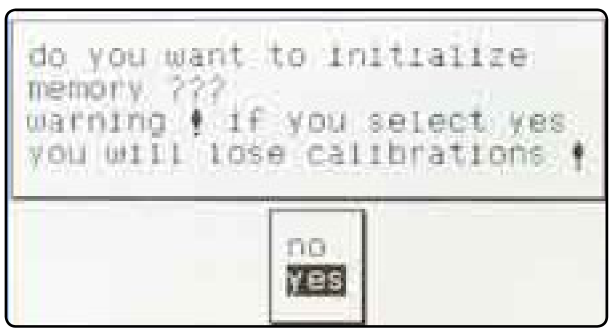
MAKE SURE THAT THE CALIBRATION SWITCH IS SET TO THE ON POSITION BEFORE STARTING CALIBRATION OF THE SYSTEM. WHEN THE CALIBRATION IS OVER SET THE SWITCH TO THE OFF POSITION TO PREVENT YOUR CALIBRATION DATA FROM BEING CORRUPTED.

3.2.1 – System initialization

Before to start the system calibration, sensors need to be verified for good working order through the diagnostic mode (refer to ‘Diagnostic Mode’ section in the i3000 Operator’s Manual).
When each sensor has been verified for its full functionality the system can be initialized in order to start the calibration procedure. This will obliterate all calibration data from the bank A memory, and therefore should be done only when a system is installed for the first time.

Perform a system initialization as follows:

1. Press and hold buttons #1 and #4  at the same time (that's the reset buttons of the system).
2. While holding button #1 and #4, press both buttons #2 and #5 at the same time. 
3. Release buttons #1 and #4 which release the system reset.
4. Use the SCROLL UP (#2) or SCROLL DOWN (#3)  button to select 'YES' within the highlighted character field.
5. Press Select (#4)  to confirm your choice.



When the initialization is done, the system will return to its normal operation.

First, rig the main hoist line with minimum parts of line (two, three or four parts is acceptable). If the hoist line friction is high, the calibration will be more difficult with four than three parts of line. Most important, the block must hang straight and directly below the head block.

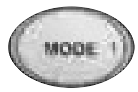
The test load that will represent near maximum line pull when lifted by the main hoist reeve with one, two, three or four parts of lines as discussed in the above paragraph must be known with ±1 % accuracy.

Repeat this procedure with other hoist lines.

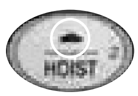
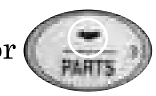
3.3 - Calibration mode

The calibration mode is a separate entity of the i3000 system. It is totally independent of the regular operating mode as if it was a different system. The purpose of the calibration mode is to calibrate the angle sensor, the load sensor(s), the radius and numerous factors or set points.

The calibration mode is accessed by the Mode menu in normal operation.



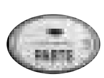
The exact procedure to enter the Calibration Mode is described in the next section. The calibration mode is organized in a linear sequence. A series of 23 items will appear. The SCROLL UP (#2) or SCROLL DOWN (#3) buttons

 or 

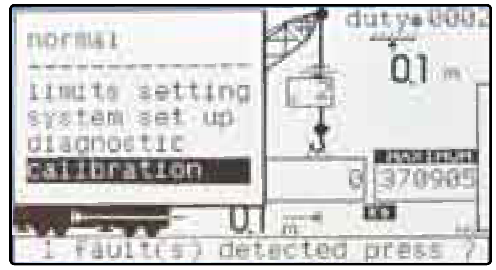
will allow you to navigate through these items. Although in calibration mode it is possible to navigate and access any stage of the calibration, it is recommended (and sometimes essential) that the system is calibrated in the order described in this manual.

3.3.1 – Entering in calibration mode

<u>To enter the calibration mode:</u>

1. Push the MODE (#1)  button.
2. Scroll down with button (#3)  to highlight the “calibration” line.
3. Push the SELECT (#4)  button to confirm your choice.
4. The system will ask for a password. The password will have a maximum of 10 numbers. The reference numbers can be found on each push button on the keyboard. **YOUR PASSWORD: 1 – 2 – 3 – 4**
6. If an error is made, Press the Escape (#5)  button and repeat the complete procedure.

Once the system receives the exact password, it will automatically display the Calibration mode menu. The System password will remain activated until the system is turned off, ie it will not be necessary to re-enter the password each time you enter the calibration mode unless power is lost to the system.



The calibration of the system can now be performed. With the HOIST/ SCROLL UP (#2) or PARTS/ SCROLL DOWN (#3) buttons, it is possible to navigate through the calibration menu.

3.4 - System configuration and calibration data

Before starting the calibration of any sensors, it is necessary to perform the system configuration and enter calibration data.

3.4.1 – Disable unused inputs

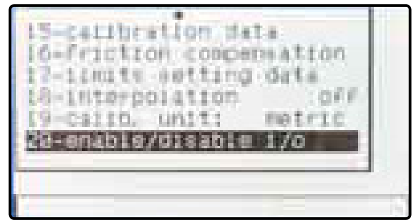
Following a system initialization, all inputs are set to Enable by default. Unused inputs should be Disabled to prevent error messages being generated for these functions. The description of the system inputs is given in table 3.4.1

TXO	Main hoist load sensor
TX1	Aux hoist load sensor
TX2	Whip1 hoist load sensor
TX3	Whip2 hoist load sensor
AIN1	Angle sensor
AIN2	Luffing angle sensor
AIN3	Cant sensor
AIN4	General analog input (option)
AIN6	General analog input (option)
AING1	General analog input (option)
AING2	General analog input (option)
REL3-REL5	Counter balance valves control (option)

Table 3.4.1 System input description

Disable unused inputs as follows:

1. Navigate in the calibration menu using buttons (#2) or (#3) or to highlight the field **“enable/disable i/o”**.



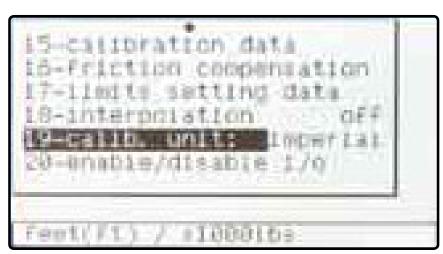
2. Push the Select (#4) button to confirm your choice.
3. Use buttons (#2) or (#3) or to highlight one of the unused inputs.
4. Pushing the Select (#4) button will toggle the corresponding input from enable to disable state. Repeat the procedure for each input not used.
5. When it’s done, push the ESC (#5) button to return to the main calibration menu.

3.4.2 - Selecting units of measure

The units of measure must be selected before starting any calibrations. Two choices can be selected: Imperial or metric, load units are displayed in 1000 x lbs or 1000 x kgs to 2 decimal places and length units are displayed in feet or metres to 1 decimal place.
Note that as soon that one calibration procedure is performed the system will not allow further changes to the unit of measure.

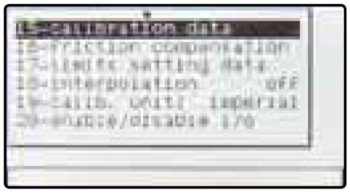
The units of measure are selected as follows:

1. Navigate in the calibration menu using buttons (#2) or (#3) or to highlight the field **“calib. Unit: imperial”**.



2. Push the Select (#4) button to toggle the choice between imperial and metric.

3.4.3 - Calibration data screen

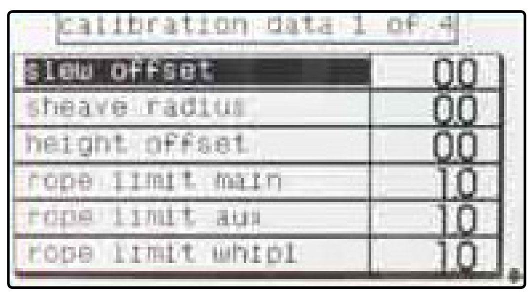


Use the sub-menu **"calibration data"** screen to enter fixed data values used for various operations of the system.

- **Slew offset:**
The distance between the center of rotation and the boom base pin in feet or metres. Negative if the boom base pin is behind the center of rotation, otherwise positive.

- **Sheave radius:**
The radius of the boom head sheave in feet or metres. It is used to compensate the radius when lifting with one part line.

- **Height offset:**
The height offset is the distance between the ground and the boom base pivot. It is used to determine the height of the boom head sheave block from the ground. Add the clearance height above the boom head sheave block to use the height display as the head room height of the crane (this will be safe but not precise).



- **Rope limit main:**
This is the maximum line pull permitted per part of line on the main hoist according to the chart. This value will be used as the load limitation if lower than the rated capacity.

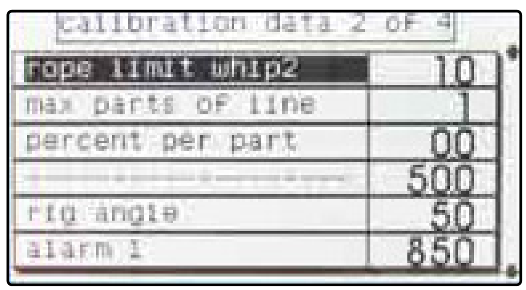
- **Rope limit aux:**
This is the maximum line pull permitted per part of line on the auxiliary hoist. This value will be used as the load limitation if lower than the rated capacity.

•Rope limit whip1:
This is the maximum line pull permitted per part of line on the whip (3rd) hoist. This value will be used as the load limitation if lower than the rated capacity.

•Rope limit whip2:
This is the maximum line pull permitted per part of line on the second whip (4rd) hoist. This value will be used as the load limitation if lower than the rated capacity.

•Max parts of line:
Set the maximum number of parts of line. This will apply to all hoists.

•Percent per part:
This value allows de-rating of the hoist line capacity when reeving with more than one part. The total rope capacity will de-rate by the percent set except for one part.



•Rig angle:
The RIG ANGLE is a set angle below which the operator can permanently bypass the lock-out by pressing the RIG button, it should be set at the lowest practical boom angle possible. This function is used to allow the rigging of jibs or reeving at angles below the chart. The RIG function is canceled when the operator booms up above the set angle or if the system is turned off.

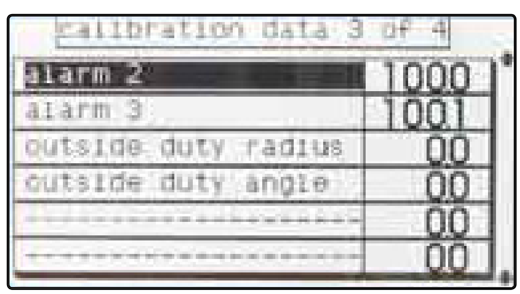
•Alarm 1:
This alarm is the pre-alarm on load. When the set percentage is reached, an intermittent buzzer is activated as well as pre-warning indicator light.

•Alarm 2:
This alarm is the maximum load limit set by the rope capacity or the chart. When the set percentage is reached, the red indicator light with the octagon and the pre-warning indicator light are on and the buzzer is continuous. The lock-out is not activated.

•Alarm 3:
This alarm is the lock-out (motion cut) load limit. When the set percentage is reached, the red indicator light with the octagon and the pre-warning indicator light are on and the buzzer is continuous. The lock-out is activated.

Note:
These three alarms are based on actual hook load expressed as a percentage of permitted load, the permitted load may be determined by the crane chart or rope limit whichever is lower. The actual percentages set depend on local regulations; the default settings in Europe are 95%, 105% and 110% respectively. If in doubt consult Wylie Systems or your local authority.

•Outside duty radius:
This variable represents a transition distance between the last radius rating and zero capacity. If the actual hook radius exceeds the maximum chart radius, the system alarms will be triggered. The system will not allow radii beyond the maximum radius given by the load charts. The OD (OUT of DUTY on RADIUS) will allow the SWL to decay evenly from the last point on the chart to zero over the distance set by this variable. Note, this is only valid if the chart interpolation is set to 'off', refer to section 3.4.5.



•Outside duty angle:
This variable works in the same way as 'outside duty radius' but is used for charts where the SWL is determined by boom angle and not radius.

3.4.4 - Entering fixed data values

1. Navigate through the calibration menu using buttons or (#2) or (#3) to highlight the field **“calibration data”**.
2. Push the Select button to confirm the choice.
3. Use buttons (#2) or (#3) or to highlight the desired variables to edit.
4. Push the Select button to obtain the setting mode. Use buttons or (#2) or (#3) to change the value and push the Select button once to confirm. Then scroll to the next variable and repeat the procedure.
5. Once all the calibration data is entered, push the ESC (#5) button to return to the main calibration menu.

3.4.5 – Crane capacity charts interpolation

This function determines whether or not the i3000 system interpolates the crane capacity charts with respect to radius/angle or whether it steps from one capacity to the next. If chart interpolation is ON, the system will display a smooth transition between rated points. If it is OFF, then once the radius/angle exceeds a listed value on the chart the capacity will drop to the next rated capacity; this known as a stepped. Refer to the crane manufacturer’s load chart to determine if the charts should be interpolated or stepped.

Change the status of chart interpolation as follows:

1. Navigate in the calibration menu using buttons (#2) or (#3) to highlight the field **“interpolation”**.
2. Push the Select (#4) button to toggle the status between ON and OFF.

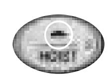
3.5 - System memory management

The i3000 system has 3 different banks of memory to store its complete data. They are noted as Bank A, Bank B and Bank C. These memories are non volatile and do not require battery backup. The calibration data will be stored permanently unless changed by re-calibration or reconfiguration of the system. The purpose of each bank is described below:

Bank A: This memory bank is used to store the calibration data and values calculated by the system after confirmation during the calibration process.
Bank B: This memory bank is a spare bank for important calibration data stored in memory bank A. If in the next calibration stages, an error is made, it is possible with a function of “14 – memory” menu to discard the new changes and retrieve the previous saved calibration data provided a back up has been done previously.
Bank C: This memory bank is used to store all general configuration data entered by the operator such as hoist selection, parts of line, etc.

3.5.1 - Backup

Calibration data and values calculated by the system during the calibration process is saved when confirmed, and stored in the memory bank A. The purpose of the Backup function is to save the calibration data in a spare bank called bank B. Thereby if in the next calibration stages, an error is made, it will be possible to discard the new changes and retrieve the previously saved calibration.

1. Navigate in the calibration menu using buttons (#2) or (#3) 

or 

to highlight the field **“backup”**.

2. Push the Select  button to confirm the choice and create the backup.

3. When the backup is done the system will return to the main calibration menu automatically.

A program is available which enables a copy of the calibration data to be downloaded to a portable computer; this data can be kept separate from the crane and used for analysis or for subsequent reloading back to the i3000 system in the unlikely event that this becomes necessary. Consult Wylie Systems for more information.

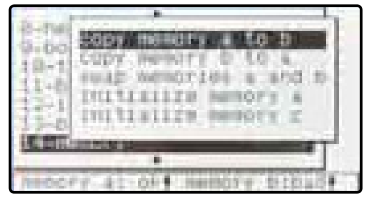
3.5.2 - Memory management functions

The memory management menu is provided to allow manipulation of the data in the various memory banks. The options available are:

•Copy memory a to b:

The contents of bank A will be copied into bank B. This is just like the menu "Backup " explained above.

•Copy memory b to a:



This option will copy the contents of bank B into bank A. All the data already in bank A will be replaced by a copy of the data from bank B and therefore will be lost.

•Swap memories a and b:

This option will place bank A data into bank B and at the same time bank B data into bank A. Both sets of data will be preserved but switched.

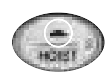
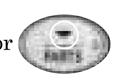
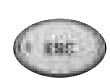
•Initialize memory a:

This option will obliterate all calibrations from bank A. This should only be done when a system is installed for the first time or if an incompatible operating system is installed in the system. This must never be done during or after calibration.

•Initialize memory c:

This option will obliterate from bank C all system configuration data entered by the operator.

3.5.3 – Memory management menu and function selection

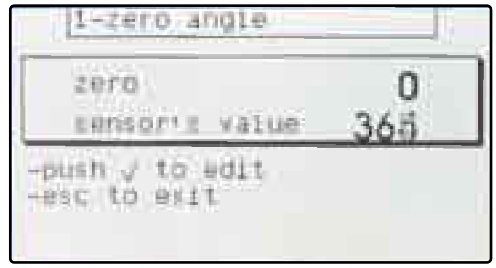
1. Navigate in the calibration menu using buttons (#2) or (#3)  or  to highlight the field **"memory"**.
2. Push the Select  (#4) button to confirm the choice.
3. Use buttons (#2) or (#3)  or  to highlight the desired memory management function.
4. Push the Select  (#4) button to perform the desired function.
5. When a specified function is done the system will return to the memory management menu automatically.
6. Push the ESC (#5) button to return to the main calibration menu. 

3.6 – Two-point angle sensor calibration

The angle sensor calibration routine is a two-point calibration.

3.6.1 - First point: Zero angle

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"Zero angle"**.
2. Push the Select button to confirm the choice. The system will display 2 lines of data. The first line is the boom angle, the second line is the angle sensor signal in term of "Bits".

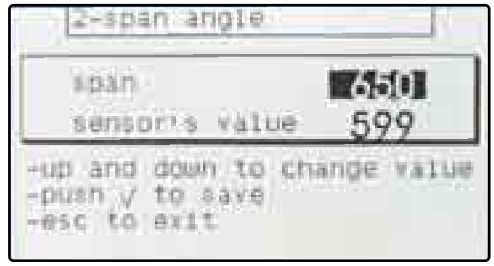


3. Boom down to minimum angle, ideally zero degrees (main boom parallel to ground). Measure the true boom angle using an independent precision angle indicator and note this value.
4. The value on the second line of the display must be close to 1400 "Bits" provided the boom angle is horizontal. To adjust this value, rotate the angle sensor on the boom. When the correct indication is shown on the display fix the sensor assembly permanently to the boom using the mountings provided.
5. The value on the first line of the display must match the true value noted with the inclinometer. To adjust this value push the Select (#4) button, the value on the first line will be highlighted. Use buttons (#2) or (#3) to adjust the indicated value of boom angle to read the actual boom angle recorded earlier.
6. Push the Select (#4) button to confirm the edited value.
7. When done, push the ESC (#5) button to return to the main calibration menu.

When you increase or decrease a value with button (#2 or #3) and press button ESC (#6), it will increase the speed by a factor of 100. Fast increase: (#2 and #6), Fast decrease (#3 and #6). These buttons may also be called "Set" buttons.

3.6.2 - Second point: Span angle

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"Span angle"**.
2. Push the Select button to confirm the choice. The system will display 2 lines of data. The first line is the boom angle, the second line is the angle sensor signal in term of "Bits".



3. Boom up to over 65 degrees (main boom referred to ground). Measure the true boom angle as before and note this value. The value on the second line should be close to 2400 Bits at 65 degrees.
4. The value on the first line must match the true value noted with the inclinometer. To adjust this value push the Select (#4) button, the value on the first line will be highlighted. Use buttons (#2) or (#3) to adjust the indicated boom angle to the actual boom angle you recorded earlier.
5. Push the Select (#4) button to confirm the edited value. The value displayed on the first line should be now the actual boom angle.
6. When done, push the ESC (#5) button to return to the main calibration menu.

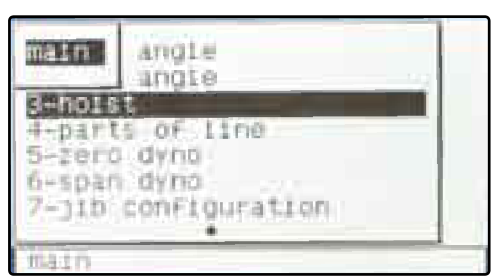
3.7 – Main hoist load calibration

Before beginning the main hoist load calibration, menu "calibration data" must be completed, refer to section 3.4.3 "calibration data" above.

3.7.1 - Hoist selection

To begin the main load sensor calibration, you must select the proper hoist. The hoist selection is done using the following procedure:

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"hoist"** and push the Select (#4) button to confirm the choice.
3. The system will display a selection of the hoists to calibrate in a window located at the upper left corner of the display. The main hoist is referred to as MAIN. Use buttons (#2) or (#3) to select the MAIN hoist.

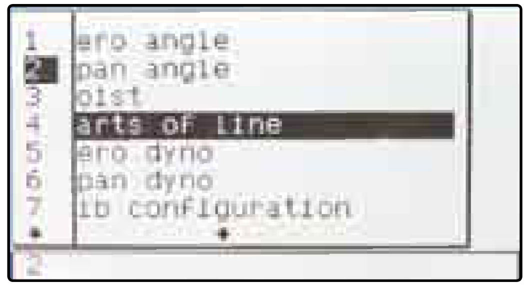


4. Push the Select (#4) button to confirm the selected hoist.

3.7.2 - Part of lines setting

The second step before calibrating the main load sensor is to specify the parts of line used for the calibration.

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"parts of line"**.
2. Push the Select (#4) button to confirm the choice.
3. The system will display a selection of parts of line in a window located at the upper left corner of the display. Use buttons (#2) or (#3) to select the actual parts of line used with the main hoist.



4. Push the Select (#4) button to confirm the selected parts of line. The system will change the value and will return to the main calibration menu automatically.

If the parts of line selection window has only one value displayed, the maximum parts of lines was not set in the menu "calibration data". Refer to that section before continuing.

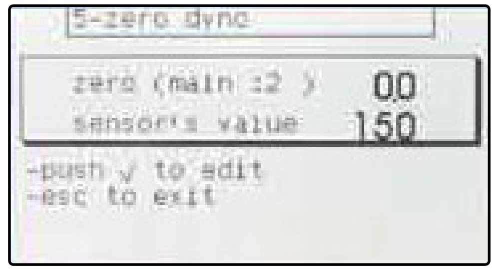
3.7.3 - Two-point Main load sensor calibration

At this point, the main load sensor is ready for calibration. Get the crane ready to lift the test load. The load should be near maximum line pull on the hoist line. The load sensor can be calibrated on any number of parts of line. However, to avoid mixing hoist line friction and rope reading fluctuations, it is preferable to calibrate the hoist line with the fewest parts of line possible.
The load sensor calibration is done using two points.

3.7.3.1 - First point: Zero dyno

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"Zero dyno"**.
2. Push the Select (#4) button to confirm the choice. The system will display 2 lines of data. The first line is the actual load (0 if not calibrated), the second line is the load sensor signal in term of "Bits".

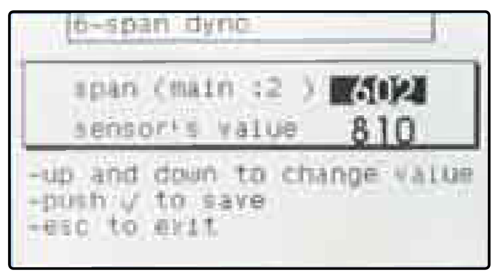
3. Lift a small test load that corresponds to approximately 10% of the maximum rated capacity for the current parts of line and crane configuration. The weight of the hook block may be sufficient. Use buttons (#2) or (#3) to enter the true value of the total suspended load (hook block, slings, hoist line below boom tip).



4. The value on the first line of the display must match the true value of the total suspended load (hook block, slings, hoist line below boom tip). To adjust this value push the Select (#4) button, the value on the first line will be highlighted. Use buttons (#2) or (#3) to adjust the indicated value to read the true value of the total suspended load.
5. Push the Select (#4) button to confirm the edited value. The system will prompt if the value is accepted or not. When the value is accepted, push the ESC (#5) button to return to the main calibration menu.

3.7.3.2 - Second point: Span dyno

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **“Span dyno”**.
2. Push the Select (#4) button to confirm the choice. The system will display 2 lines of data similar to that seen during zero dyno calibration.



3. Slowly lift a large test load (between 50% and 90% of the maximum rated capacity for the current parts of line and crane configuration) and then stop smoothly. The value on the second line of the display should be between 615 and 820.
4. The value on the first line of the display must match the true value of the suspended load (load, slings, hook block, shackles, hoist line below boom tip) in thousand pounds or kilos depending the units of measure selected (eg: 30000lbs is displayed as 30.00). To adjust this value push the Select (#4) button, the load value on the first line will be highlighted. Use buttons (#2) or (#3) to adjust the indicated value to read the actual value of suspended load.

5. Push the Select (#4) button to confirm the edited value. The value displayed on the first line should now be the actual lifted load.
6. When done, push the ESC (#5) button to return to the main calibration menu.

3.7.3.3 - Load accuracy verification

The required accuracy for actual load indication depends on local regulations, if in doubt consult Wylie Systems or your local authority.

Verify the weight displayed with the load suspended. Hoist up and stop at least 5 different heights. Lower and stop at least 5 different heights. Hoist at constant speed. Lower at constant speed.

Deposit the test load on the ground. Verify the display of weight of the hook block with no load. The value should be between 70% and 130% of the actual total weight including hoist line.

If consistent but inaccurate, it is possible that a fluctuation or a movement of the load while calibrating may have cause a load increase or decrease when pressing ENTER. Return to calibration mode and repeat menu “HOIST”, “PARTS of LINE”, “ZERO DYNO” and “SPAN DYNO”. Repeat the procedure as many times as necessary until the hook load with and without the calibration weight shows proper accuracy.

If the load reading varies unacceptably with direction of operation it may be necessary to fit rope direction sensing equipment and calibrate additional compensation factors to correct for hoist rope friction, refer to section 3.11 for details.

If the load reading is inconsistent even with one part line when stationary after hoisting or after lowering, the hoist line may be unevenly worn or simply uneven. To correct the problem, change the hoist line or change the load sensor. It may be possible to reconfigure the load sensor or replace it with a different model. Refer to load sensor technical specifications or obtain technical support to perform this task.

3.8 - Auxiliary or whip hoist calibration

The boom configuration has no impact on hoist calibrations. Therefore, the auxiliary or whip hoist calibrations can be done from the main boom head, manual extensions, rooster tip or from a jib.

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field " hoist ".

2. Select the hoist to be calibrated as described in section 3.7.1"Hoist selection". The auxiliary hoist is referred to as AUX, the whip hoists as whip1 or whip2.

3. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field " parts of line ".

4. Select the parts of line in use for the hoist selected as described in "parts of line setting" of the Main load calibration section.

5. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field "zero dyno ".

6. Calibrate the zero dyno point as described in "Calibration of the Zero dyno" of the Main load calibration section.

7. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field "span dyno ".

8. Calibrate the span dyno point as described in "Calibration of the Span dyno" of the Main load calibration section.

9. Verify the load accuracy as described in "Load accuracy verification" of the Main load calibration section.

Repeat for each load sensor fitted.

3.9 - Main boom operating radius calibration

Before beginning this section, Slew Offset and Sheave radius items of the sub-menu “calibration data” must be entered as described previously and the angle sensor must be calibrated.

The purpose of this calibration function is to set the parameters which will allow the i3000 system to calculate accurately the operating radius according to the crane configuration.
Before calibrating the operating radius with menu “basic boom length p1-2”, you must set the actual crane configuration ie boom configuration, head type, boom length and tare load used. Thereafter the calculated parameters will be referenced to this specific configuration (duty).
It is important to note that the basic main boom selected in the “jib configuration” menu must be calibrated before any other boom configurations including jibs or rooster. If the basic boom configuration is not calibrated, and another configuration is selected, the system will warn that it can’t proceed until the basic boom configuration is calibrated.

3.9.1 - Crane configuration setting

The crane configuration is defined as boom and jib configuration, head type, boom length and tare load. The following sections will explain how to set each crane configuration parameter.

3.9.1.1 - Jib configuration selection

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **“jib configuration”**.
2. Push the Select (#4) button to confirm the choice.
3. The system will display a selection of the jib configurations available to calibrate in a window located at the upper right corner of the display. Use buttons (#2) or (#3) to select the desired jib configuration but note the first calibration must be for a main boom duty – not a jib or rooster.
4. Push the Select (#4) button to confirm the selected configuration.
5. When done, push the ESC (#5) button to return to the main calibration menu.

3.9.1.2 - Head type selection

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"head type "**.
2. Push the Select (#4) button to confirm the choice.
3. The system will display a list of the boom head types available (eg taper tip or hammerhead) in a window located at the upper right corner of the display. Use buttons (#2) or (#3) to select the actual head type fitted.
4. Push the Select (#4) button to confirm the selected configuration.
5. When done, push the ESC (#5) button to return to the main calibration menu.

3.9.1.3 - Boom length selection

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **" boom length "**.
2. Push the Select (#4) button to confirm the choice.
3. The system will display a list of the boom lengths available in a window located at the upper right corner of the display. Use buttons (#2) or (#3) to select the actual boom length fitted.
4. Push the Select (#4) button to confirm the selected configuration.
5. When done, push the ESC (#5) button to return to the main calibration menu.

3.9.1.4 - Tare load setting

The purpose of the tare load is to take into account the weight of the hook block during unloaded boom deflection calibration.

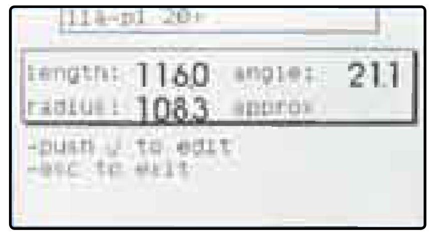
1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"tare load"**.
2. Push the Select (#4) button to confirm the choice.
3. The system will display the tare load variable. Push the Select (#4) button to highlight the variable for editing.
4. Use buttons (#2) or (#3) to change the value and push Select (#4) button once to confirm.
5. When the value is accepted by the system, push the ESC (#5) button to return to the main calibration menu.

3.9.2 - Two-point Operating radius calibration

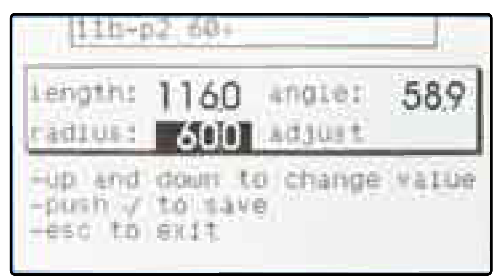
At this point, the operating radius is ready to be calibrated. Prepare the crane as specified in the crane's operating manual in a way to be able to move the boom freely.

The radius calibration computing routine needs 2 values of radius measured at 2 different boom angles in order to set the radius calibration parameters.

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"Basic boom length p1-2"**.
2. Push the Select (#4) button to confirm the choice. The system will display 2 lines of data. The first line shows the actual boom length selected plus the boom angle from the angle sensor. The second line shows the operating radius calculated by the system. The system will automatically start the routine with the first point to calibrate called "P1 - 20°".



3. Look at the boom angle display and bring the boom down to between 15 and 20 degrees.
4. Measure the actual radius according to the calibration units selected in the menu "Calib. Unit", ie imperial or metric. If it's imperial use feet and decimals of feet, otherwise if it's in metric use metres and centimetres. Note this value.
5. Push the Select (#4) button highlight the radius variable for editing.
6. Use buttons (#2) or (#3) to adjust the variable to match the value previously measured and push Select (#4) button once to confirm when done. The system will automatically continue the routine with the second point to calibrate called **"P2 - 60°"**.



7. Look at the boom angle display and bring the boom up to between 60 and 65 degrees.
8. Measure the actual radius according to the calibration units selected in the menu "Calib. Unit". Note this value.
9. Push the Select (#4) button to highlight the radius variable for editing.
10. Use buttons (#2) or (#3) to adjust the variable to match the value previously measured and push Select (#4) button once to confirm when done. The system will return to point "P1 - 20°", at this stage the radius value should display the real value.
11. Push the ESC (#5) button to return to the main calibration menu.

3.9.3 - Check point

At this stage, the entire system should work properly up to the configuration calibrated. Push the ESC (#5) button to return to the normal operating mode. Use the DUTY or PART buttons to configure the crane properly. Verify the radius, the angle and the load display at two different boom angles. For capacity comparison, use the load table matching the crane configuration selected in the system and interpolate between radii if the system is set up to interpolate.

3.10 - Jib operating radius calibration

All crane configurations listed in menu “Jib configuration” must be calibrated in the same manner as the main boom in terms of operating radius. The only exception is for the Load bend correction “ load bend correction” which is only relevant for configurations which include lifting over a jib.

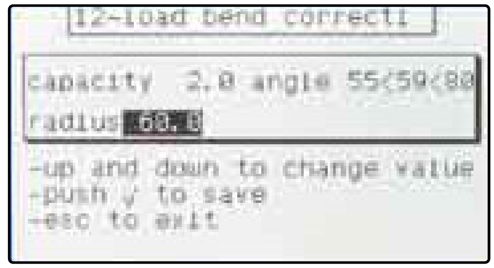
The jib operating radius calibration is done using the following procedure for each jib configuration.

1. Rig the crane according to the desired configuration.
2. Set the crane configuration parameters (Jib configuration, head type, boom length and tare load) as described previously for the basic main boom.
3. Calibrate the operating radius with menu “basic boom length p1-2” following the same procedure used for the basic main boom.

3.10.1 – Loaded Boom deflection calibration

When the operating radius calibration has been performed for a jib, a boom deflection calibration must also be done.

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field “load bend correction”.
2. Push the Select (#4) button to confirm the choice. The system will display the permissible load, boom angle, the actual operating radius calculated by the system.
3. Look at the boom angle display and bring the boom to the expected angle or between 55 and 80 degrees depending on software revision.



4. Lift a load between 50% and 100% of the crane capacity for this configuration at this angle.
5. Measure the actual radius according to the calibration units selected. It should be either equal to or slightly greater than the displayed radius. Take note this value.
6. Push the Select (#4) button to highlight the radius or angle correction factor variable for editing depending on software revision. In some software revision there is a percentage sign beside the angle correction factor ignore it, the correction factor is a scaled multiplier. Increase it or decrease until you get the appropriate radius value.
7. Use buttons (#2) or (#3) to adjust the variable to match the value previously measured and push Select (#4) button once to confirm when done.
8. Push the ESC (#5) button to return to the main calibration menu.

3.11 - Friction compensation

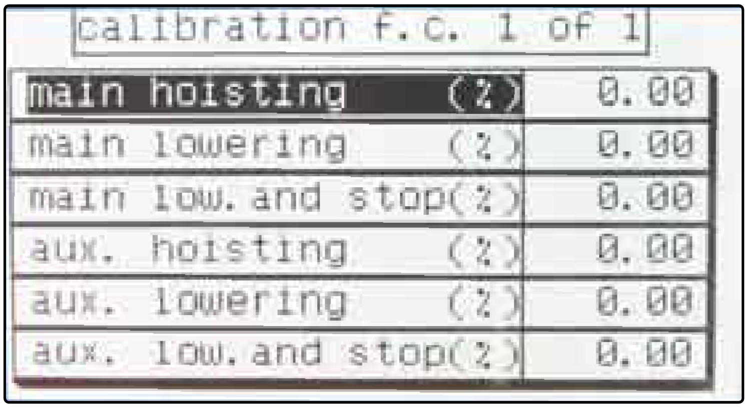
While a load is being hoisted up, some friction is created by the sheaves. This friction puts more stress on the rope and, as a result, on the load cell. Therefore, the load displayed by the i3000 is the sum of the load and the friction in the sheaves. The friction is proportional to the number of sheaves, so this can become a problem on lattice cranes when multiple parts of line are used.

While lowering the load, the friction will try to hold back the load. The load displayed by the i3000 is the difference between the weight of the load and the frictions in the sheaves. In the lower and stop condition, the load displayed by the i3000 is the difference between the weight of the load and the residual frictions in the sheaves. In the hoist and stop condition the friction problem still exists but since the load calculated by the i3000 is calibrated in the hoist and stop condition there is no need to compensate.

The Rope Direction Sensor (RDS) is used to tell the i3000 the movement of the rope (hoisting, hoist and stop, lowering, lower and stop). By setting the main hoisting, lowering and lower and stop values in the calibration mode of the i3000 to the proper values, the actual load will be calculated and corrected by the i3000 during movement of the load.

3.11.1 - Friction compensation factors description

Use the sub-menu "16 – friction compensation " screen to access different variables used for friction compensation when rope direction sensors are fitted. These values are described in the following table.



Main hoisting	Compensation factor for hoisting state on main hoist.
Main lowering	Compensation factor for lowering state on main hoist.
Main low and stop	Compensation factor for lowering and stop state on main hoist.
Aux hoisting	Compensation factor for hoisting state on auxiliary hoist.
Aux lowering	Compensation factor for lowering state on auxiliary hoist.
Aux low and stop	Compensation factor for lowering and stop state on auxiliary hoist.

If rope direction sensors are not fitted to your system, all of these variables must stay at zero (0) value.

3.11.2 - Friction compensation factors calculation

The i3000 must be fully calibrated before attempting to determine the friction compensation factors.

Hoist a load with the main hoist at constant speed. While the load is being hoisted up, look at the displayed load and write down the peak load (Lp). Stop hoisting and write down the load (L). Use the following equation to calculate the friction compensation while hoisting:

$$\text{Main hoisting} = \frac{(L / Lp) - 1 \quad * \ 100\%}{\text{Parts of lines used}}$$

Lower the load at constant speed. While lowering the load, look at the displayed load and write down the lowest load (Lmin). Use the following equation to calculate the friction compensation while lowering :

$$\text{Main lowering} = \frac{(L / Lmin) - 1 \quad * \ 100\%}{\text{Parts of lines used}}$$

Stop the load above the ground. The load displayed is Ls. The compensation for the lower and stop condition is :

$$\text{Main lower and stop} = \frac{(L / Ls) - 1 \quad * \ 100\%}{\text{Parts of lines used}}$$

3.11.3 - Entering friction compensations factors

Enter a friction compensation setpoint as follows:

1. Navigate through the calibration menu using buttons (#2) or (#3) to highlight the field **"friction compensation"**.

2. Push the Select (4) button to confirm the choice.

3. Use buttons (#2) or (#3) to select the desired variables to edit.

4. Push the Select (#4) button to obtain the setting mode. Use buttons (#2) or (#3) to change the value and push Select (#4) button once to confirm. Then scroll to the next variable and repeat the procedure.

5. When all friction compensation factors are entered, push the ESC (#5) button to return to the main calibration menu.

Repeat the friction compensation calibration for the auxiliary hoist if required. Note, this option is not available for load inputs 'whip1' and 'whip2'.

Calibration of the system is now complete. It is recommended that a calibration memory backup is done after each successful calibration step and particularly when complete.

Notes

This page has been intentionally left blank

This page has been intentionally left blank

This page has been intentionally left blank