

PHASE FINDER USER MANUAL

PHASE FINDER



HAYSYS LIMITED

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1 SAFETY AND WARNINGS

1.1 Lithium-Ion Battery

Please observe the following warnings, as the PHASE FINDER batteries contains lithium that may cause heating rupture or ignition if not used correctly.

THE PHASE FINDER UNIT IS NON-USER SERVICABLE AND NO ATTEMPT SHOULD BE MADE TO CHANGE THE LITHIUM-ION BATTERY.

The PHASE FINDER contains a Lithium-Ion Battery and must not be packaged or transported if damaged. The charging time from a discharged state to a fully charged state is 5 hours with the battery supplying sufficient power to the PHASE FINDER to enable operation for a minimum of 12 hours from a fully charged state.



2 PHASE FINDER SHIPPING

2.1 Package Contents

The supplied PHASE FINDER package includes the following items:

- | | |
|--|------------------------|
| a. PHASE FINDER unit | Part Number: H00581 |
| b. USB Lead, Type A Plug to Type B Plug, 2m, Black | Part Number: MC002725 |
| c. 240V Mains to USB Charger, Quick Charge 3.0 | Part Number: MGXW151QB |
| d. PHASE FINDER Carry Case | X33080 |

3 BUTTONS AND INDICATIONS

The PHASE FINDER unit has been designed so that user interaction is kept to a minimum whilst providing clear phase indication. However, to further aid the user, additional functionality and displays have been provided but this is deliberately kept to a minimum.

Table 1 - Table of Buttons and Indications	
BUTTON LABEL	FUNCTIONS
ON/OFF	a) Turn on. Press for more than 3 seconds and release. b) Turn off. Press for more than 3 seconds and release. c) Wake-Up. Press to activate the favourite buttons.
<i>Rotate</i> SET REF	a) Press and release to set/unset Phase Reference (when setting, 20 second timer starts as indicated by the left Green LED. The left Green LED will go off after 20 seconds and the reference will set, indicated by the illuminated phase vector. b) When pressed with 'Shift', the reference will rotate clockwise one phase at each press.
UPLOAD	a) A short press causes the PHASE FINDER to perform an Upload of data to the Remote Reference Unit (RRU) location, indicated by the left Green LED. b) An Upload is also sent to the Remote Reference Unit (RRU) when the PHASE FINDER is first turned on.
<i>Shift</i> BATTERY	a) A short press and release will cause the Battery Charge thermometer to be displayed. This is the same for both when the unit is on or off. b) When the unit is off but in Wake-Up mode and the 'BATTERY' button is pressed the battery charge will only be displayed for 5 seconds. When the unit is turned on and the 'BATTERY' button is pressed the battery charge will remain displayed until the button is pressed again.
ELECTRIC FIELD	Gradient display showing the Electric Field strength being detected.
SATELLITES/BATT	a) Gradient display showing the number of Satellites in view by the unit. b) Thermometer display temporarily showing the Battery Charge status, when 'BATTERY' button is pressed.
Red LED	Red LED turns on indicating the unit is going through its power-up or power-down cycle.

Table 1 - Table of Buttons and Indications	
BUTTON LABEL	FUNCTIONS
Amber LEDs	Button press confirmation. ON/OFF amber LED flashing indicates the unit is going through its power-up or down cycle.
Left Green LED	a) The PHASE FINDER is performing a data upload. b) Indicates that the 20 second reference setting timer is running.
Right Green LED	Indicates when the PHASE FINDER is connected to the Remote Reference and receiving data.
Blue LED	Indicates when the unit is charging. This LED will not show when the unit is in 'sleep-mode'
Help & Support	Should you have any issues with your unit(s), support can be requested directly from HAYSYS Limited, by emailing help@haysys.co.uk , quoting your model number, serial number and a brief description of the problem.

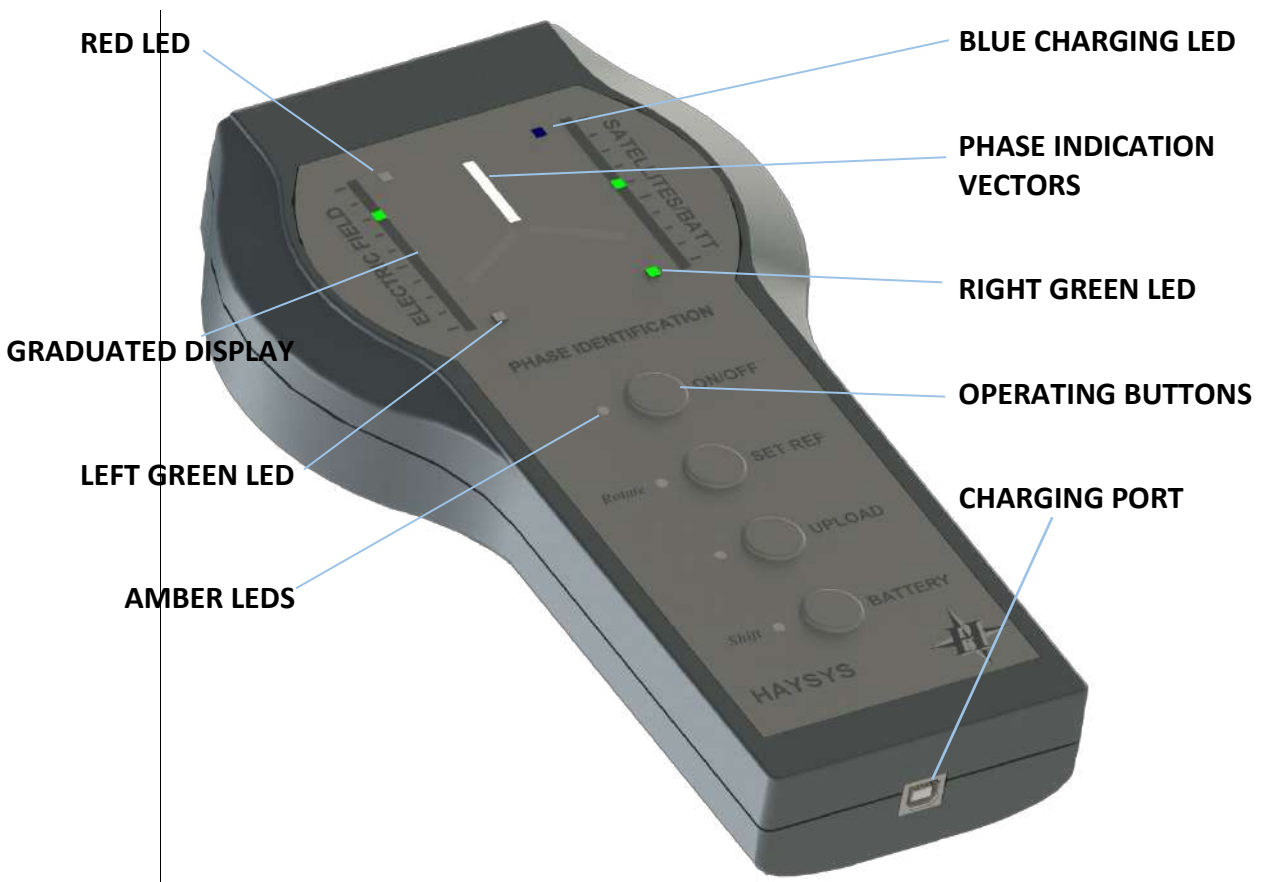


Figure 1 - Front Panel Buttons

4 THEORY OF OPERATION

4.1 General Operation

The purpose of the PHASE FINDER is to identify the connected electrical phase of a residential or commercial property without entering the property or connecting equipment to the property.

Equally, there is no requirement to install any equipment within the local substation.

Figure 2 below, shows the context in which the PHASE FINDER is used and the various data connectivity the unit uses to achieve this identification.

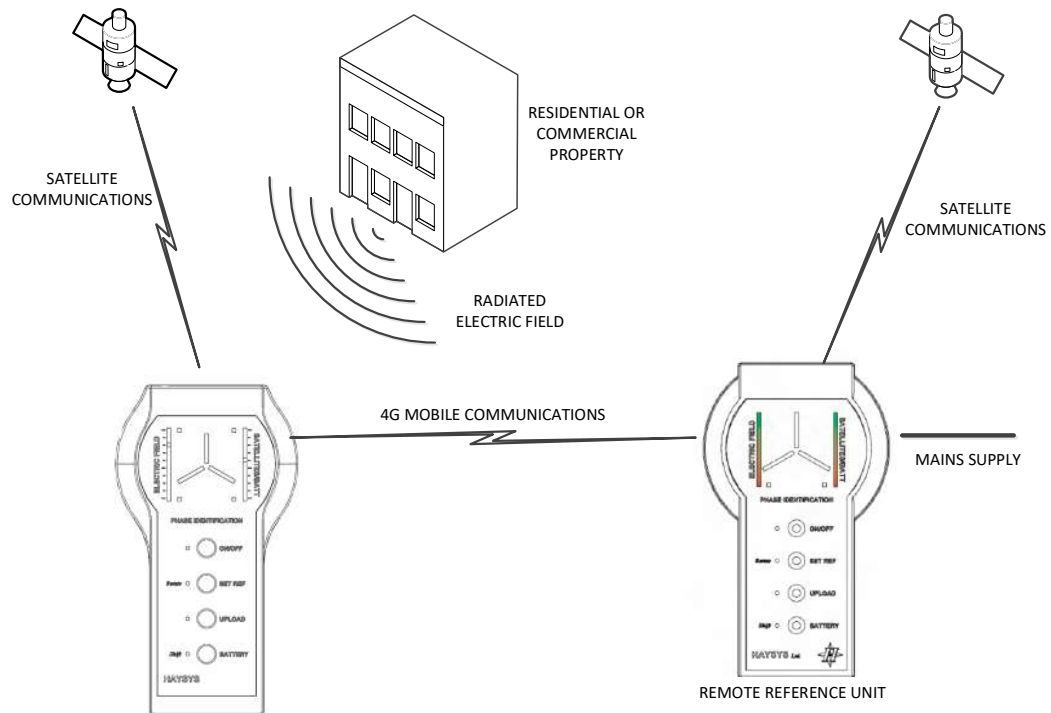


Figure 2 - Theory of Operation – PHASE FINDER Context

The PHASE FINDER is able to measure the instantaneous phase of the electrical field being radiated by any property. The original source of this radiation does not have to be the properties internal electricity meter, but can be any live cable, including the electrical connection to internal lights, sockets and any external lights.

The PHASE FINDER is then time synchronised with a remote reference unit that is also measuring the instantaneous phase of the mains supply connected to it. The remote reference unit then communicates this phase measurement (along with other data, such as GPS time), to the PHASE FINDER using the integral mobile communications link.

The time synchronisation between the PHASE FINDER and the Remoter Reference Unit is achieved through the 1-second timing provided by the GPS Satellites. This is a very accurate timing reference source.

With the two units in synchronisation and communicating, the PHASE FINDER compares both sets of data and is able to determine and display the properties connected phase, within 10 seconds.

The PHASE FINDER measures the instantaneous phase that varies with the changes in the mains frequency. However, since the same frequency variation is also seen by the Remote Reference Unit, the variation is cancelled out.

NOTE: A Remote Reference has been installed within the United Kingdom, Ireland and in Jersey. The UK reference provides the phase reference for all Phase Identification Units used in the UK and the Jersey reference provides the phase reference for all of the Phase Identification Units being used anywhere across Europe.

The measured phase is required to be within $\pm 30^\circ$ of one of the three display vectors that are separated by 120° , in order to display the vector on the unit.

The measured phase can be uploaded to the SQL Server database at the location of the RRU, by pressing UPLOAD and releasing the button. An example of the data uploaded is shown at the HAYSYS Electrical website (<http://electrical.haysys.co.uk>) below:



PIU Upload Report Details	
Upload ID	304
Unit Serial Number	000048
Upload Date Time	23/12/2018 13:54:26
Phase	L0
Latitude	50.92561766 View In Google
Longitude	-1.51750866
Status	Active
Number Satellites	6
Horizontal Dilution of Precision	1.42
Raw Phase	123
Ref Phase	1
PIU Version	
SIMS Job Number	
Job Type	
Feedback	
Edit New Delete	

As shown above, the data includes the unit serial number, Date/Time, the measured Phase (L0 is no phase measured), the GPS co-ordinates, further satellite information.

4.2 Location of the Remote Reference Unit

Traditionally, other systems require a reference unit to be installed within the local substation. This is not the case with the HAYSYS PHASE FINDER. **Only a single Remote Reference Unit is required for the whole Distribution Network.** The only need for an additional reference unit is when one Distribution Network is not Phase Synchronised with the Distribution Network where the PHASE FINDER is being used (e.g. using the PHASE FINDER in Europe and connecting to a Remote Reference Unit installed within the UK). HAYSYS has a Remote Reference Unit installed at its offices in Cardiff, along with a further reference installed in Jersey. This is sufficient to allow PHASE FINDER users to operate the PHASE FINDERS anywhere within the United Kingdom and across Europe.

Customers can also purchase their own Remote Reference Unit if they so wish, but this is not necessary.

Should a phase change be present between two points across a single Distribution Network, then the HAYSYS PHASE FINDER allows the phase reference to be offset locally from the Remote Reference Unit. The unit also accepts changes due to Y-DELTA connections. The PHASE FINDER operator can rotate the phase reference stored within the PHASE FINDER to correct for this phase change (see section 5.4 to see how to do this).

It is recommended that prior to its use, the phase indicated by the PHASE FINDER is confirmed to be correct by measuring the phase of a known point (this could be within the substation or any other property where the phase is known to be correct). If it is not, then the reference phase of the PHASE FINDER should be rotated until the PHASE FINDER indicates the correct phase.

5 USING THE PHASE FINDER

5.1 Checking the battery charge state

The charge state of the internal PHASE FINDER Battery can be checked, whilst powered down, with a short press of the 'ON/OFF' button to 'wake-up' the unit followed by a short press on the 'BATTERY' Button. The charge state will be displayed on the graduated display labelled 'SATELLITES/BATT'. The charge state will be displayed for 5 secs, before returning to the original display when the unit is turned off. The charge state can be checked with the unit turned on or off. When the unit is turned on the charge display will remain on until the 'BATTERY' button is pressed again.

5.2 Turning the Unit On

Press ON/OFF button for three seconds or more and then release. The unit will then commence its power up sequence, indicated by the Red LED and the 'ON/OFF' amber LED will flash. The sequence will be completed when all three phase vectors are illuminated completely. The unit will also confirm its connectivity to the RRU by showing the right green LED. Once the unit is receiving data from satellites, it is ready to have its reference set or use to determine phase connections.

Once the unit has satellites in view (as indicated by the 'SATELLITES' gradient display), the unit will automatically upload its position and create three records within the system SQL Database, 4 seconds apart. During this process, the left-hand Green LED will be shown.

When the unit is turned off it is in 'sleep-mode', the favourite buttons do not have any function. To 'wake-up' the unit the 'ON/OFF' button must be pressed, now the favourite buttons are active, indicated by the corresponding amber LEDs

NOTE: if the reference phase has been previously set then the unit will remember this and after a short period following its power cycle, will turn off the phase vectors or display a single vector if within the proximity of a detectable cable.

5.3 Turning the Unit Off

Press the ON/OFF button for three seconds or more and then release. This will cause the unit to start its power down sequence, indicated by the Red LED and the 'ON/OFF' amber LED will flash, which will turn off all LED indications when completed.

5.4 Setting the Reference Phase

In order to set the reference phase, the unit must be in communication with the Remote Reference Unit and have a GPS lock, as indicated by the right-hand green LED and the display of the number of Satellites respectively.

With the PHASE FINDER On, hold the PHASE FINDER close to a single-phase powered item (e.g. substation fuse holder, lighting switch etc.), where the phase of the powered item is known. The Electric Field signal level should be showing near to a maximum signal level. Press and release the 'SET REF' button. The unit will respond by starting a 20 second timer, indicated by the left-hand Green LED showing. Once the 20 second timer has expired, the left-hand Green LED will go off

and the unit should respond by leaving only the vertical phase vector illuminated. If the unit does not turn off the other phase vectors then this indicates that the unit has been unable to identify a single-phase field free of interference from other phases. In this case, the user should repeat the procedure or set the phase at a different location.

To unset the Reference Phase of the unit, press and hold the 'SET REF' for three or more seconds. All three phase vectors should be illuminated, the unit is now ready for the phase reference to be set again.

NOTE: If the known phase corresponds to the phase vector being displayed (e.g. Red phase or L1), then the reference phase will not need to be rotated (as described in the section 5.5).

5.5 Rotating the Reference Phase

With the reference phase set but the unit is displaying the incorrect phase vector, Press and hold the 'Shift/BATTERY' button and then press the 'Rotate' button briefly and release both buttons. The unit will respond by rotating the phase vector clockwise to the next phase vector. Repeating this procedure will rotate to the next phase vector and so on.

5.6 Measured Phase Indications

In this section, it is assumed that the reference phase of the PHASE FINDER being used has been set (see sections 5.4 and 5.5 for further details).

Place the unit as close as possible to the property or equipment where the single phase is being determined. If the unit can identify the phase of the measured Electric-Field, then it will illuminate the corresponding phase vector. If the Electric-Field is weak, the sensitivity of the PHASE FINDER can be improved by fitting the external Electric-Field probe (supplied).

For the user to be confident that the displayed vector is the correct phase, the displayed vector must remain illuminated for a minimum of 10 seconds.

The single phase of the property or equipment supply has been identified and displayed.

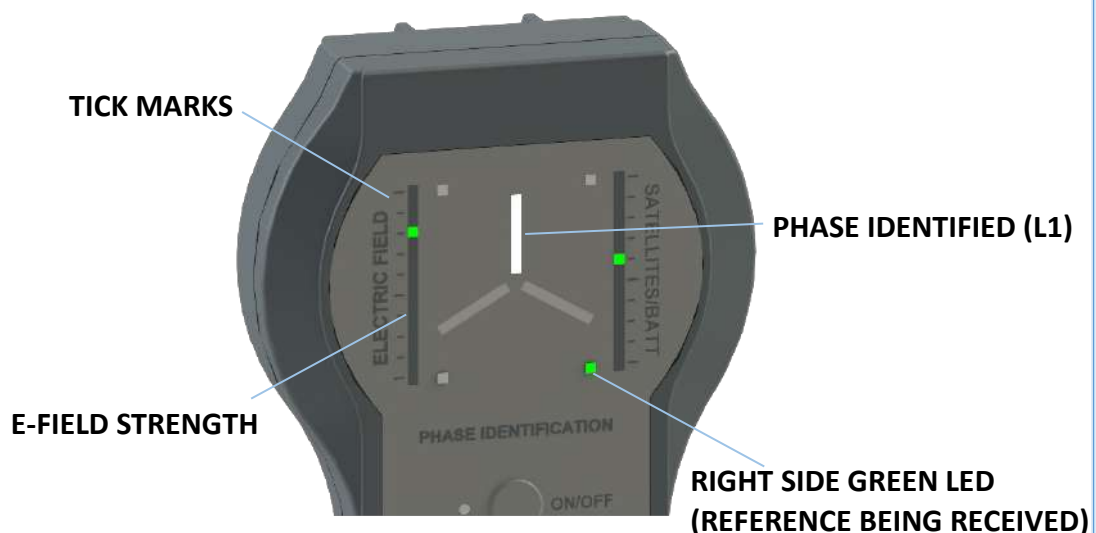


Figure 3 - Phase Indication Vectors

Whilst the PHASE FINDER is displaying the identified vector, a press and release on the 'Upload' button will upload and create a data record in the SQL Database indicated by the left-side Green LED. This data will include the measured phase, date/time, the number of satellites in view etc.

5.7 Error Indications

The PHASE FINDER requires a minimum level of data and battery charge in order to operate.

5.7.1 Low Battery Charge

The unit's battery charge level is indicated by 'SATELLITES/BATT' display when the 'BATTERY' button is pressed. If the unit is not sufficiently charged, then it will not successfully complete its power up procedure when initially switched on.

The unit should be placed on charge with either the mains D.C. 12V power supply (supplied) or by using a high current (1A or greater) USB charger (see section 6 for further details).

5.7.2 No Reference Received

If the PHASE FINDER is not receiving data from the reference unit, then a phase cannot be determined. This can be caused by either the remote reference unit not being operational or communications with it is not operational.

Loss of reference data from the Remote Reference Unit is indicated by the right-side Green LED not being on. If the Red LED is on, this indicates that communications with the reference have failed and the unit is trying to re-establish communications.

5.7.3 No GPS Signal

If the unit has lost communications with the GPS Satellites, then the 1 second reference timing pulse will not be available. In this situation, the unit will use its internal 1 second reference and continue to provide a reference indication.

The number of Satellites 'in view' by the unit is indicated on the 'SATELLITES/BATT' gradient display.

If no Satellites are in view then the tips of the Phase vectors (if showing), will also flash on and off.

6 CONNECTIVITY

The PHASE FINDER has a full speed USB 2.0 Interface located at the base of the unit.

The PHASE FINDER is charged from the USB Connector.

7 UPLOADING PHASE MEASUREMENT DATA

A press on the 'Upload' button transmits the PHASE FINDER data back to the reference and creates a new record within the system SQL Database. These records can then be viewed on the HAYSYS Electrical website (<http://electrical.haysys.co.uk>).

This information includes the GPS position of the PHASE FINDER at the time of the Upload button press, along with the date/time. Having access to this information, allows the import to third party software, such as to overlay the identified phase in a Geographical Information System (GIS).

8 CHARGING

8.1 Charging Voltage and Details

The PHASE FINDER has the capability to be charged via its USB connector. The unit is supplied with a standard 240V mains to USB Charger.

The PHASE FINDER is fitted with a USB 2.0 connector that in addition to providing communications to a USB Host, can also be used to charge the unit. The charging circuits inside the PHASE FINDER are intelligent and will recognise the type of charger connected and charge at the appropriate charging current. This minimises the charging time for the PHASE FINDER.

9 MECHANICAL DETAILS

The outline dimensions of the PHASE FINDER are shown in Figure 20 below. The PHASE FINDER reference unit also uses the same case and therefore has the same outline dimensions.

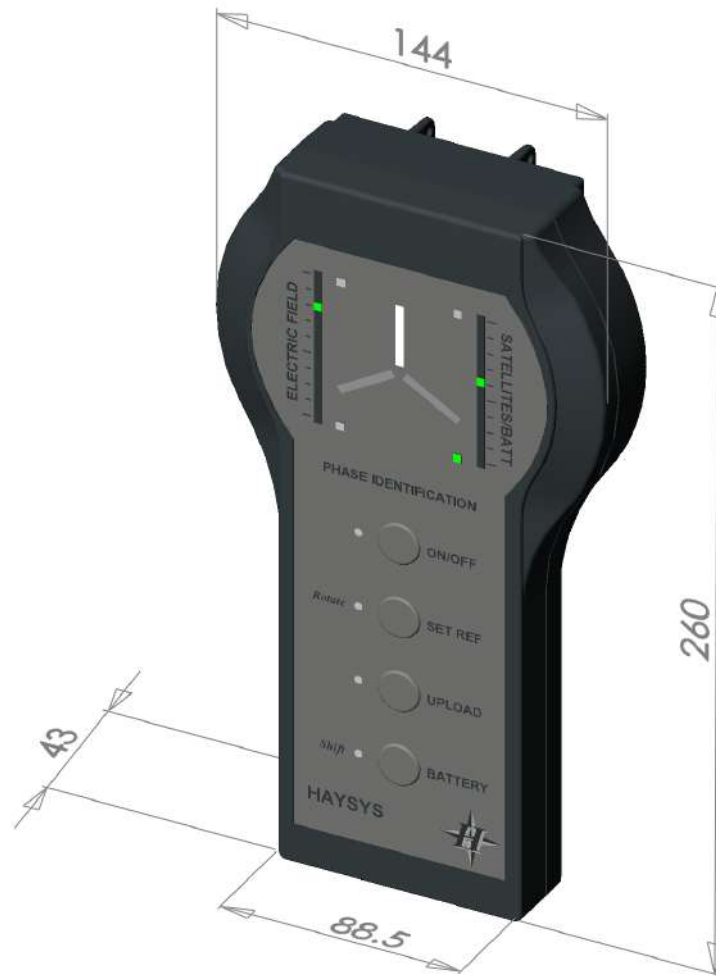


Figure 4 - PHASE FINDER and Reference Dimensions

The PHASE FINDER unit weighs 1 Kg, including the battery.

9.1 Environmental Protection

The PHASE FINDER is rated to IP65. This protects the unit from both dust and water splash ingress. The unit should only be charged indoors or from within a covered vehicle.

9.2 Insertion and Removal of SIM Card

The PHASE FINDER uses a standard size SIM card that is inserted into the SIM Card Holder, that is mounted on the internal Circuit Board within the unit. The internal board is accessed by removing the six screws at the rear of the unit, as shown in Figure 5 below.



Figure 5 - Access screws

10 THE PHASE FINDER UTILITY APPLICATION

10.1 Configuring the PHASE FINDER and SIM Card Connection

In order to configure a PHASE FINDER, the unit must be placed into its configuration mode, with an active SIM card installed (see section 9.2 for details). With the unit powered off, press and hold the 'shift' button and then press 'ON/OFF' for 3 seconds or more, then release both buttons. The unit will power up into its configuration mode as indicated by the amber shift LED staying on. The unit may now be plugged into the host PC using the supplied USB cable.

On checking the Device Manager of the Host PC that the PHASE FINDER is connected to, the PHASE FINDER Device will be listed under the Ports (COM & LPT) section along with its allocated COM port number – COM3 in the example shown in Figure 8 below.

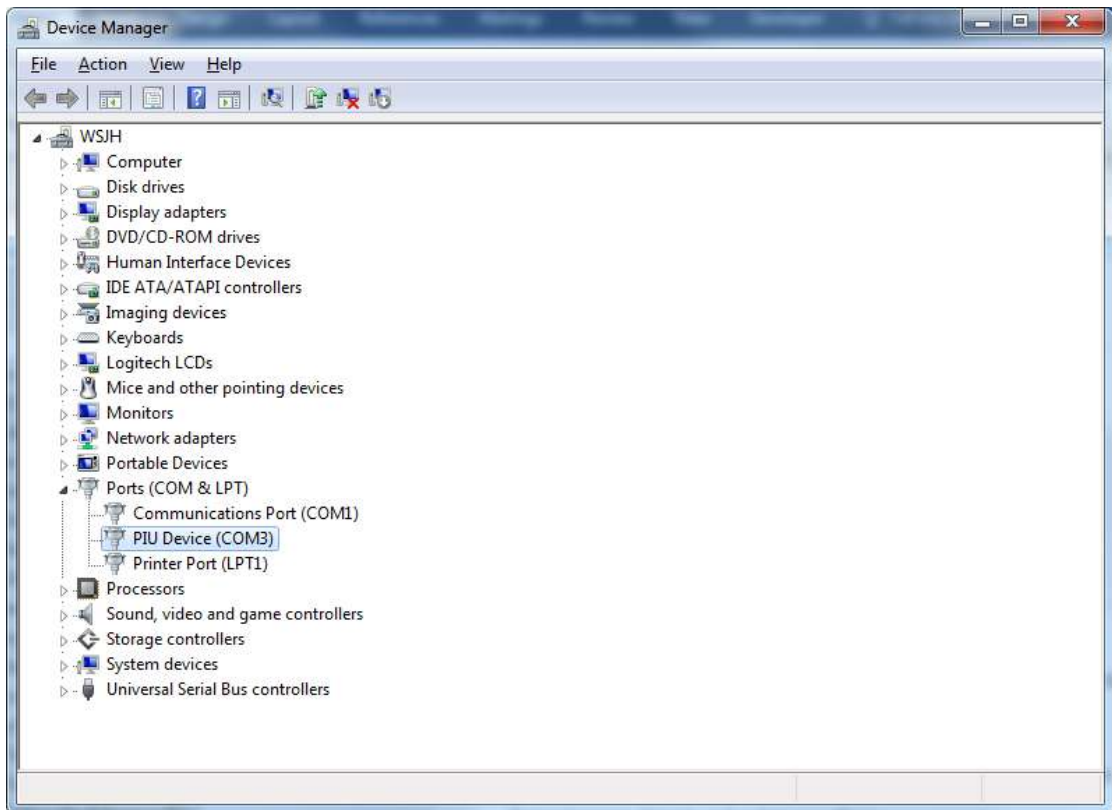


Figure 6 - Device Manager Screen

The HAYSYS PHASE FINDER application can now be started and the 'Scan for devices' button pressed. The application will respond by automatically identifying if the connected unit is a PHASE FINDER or a Remote Reference Unit (RRU).

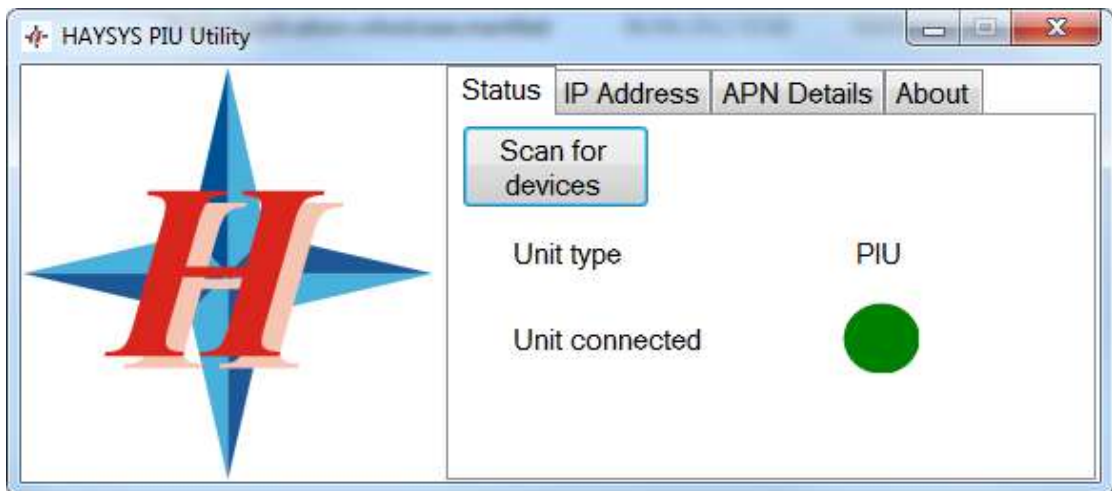


Figure 7 - PHASE FINDER connected

Next, select the IP Address tab and enter the external static IP address and port of the Remote Reference Unit (RRU) to be used with the PHASE FINDER. Press the 'Save' button and ensure that the button changes to the green colour as shown in Figure 10 below.

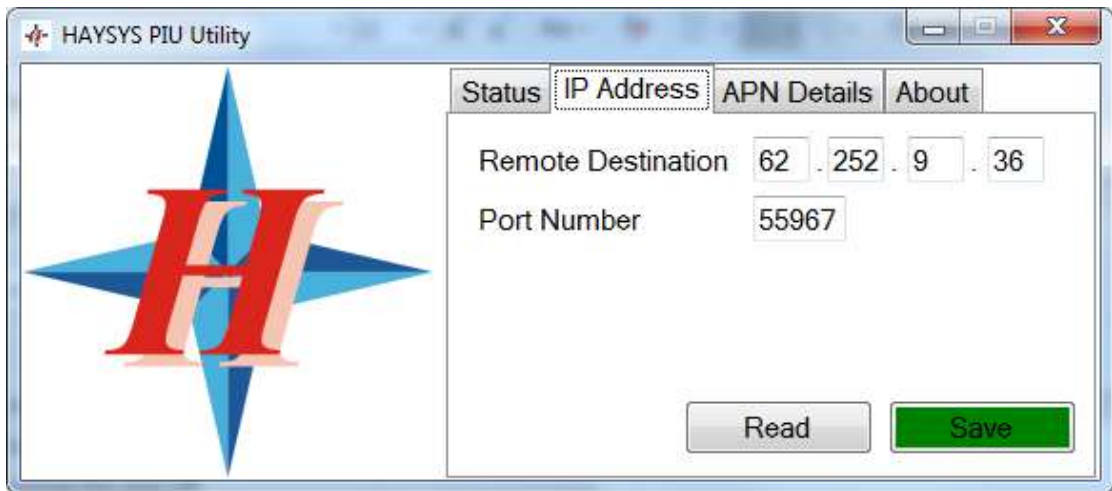


Figure 8 - IP Address details entered and saved

Next set the Access Point Name (APN) Details by selecting the 'APN Details tab'. Here, enter the APN details for the mobile carrier's SIM Card that will be used in the PHASE FINDER.



Figure 9 - PHASE FINDER APN Details

Press the 'Save' button and ensure that the button changes to the green colour.

The PHASE FINDER configuration is now complete and the unit can be fully powered up by pressing the 'Shift' button for 3 seconds, or more, to place the unit into its operational state.

10.2 Setting up the Remote Reference Unit

If a Remote Reference Unit is to be used, then this section details how the HAYSYS PHASE FINDER Utility is used to perform the data 'bridge' between the IP Address and the USB port on the RRU.

NOTE: The PHASE FINDER Utility must be running on the Host PC at all times when the PHASE FINDER units are being used in the field.

As with the PHASE FINDER configuration procedure, connect the RRU to the host PC via the supplied USB cable. Start the PHASE FINDER utility application on the host PC and press the 'Scan for device' button. The utility will automatically identify the connected RRU as a reference unit as shown in Figure 12 below.

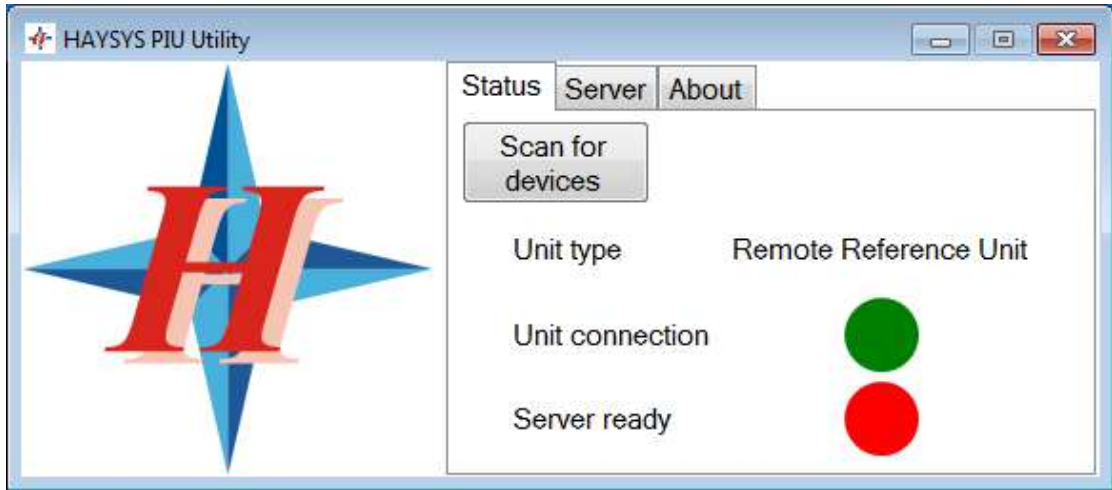


Figure 10 - Reference Unit connected

Next, set the server address by selecting the 'Server' tab and entering the IP address of the host PC. The IP address can be 'discovered' by clicking on the 'Discover' button. This will automatically enter the IP address of the host PC or present a 'drop-down' list, if multiple IP Addresses are discovered. Next enter the port number to be used, as shown in Figure 13 below.

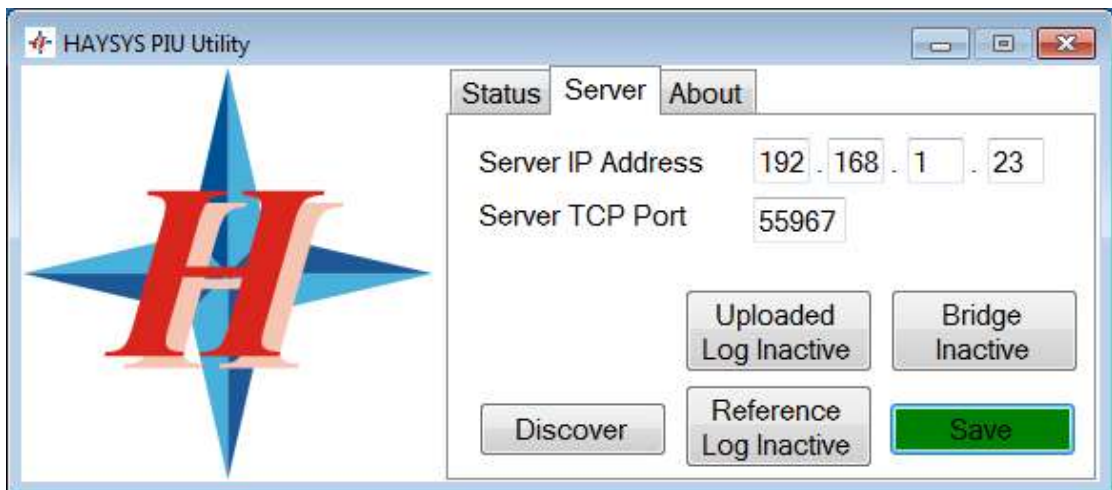


Figure 11 - Bridge Server details

Note: The IP address of the server must be accessible from outside of the customers internal network. The example shown in Figure 13 above shows the internal IP address of the host computer. In this example, the external IP address and port is re-directed to an internal IP address.

Press the 'Save' button and confirm that the green colour is shown.

Next, activate the bridge server by pressing the 'Bridge Inactive' button, which will respond by the button text changing to 'Bridge Active' as shown in Figure 14 below.

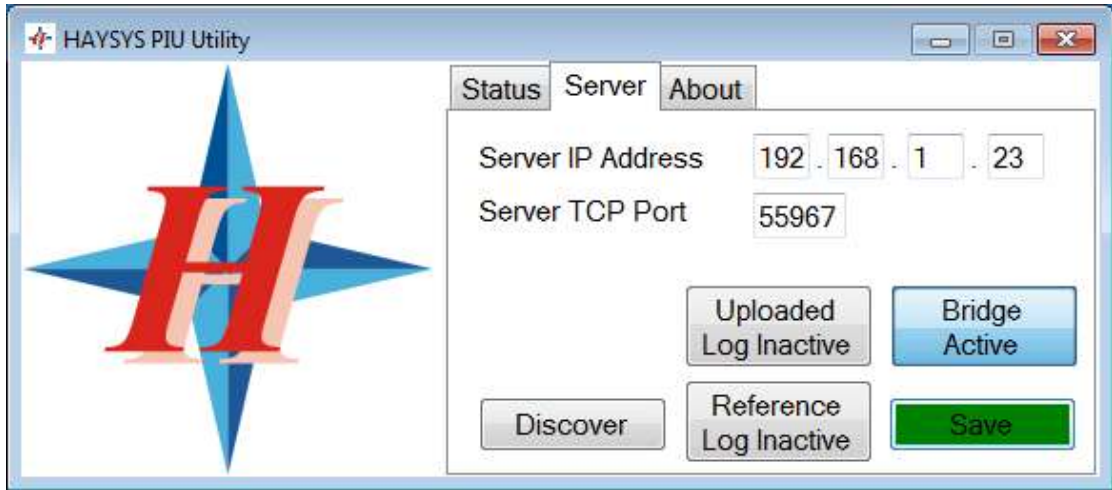


Figure 12 - Bridge Server Active

Next, select the 'Status' tab to show the status of the bridge server. This should look the same as Figure 15 below. The number in the centre of the green 'Server ready' indication, shows the active count of PHASE FINDERS currently connected and communicating with the bridge.

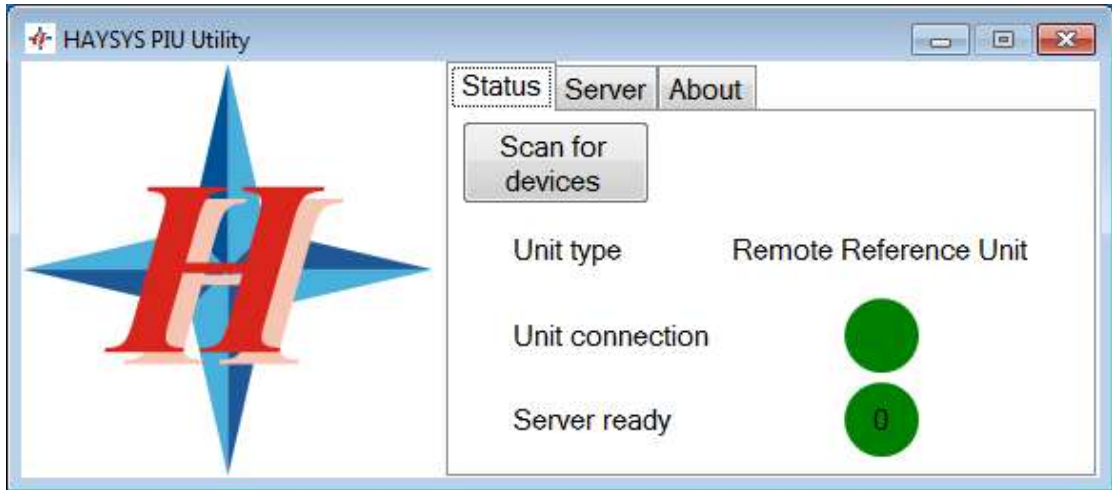


Figure 13 - Bridge Server

10.3 Closing the PHASE FINDER Utility Application

The PHASE FINDER application can be closed by clicking on the cross in the red box in the top right corner. There will be two warnings shown, the first is shown in Figure 16 below, asks if the application should be minimised or closed. The second warning, shown in Figure 17 below, seeks final confirmation of the closure.

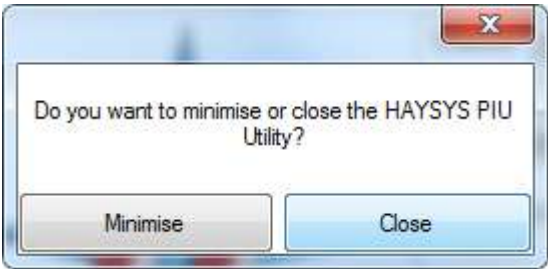


Figure 14 - Closing the PHASE FINDER Utility

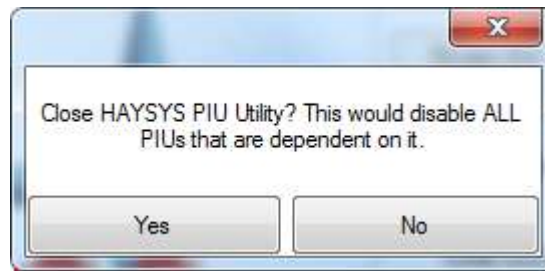


Figure 15 - Closing the PHASE FINDER Utility warning

11 REMOTE REFERENCE UNIT

As detailed in section 3, the determination of the measured phase requires communications with a Remote Reference Unit. The unit can provide immediate phase indication if the communications with the Remote Reference Unit is available.

NOTE: The Remote Reference Unit is not installed into the local substation. The Remote Reference Unit only needs to be installed at a point where the Supply Network is synchronised. For example, the supply network across the United Kingdom is synchronised and therefore the Remote Reference Unit can be installed at any location anywhere in the United Kingdom. There is already a Remote Reference Unit installed at the HAYSYS Offices in Cardiff and all UK based PHASE FINDERS can communicate with this Remote Reference Unit.

The Remote Reference Unit is for indoor use only.

If required, a Remote Reference Unit can be supplied and installed within the customer's own premises. The Remote Reference Unit has a different mains charger socket (a 2.5mm socket) and different firmware installed.

The reference unit does not use the E-Field Probe to measure the local phase, but the connected A.C. mains charger instead.

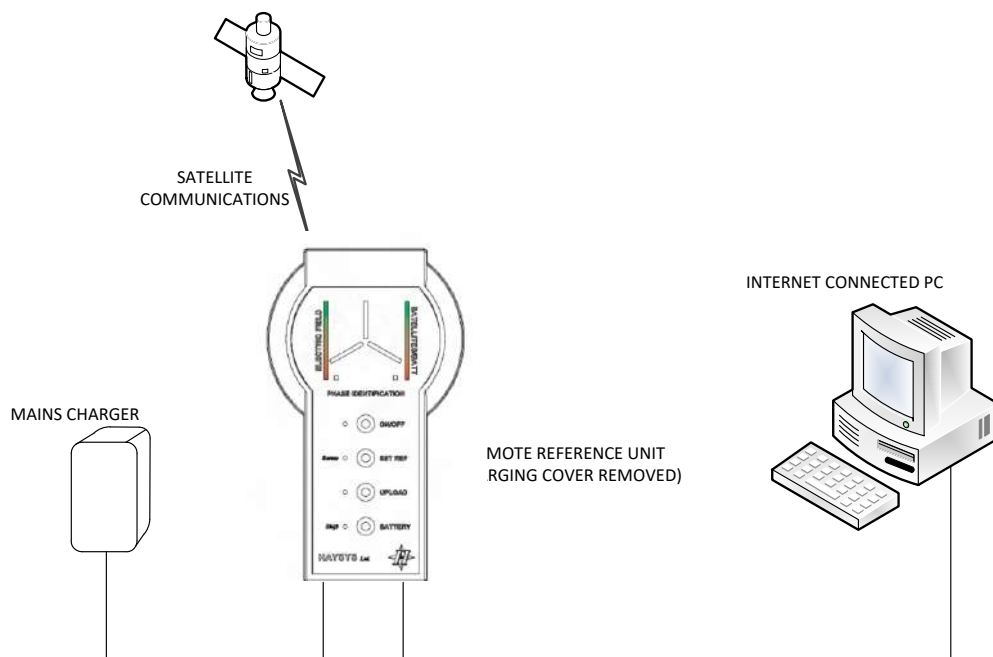


Figure 16 – Remote Reference Unit Configuration

The Remote Reference Unit is connected via USB to the Internet Connected PC (not supplied), that runs a Bridge application (supplied). The PC must be connected using a public static IP address. The Bridge application is a Windows based application that provides a data link between Remote Reference Unit and PHASE FINDER units.

The Remote Reference Unit measures the instantaneous phase of the mains connected charger and not the E-field sensor (no E-Field sensor is required).

The Remote Reference Unit also communicates with the GPS Satellites to obtain the 1-second timing reference and as such the Remote Reference Unit is supplied with an external GPS Antenna that must be positioned such that GPS Satellite Communications is achieved.

The Internet connected PC also contains Data Logging software (supplied), that will allow the data from PHASE FINDER units to be stored on a suitable SQL Server Database (see section 9).

12 WARRANTY AND SUPPORT

All PHASE FINDER units are supplied with a 24-month parts and labour warranty as standard.

Should you have any issues with your unit(s), support can be requested directly from HAYSYS Limited, by emailing help@haysys.co.uk, quoting your model number, serial number and a brief description of the problem.