Instruction manual

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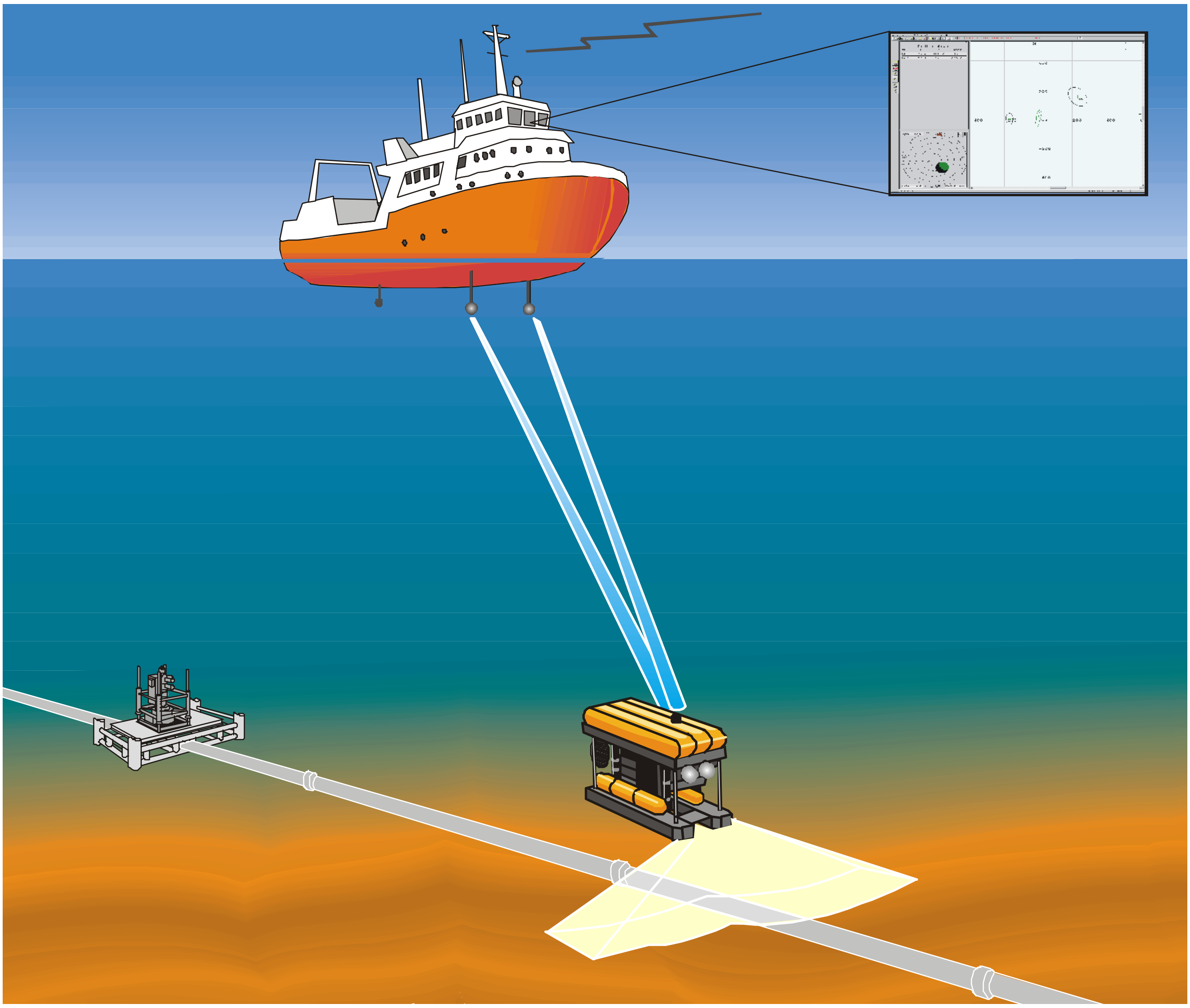
APOS for the HPR 400 series



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APOS for the HPR 400 series

Acoustic Positioning Operator Station (APOS)

Instruction Manual

Document history

Rev	Date	Written by	Checked by	Approved by
F	20.02.08	GM	JEF	JEF
	Updated layout. Moved attitude formats, protocols and telegrams information to APOS on-line help.			

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Support

All Kongsberg Maritime products:
Phone 24 hour: +47 815 35 355
E-mail: km.support@kongsberg.com

HiPAP, HPR, transponders and ACS:
Phone 24 hour: +47 992 03 808
E-mail: km.support@kongsberg.com

Kongsberg Maritime AS

Strandpromenaden 50
P.O.Box 111
N-3191 Horten,
Norway

Telephone: +47 33 02 38 00
Telefax: +47 33 04 47 53
www.kongsberg.com
E-mail: subsea@kongsberg.com

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Sections

This is the Instruction manual for the Acoustic Positioning Operator Station (APOS) used with a Hydroacoustic Position Reference (HPR) 400 system It contains a general description of the HPR400 series systems, and how to get started on the APOS. The manual includes the following sections:

1 APOS Operator Manual

This section includes the standard operator manual for the APOS and includes an introduction to the APOS, abbreviations and terms, how to getting started on the APOS, LBL and SBBL principle of operation and operator maintenance.

2 HPR 400 Product description

This section describes the HPR 400 acoustic positioning system. It includes positioning principles, applications, system units, configurations and functions. It also includes technical specifications and outline drawings.

Remarks

References

Further information about how to operate the Kongsberg Acoustic Positioning Operator Station (APOS) is found in:

- APOS on-line help system

Further information about the Kongsberg Acoustic Positioning systems using APOS software, are found in the following manuals

HPR 400 Series system	Hull units
HPR 400 series Installation manual HPR 400 series Maintenance manual	HL 3880 Hull Unit Instruction manual

The reader

This manual assumes the operator has some knowledge of the general principles of operation, the standard display modes and terminology used in acoustic positioning systems.

References

(The information on this page is intended for internal use)

Documents

Sect	Title	Reg. no.	Rev.
0	Cover and contents	160925	F
1	Acoustic Positioning Operator Station (APOS) Operator manual	850-160841	*
2	HPR 400 Product description	855-201391	*

(* The latest versions of all document modules are included as standard.)

APOS

Acoustic Positioning Operator Station

Operation Manual

This document is the Operator manual for the Acoustic Positioning Operator Station (APOS) for use with the High Precision Acoustic Positioning (HiPAP) and Hydroacoustic Position Reference (HPR) 400 series of systems.

About this document

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E	06.02.08	GM	JEF	JEF
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All Kongsberg Maritime products:
Phone 24 hour: +47 815 35 355
E mail: km.support@kongsberg.com

HiPAP, HPR and ACS:
Phone 24 hour: +47 992 03 808
E mail: km.support.hpr@kongsberg.com

Kongsberg Maritime AS

Strandpromenaden 50
P.O.Box 111
N-3191 Horten,
Norway

Telephone: +47 33 02 38 00
Telefax: +47 33 04 44 24
www.kongsberg.com
E-mail: subsea@kongsberg.com

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Further information about how to operate APOS Operator station may be found in:

- APOS on-line help system

The reader

The manual assumes the operator has some knowledge of the general principles of operation, standard display modes and terminology used in acoustic positioning systems.

Table of contents

INTRODUCTION

Manual content

This Operator manual provides a general introduction to the APOS, and how to get started. Operator maintenance, Long Base Line (LBL) and Super-Short Base Line (SSBL) principles of operation are also included.

General description

The HiPAP and HPR 400 Series of systems are both controlled and operated by use of the APOS software. The APOS runs on the APC 1x as a stand alone system, or on the Common Operator Station (COS) unit in an integrated Dynamic Positioning (DP) and HiPAP / HPR 400 system.

The APOS software includes the following main functions:

- Integrates several HiPAP / HPR 400 transceivers
- Integrates DP and HiPAP / HPR 400 system
- User interface
- Interfacing HiPAP / HPR 400 transceivers
- Ray bending compensation
- LBL calculations
- SSBL calculations are done in the transceiver
- Interfaces DP and survey computer
- On-line help

The APOS software runs on a Windows XP platform. It uses standard Windows graphical user interface.

ABBREVIATIONS, TERMS AND DEFINITIONS

Introduction

This chapter includes abbreviations used in this manual, general terms used within the APOS, and basic Windows terminology.

Abbreviations

APC	Acoustic Positioning Computer
APOS	Acoustic Positioning Operator Station
COS	Common Operator Station
DGPS	Differential GPS
DP	Dynamic Positioning
GPS	Geographical Positioning System
HiPAP	High Precision Acoustic Positioning
HPR	Hydroacoustic Position Reference
LBL	Long Base Line
ROV	Remotely Operated Vehicle
SSBL	Super-Short Base Line
TD	TransDucer
TP	TransPonder
UTM	Universal Transverse Mercator

General terms

The general terms are described in alphabetically order.

Bearing - The horizontal direction of one terrestrial point from another, expressed as the angular distance from a reference direction, clockwise through 360°.

Cartesian coordinate system - A coordinate system (local system) where the axes are mutually-perpendicular straight lines.

Clump weight - An anchor line element connected at a fixed position on an anchor line, causing a concentrated vertical force downwards on the anchor line.

Course - The horizontal direction in which a vessel is steered or is intended to be steered, expressed as angular distance from north, usually from 000° at north, clockwise through 360°. Strictly, this term applies to direction through the water, not the direction intended to be made good over the ground. Differs from **heading**.

Datum - Mathematical description of the shape of the earth (represented by flattening and semi-major axis).

Geodetic coordinate system - A mathematical way of dealing with the shape, size and area of the earth or large portions of it. Normally UTM coordinates with reference to a datum.

Heading - The horizontal direction in which a vessel actually points or heads at any instant, expressed in angular units from a reference direction, usually from 000° at the reference direction clockwise through 360°. Differs from **course**.

Windows terminology

General

Windows are the basic objects of the Microsoft Windows operation system. They will always be displayed with the same layout and functionality, as long as the system programmer did not change the configuration.

Note *The APOS on-line help includes an illustration of a general window, and the including general properties.*

The following paragraphs present a short description of the most used general properties in alphabetical order.

Check box - A small square box 

that appears in a dialog box and that can be turned on and off. A check box contains a tick mark when it is selected and is blank when it is not selected.

Choose - To perform an action that carries out a command in a menu or dialog box. *See also* **Select**.

Command - A word or phrase, usually found in a menu, that you choose in order to carry out an action.

Command button - A rectangle with a label inside that describes an action, such as OK, Apply or Cancel. When chosen, the command button carries out the action.

Cursor - The pointer symbol that is displayed on the screen and that can be moved with the trackball.

Dialog box - A box that appears when the system needs additional information before it can carry out a command or action. *See also* **Check box**, **Command button**, **List box**, **Option button** and **Text box**.

Greyed - Describes a command or option that is listed in a menu or dialog box but that cannot be chosen or selected. The command or option appears in grey type.

List box - A box within a dialog box containing a list of items. If the list of available items is longer than the displayed list box, the list box will have a vertical scroll bar that lets you scroll through the list. A list box may be closed when you first see it. Selecting the down arrow next to the first item in the list will display the rest of the list.

Menu - A group listing of commands. Menu names appear in the menu bar beneath the caption bar. You use a command from a menu by selecting the menu and then choosing the command.

Point - To move the cursor on the screen so that it points to the item you want to select or choose.

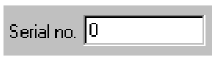
Radio button - A small round button is appearing in a dialog box 

(also known as an “Option” button). You select a radio button to set the option, but within a group of related radio buttons - you can only select one. An option button contains a black dot when it is selected and is blank when it is not selected.

Select - To point and click at the item that the next command you choose will affect. *See also* **Choose**.

Slider - Used to setting parameter values between a minimum and a maximum value. Drag the slider in the required direction.

Status bar - Displays general useful information.

Text box - A box within a dialog box 

in which you type information needed to carry out a command. The text box may be blank when the dialog box appears, or it may contain text if there is a default option or if you have selected something applicable to that command. Some text boxes are attached to a list box - you can type in information or select from the list.

Title bar - Displays an application-defined line of text. The title bar also used to move/drag the window.

Toolbar - A collection of buttons to give a fast entry to the most used commands.

Screen

The screen presentations are described in detail in the APOS on-line help.

Menus

Main menus are items in the menu bar. They may contain:

Sub menus:	marked by ▶
Dialogue windows:	marked by **…**
Commands:	unmarked

Cursor operation

The trackball is used to positioning the cursor on the screen. The most common operations are:

Function	Definition	Common use
Click -	To press and release a button, without moving the cursor. If no trackball button is specified, the left button is assumed.	Select the cursor insert point, activate an operation, activate / inactivate windows or controls.
Drag -	To press and hold down a button while moving the trackball.	Move items. For example, you can move a dialog box to another location on the screen by dragging its title bar. Press and hold the button down while moving the trackball.
Point -	Move the cursor to the wanted screen location.	Prepare for selection /operation.

GETTING STARTED

This chapter describes the basic operation, how to switch the APOS on and off, and how to lower and raise the transducer(s).

The “getting started” description is based on an already installed APOS software.

Note *For more information refer to the APOS on-line help system.*

Topics

→ *APOS on-line help system on page 12*

→ *How to lower and rise the transducer(s) on page 11*

→ *Keyboard on page 9*

→ *Trackball on page 9*

→ *Start and stop on page 10*

→ *User levels on page 8*

User levels

The APOS is - regarding functional possibilities and operation, configured in the following two user levels:

Operator: This level is used for the daily normal operation.

Service: This level requires password, and is for service personnel only.

Keyboard

The keyboard is a PS/2 keyboard. It is a QWERTY keyboard with US layout and includes back-lighting.

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Trackball

The trackball is designed for easy use, and is delivered with cable.

How to use the trackball

The trackball is used to position the cursor on the screen. Each movement of the trackball moves the cursor.

Left button: Used to click on buttons, operate menus and select displayed symbols.

Right button: Used to display menus and pop-up windows.

The most common trackball operations are; pointing, clicking and dragging.

Start and stop

Start up procedure

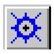
The following procedure describes how to start the APOS from **Power Off** position.
Normally the system is kept on 24 hours a day.

1 Switch on the power. (The power On / Off switch is normally located at the front of the cabinet.) The APOS is ready for use after approximately 1 minute.

2 Switch on the monitor. (The power On / Off switch is normally located at the lower front part of the monitor.)

- First the desktop menu appears, and after some time the APOS main window appears.

3 If required, adjust contrast and brightness in order to obtain required display settings. (The buttons are located at the lower front part of the monitor.)

4 Ensure that you are in control of the system by pressing the  button. When in control, the button becomes disabled.

- If the system is already in control, <u>*do not*</u> click the button.

Note — *If there is more than one operator station in the system, the button will automatically become enabled again if another operator station takes control.*

Note — *Ensure that the configuration of the transponders available in your system is performed. How to configure the transponders, see the APOS on-line help.*

Caution — *Remember to lower the transducer(s)!*
Refer to page 11.

You are now ready for operation!

Note

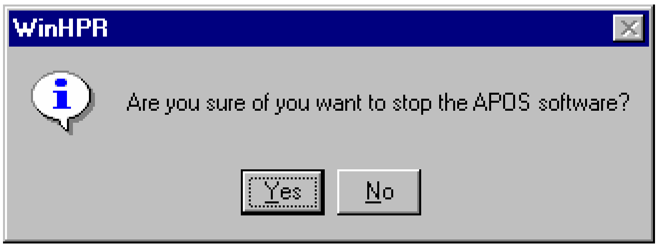
How to operate the APOS, see page 12 and the APOS on-line help system.

Stop procedure

Normally the system is kept on 24 hours a day. If a controlled shutdown is required, it is important to proceed as follows:

1 Select **File -> Stop/Shutdown**

- The following windows is displayed.



2 Select **Yes**.

3 The APOS software will shut down, and you will return to the desktop.

How to lower and rise the transducer(s)

Note

The HiPAP / HPR may be a part of a larger system. Switching on the larger system will then normally power up the HiPAP / HPR system as well, and only lowering of the transducer will be required.

Using the remote control

1 To lower the transducer, press the **DOWN** button on the Remote Control Unit. Observe that the **IN** and **STOP** lamps extinguish. When the transducer is fully lowered, the yellow **OUT** lamp will be lit.

2 To rise the transducer, press the **UP** button on the Remote Control Unit. Observe that the **IN** and **STOP** lamps extinguish. When the transducer is fully risen, the yellow **IN** lamp will be lit.

Note *The red STOP button on the Remote Control Unit may be used to stop the transducer hoisting and lowering operations at any position. When this button is pressed, the yellow STOP lamp will light. The hoisting or lowering operations are continued from the stop position by pressing the UP or DOWN buttons.*

Using the hoist control

1 To lower the transducer, open the Hoist Control Unit door and set rotary switch **S1** to **LOWER**. Once the Hull Unit has reached the required position, (will stop automatically) set the switch **S1** to **STOP**.

2 To rise the transducer, open the Hoist Control Unit door and set rotary switch **S1** to **HOIST**. Once the Hull Unit has reached the required position, (will stop automatically) set the switch **S1** to **STOP**.

Note *The red STOP button on the remote control unit may be used to stop the transducer hoisting and lowering operations at any position. When this button is pressed, the yellow STOP lamp will light. The hoisting or lowering operations are continued from the stop position by pressing the UP or DOWN buttons.*

APOS on-line help system

When operating the APOS, the on-line help is available by activating the APOS Help menu button, or the F1 button on the Keyboard.

The on-line help may also be activated from a dialog box, provided that the help button is available in that particular dialog box.

The on-line help menu includes the following selections:

- **Help**
  General help
- **About APOS**
  Includes the APOS version

OPERATOR MAINTENANCE

Topics

Maintenance philosophy

For the APOS, corrective maintenance is normally performed by replacing modules and circuit boards. This type of maintenance must be carried out by a qualified maintenance engineer.

Further information about maintenance of the Acoustic Positioning systems are found in the following manuals:

- HiPAP Instruction manual
- HPR 400 Series Maintenance manual.

Preventive maintenance however, may be performed by the system operator.

Preventive maintenance

Caution *Do not use strong liquid detergent when cleaning the units. This may be fatal to the surface.*

Cable terminals

All cables should be checked and tightened at least once every three months. This will prevent the screws from loosening resulting in poor contact for the cables.

Operator station

Clean the operator station and display exterior with a damp cloth to remove dirt, dust, grease etc.

The keyboard should be cleaned carefully with a damp cloth.

LBL PRINCIPLES OF OPERATION

This chapter describes the theory of operation of the LBL. The terms used in LBL positioning are defined, and the mathematical principles are described.

Topics

Definitions

Mathematical terms

Standard deviation tells how much a variable varies around its mean value. It is often written as σ. If the variable is normally distributed, 68% of its values are expected to be between (Mean_value - σ) and (mean_value + σ).

Variance is the square of the standard deviation, i.e. σ^2.

Root Mean Square (RMS) of a set of values is a mean of the values in which the greater values contribute more than the smaller values. It is often used instead of the mean value.

Iteration is a repetitive mathematical process. Some algorithms need starting values for some of the variables before they may be executed. The result of the calculation is a new set of values for those variables that are closer to the answer than the old ones. By repeating the algorithm starting at the new values, the result becomes more accurate each time. Each execution is called an iteration, and the algorithm is termed iterative.

Cartesian coordinates are measured in a coordinate system with three mutually perpendicular axes. In this text, the axes are named EAST, NORTH and DEPTH. NORTH is normally the geographical north direction, and EAST the geographical East direction. You are allowed to select other directions, but you must be consistent. The origin of the coordinate system has the coordinates (0,0,0).

Polar coordinates. The polar coordinates of a point are:

Range - The horizontal distance from the origin to the point.

Bearing - The horizontal direction from the origin to the point. 0 is the north direction. The bearing increases clockwise to 360º.

Depth - The vertical distance from the origin to the point.

LBL terms

TP Array. LBL positioning is based on range measurements to the transponders on the seabed. These transponders are called a “transponder array”.

Local calibration. The LBL positioning algorithms must know the coordinates of the transponders in the transponder array relative to a local origin. The process to decide these coordinates is called the local calibration of the transponder array. It is performed by first measuring the ranges between the transponders in the array and then calculating their coordinates based on the ranges.

Geographical calibration. Decides the location of the local origin in latitude and longitude, and the rotation of the local north axis relative to geographical north.

Range residual. HiPAP / HPR measures ranges to decide the position of a transponder or a transducer. Normally, more ranges than necessary are measured. Then the position is calculated based on a best fit of the measured ranges. The residual of a range is the measured range minus the range calculated by using Pythagoras' theorem on the calculated positions.

Local coordinates. The origin of the local coordinate system is in the area covered by the transponder array. The axes are called EAST, NORTH and DEPTH. The NORTH axis is not necessarily pointing in the geographical north direction. The names of the axes in the coordinate system are written in upper case letters (EAST, NORTH), and the geographical directions are written in lower case letters.

Geographical coordinates. When a geographical calibration is performed, positions may be presented in geographical coordinates; either in latitude and longitude or in UTM coordinates.

Initial positions. The positions of the transponders in the transponder array inserted before the local calibration is performed. The positions are given in local or geographical coordinates. The only requirement to the accuracy of these positions is that they roughly indicate the transponder positions relative to each other.

Calibrated positions. The positions of the transponders in the transponder array calculated in the local calibration. The positions are given in local coordinates.

Error ellipse. There is an uncertainty associated with all positions, both initial and calibrated. This uncertainty is expressed as a 1-sigma error ellipse both in the input to and the output from the HiPAP / HPR system. The error ellipse has a major and a minor semi-axis, and the direction of the major semi-axis relative to north is specified. Assuming that the uncertainty of the position is normally distributed, the probability that the position really is within the error ellipse is 0.67 x 0.67 = 45%.

HiPAP / HPR terms

The APOS is the HiPAP / HPR System controller. It consists of a Pentium based PC. It can also contain a keyboard and circuit boards for serial lines, Ethernet etc. as options.

HPR 400 is a transceiver. It consists of single Europe circuit boards normally mounted in a 19" rack. The PCBs may be mounted in a cylinder for subsea use. The transceiver measures ranges and SSBL directions and handles telemetry.

HiPAP is a transceiver with one spherical transducer.

A Transducer consists of elements (vibrators) and some electronics. It converts the electrical transmission signals generated by the transceiver into hydroacoustic pulses. It also converts the hydroacoustic pulses received into electrical signals for the transceiver.

The transducer may be of the ordinary LBL type or of the SSBL type. Both are capable of measuring ranges. The SSBL transducer can also measure directions.

The HPR 4xx consists of an Operator unit, transceiver(s) and transducer(s). There may be up to four transceivers connected to the Operator unit, and there may be two LBL transducers plus two SSBL or LBL transducers connected to each transceiver.

- HPR 410 is an SSBL system
- HPR 408 is an LBL system
- HPR 418 is a combined LBL and SSBL system.

A Transponder consists of a LBL type transducer, electronics and batteries. It is placed on the seabed or on an ROV. The transponders may be commanded by telemetry to execute functions.

Most LBL transponders contain a pressure and a temperature sensor. These are used to decide the transponder depth.

When enabled for positioning, the transponder may be interrogated by two pulses on different frequencies and will then reply with a pulse on a third frequency. The HiPAP / HPR system may command it to switch frequencies.

Each transponder is uniquely identified by a serial number.

LBL measurement principles

LBL positioning is based on range measurements, both for the calibration and for the positioning. The principle is basically the same for positioning and for calibration, but the explanation is split into separate paragraphs in this text.

Positioning

The HiPAP / HPR system measures ranges from a transducer to the transponders on the seabed. A common interrogation channel is used for all the transponders in the transponder array. The HiPAP / HPR system knows the transponder positions. Each range measurement indicates that the transducer is on a sphere with its centre at the transponder and with its radius equal to the range. If more than one range measurement is made, the transducer's position must be on the lines where the spheres intersect.

When the measurements are done on a SSBL type of transducer, the directions may be used together with the range in the calculations. In shallow water, and when an accurate HiPAP transducer is used, the measured directions contribute to a more accurate position.

The depth of the transducer is often known. In these cases, each range measurement indicates that the transducer is on the circle where the sphere around the transponder intersects with the horizontal plane at the transducer. This is illustrated in Figure 1. Here three circles are drawn where the transducer's depth plane crosses the three spheres.

Normally there will be noise on each measurement. That is illustrated on the figure by not letting the three circles intersect exactly in one point. There are three intersections close to each other, and the position can be assumed to be somewhere in the triangle formed by the intersections.

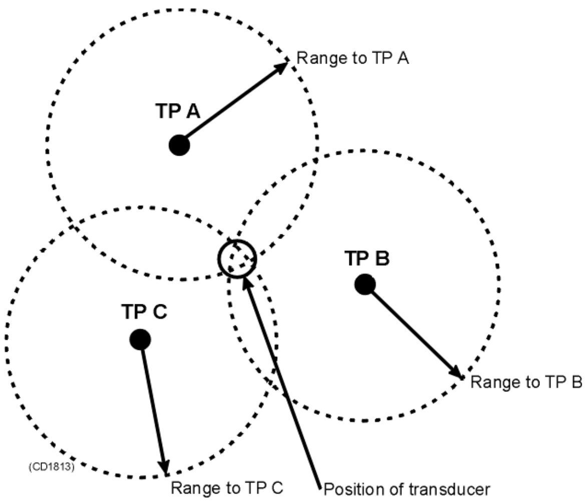


Figure 1 LBL positioning

Normally, more ranges than necessary are measured, and the number of intersections close to each other increases. Still the best guess of the position is somewhere in the space between these intersections. The program uses a weighted least square error algorithm to decide the position. The algorithm is iterative, and the errors are the differences between the measured ranges and the corresponding ranges calculated by using Pythagoras' theorem on the vessel position. These errors are called range residuals.

The iterations start at the vessel's previous known position, and continue until the increment from the previous iteration is less than a preset number of centimetres. The accuracy of the old position does not influence the accuracy of the new position.

Situations may arise when too few ranges are measured. Then there are two possible solutions for the new position. The programs will iterate towards the position closest to the old one.

In standard LBL, the replies from the transponders in the TP array are received on the same transducer as doing the interrogation of the array. In the APOS you can request the replies to be received on other transducers too. The extra measurements make the LBL system more accurate and robust.

Calibration

The ”position” used during the calibration consists of the position of each array transponder. Consequently, it contains many coordinate values.

The programs must know something about the transponder positions before the calibration calculations can start. These positions are called “Initial positions”. That information must be inserted by you, or it may be read from an ASCII file. SSBL measurements may be used to identify the initial transponder positions.

You must inform the system of the accuracy of the initial positions. This is achieved by specifying a 1-sigma error ellipse for the horizontal position and a standard deviation for the depth. The transponders are often at approximately the same depth, and the range measurements then contain no information about their relative depths. In this case, the depth standard deviation should be set to 0.00 m for all the transponders.

The next step of the calibration is to measure the subsea ranges between the transponders. The range from one transponder to another is normally measured many times. The mean value and the standard deviation of these ranges are then calculated and used later in the calculations.

The programs use a weighted least square error algorithm to decide the positions of the transponders. The algorithm is iterative, starting at the initial positions of the transponders. There are two types of errors as seen from the algorithm.

The **range errors** are the differences between the measured ranges and the corresponding ranges calculated by using the Pythagoras formula on the transponder positions. These errors are called **range residuals**. In the algorithm the squares of the range residuals are weighted with the inverse of the variance calculated during the range measurements. In this way the ranges measured with a small standard deviation have a greater impact on the resulting transponder positions than the ranges measured with a large standard deviation.

The **position errors** are the differences between the calculated transponder positions and the starting values of those positions. In the algorithm, the squares of these errors are weighted with the inverse of the squares of their uncertainties. The uncertainty of a transponder position starts at the error ellipse for the initial position. The uncertainty reduces in size during the calculation, and the result is the uncertainty of the calibrated transponder position.

Combined use of LBL and SSBL

When a transponder array is active on an SSBL transducer, the HiPAP / HPR system may perform SSBL measurements when receiving the replies. The direction information is then used together with the range information to make the system more accurate and robust. The transponders in the transponder array are still classified as LBL transponders.

Transponders may be interrogated as SSBL transponders. They are interrogated using their individual frequencies, and the SSBL measurements are performed as on a pure SSBL system.

The same transponder may not be interrogated as an SSBL transponder and an LBL transponder simultaneously.

When both a transponder array and one or more SSBL transponders are active, the system will alternate between LBL interrogations and SSBL interrogations. The sequence is controlled by the interrogation rate parameters for the LBL and SSBL interrogations.

The transponders used as SSBL transponders are of the same physical type as the LBL transponders. They are, however, commanded to be interrogated on their individual channels and not on the LBL common interrogation channel.

Geographical calibration

Many LBL applications do not perform geographical calibrations. For those applications, you may ignore this chapter.

The relative positions of seabed transponders in TP arrays are calculated based on range measurements between the transponders. When finished, the transponder positions relative to an origin are calculated. This process is called the local calibration.

Normally the position of the origin, and the rotation of the local North axis relative to the geographical north axis, remain unknown after the local calibration. These unknowns are decided in the geographical calibration.

The APOS uses positions of the vessel, simultaneously received from a DGPS system and calculated by the LBL system, as basis for the geographical calibration. DGPS and LBL position pairs are logged at many positions in the area before the calculation is performed. The calculation decides the origin latitude and longitude, and the rotation of the local north axis relative to geographical north axis, using a least square error algorithm.

When the latitude, longitude and rotation of the local origin are calculated, the LBL positions logged are converted to geographical coordinates. There is normally a difference between the LBL geographical position and the DGPS position logged in the same place. This is called the distance residual of the position pair. The residual is the statistical sum of the DGPS error and the LBL error. When these systems work correctly, the sound velocity profile used is accurate, and the local calibration was performed accurately, these residuals are normally in the 1 m order of magnitude.

The most accurate results for the origin position calculations are given if the position pairs are logged evenly distributed around the area. If for example the sound velocity profile is inaccurate, the distance residuals of the position pairs logged in the outer parts of the array may be much larger than the error in the origin calculated. If, on the other hand, position pairs are logged in only one part of the array, the situation could be the opposite - with small residuals but an inaccurate calculation of the origin. It must always be remembered that the objective of the calibration is to establish accurate positions, not to obtain small residuals.

The three parameters calculated in the geographical calibration are the latitude, longitude and rotation. When performing LBL positioning in the area later, errors in latitude and longitude will always contribute to errors in the LBL geographical position. The error in the rotation contributes an error proportional to the distance from the centre of the area in which the position pairs were logged.

The origin calculated is valid for the locations in the transponder arrays used in the LBL positioning during the geographical calibration.

Super array and Tp array

A limit of eight transponders can be in use simultaneously when performing LBL positioning or range measurements for local calibration. The limit is due to the use of frequencies within the frequency band available. The transponders in use simultaneously are named a TP array. The APOS can handle many TP arrays, but only one can be active at any one time.

In many applications, as for example pipe laying and inspection, there is a need to use more than 8 transponders. The places on the seabed where the transponders are placed are called locations.

When all the locations are grouped together, the resulting array is often called the “superarray”.

Each location is a physical transponder. The same physical transponder may be used in more than one TP array, meaning that the TP arrays can overlap.

Example: Location 8 and 9 are used in both TP array 1 and TP array 2 because the arrays overlap, as shown in below.

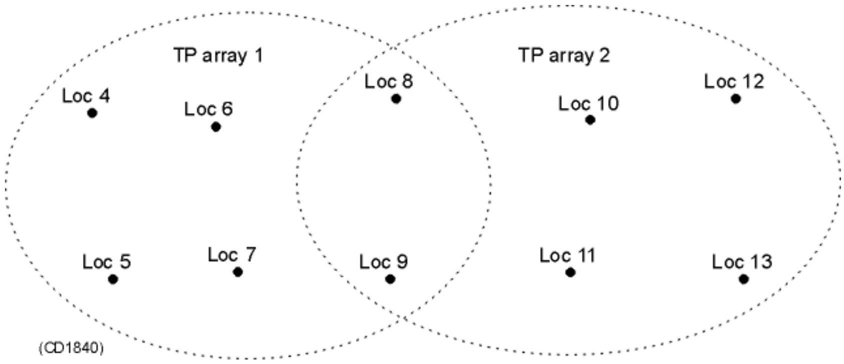


Figure 2 Two TP arrays with overlapping locations

All range measurements for the local calibration are performed within the TP arrays. When finished with the measurements in one TP array, a calculation using only those measurements should be performed to check the measurements. Then, only the locations specified as being part of the actual TP array receive new calibrated positions. The positions of the other locations will remain at their initial values. Normally, some of the locations receiving new calibrated positions will also be used in other TP arrays. The new positions will then also be valid for those arrays, i.e. one location has one and only one position, even when used in more than one TP array.

When the ranges are measured in all the TP arrays with overlapping locations, a local calibration calculation for the super array should be performed. The range measurements performed in all the TP arrays are then used, and all locations receive new calibrated positions.

Geographical coordinates

Many LBL applications do not use geographical coordinates. For those applications, you may ignore this chapter.

The APOS may receive geographical positions from a DGPS receiver, and it may present the calculated LBL positions in geographical coordinates.

Geographical coordinates are always referred to a datum defining the ellipsoid model of the earth. The APOS may work with three datum simultaneously. These are:

1. **Reference datum**. This datum is used by the HiPAP / HPR system in the internal calculations. It is by default WGS 84, and you should not change it.
2. **GPS datum**. This datum is the one used by the DGPS receiver. After having received a geographical position from the DGPS receiver, the HiPAP / HPR system converts the position to the reference datum before starting any calculations. You may select the GPS datum from a list of datum in a menu.
3. **APOS datum**. This datum is used by the HiPAP / HPR system when presenting LBL positions in geographical coordinates, both on the screen, in printouts and in binary telegrams. You may select the APOS datum from a list of datum in a menu.

The system always performs the LBL calculations in local coordinates. If the LBL positions are to be presented in geographical coordinates, the transformation from local to geographical is performed just before the presentation. The APOS must know the geographical coordinates of the local origin and the rotation of the local north axis to perform this conversion.

When the initial coordinates for the locations are entered in UTM coordinates, the APOS must convert the position to local coordinates before performing any calculations. To perform this conversion, it must know the geographical coordinates of the local origin to be used. That is inserted by you as a UTM centre. The rotation parameter of this origin is calculated automatically to the angle between the geographical north and the UTM north. You should not change the UTM centre when it is in use for the locations.

The use of the UTM centre as an origin is similar to the use of the origin calculated in a geographical calibration.

The UTM centre or the origin calculated in the geographical calibration may be transferred to the origin(s) of the TP array(s). When transferred to a TP array, the origin is used when:

- Positioning in the TP array. The LBL position calculated may be presented in UTM or in geographical coordinates.

- Printing the calibrated positions of the locations. The calibrated positions are always printed in local coordinates. Those locations used in a TP array with an origin are also printed in UTM coordinates.

Quality control of data

The quality control of the data is performed on many levels. The HiPAP / HPR system measures more than is strictly necessary, and thereby gains the possibility to check the quality of the results.

Local calibration

The calibration is primarily based on range measurements between the transponders. Each range is measured many times, and the program calculates a standard deviation on each range. You may examine the measurements, and the ranges may be measured anew. You may exclude ranges from the calibration calculations if no acceptable standard deviation is obtained.

The inverse of the standard deviations are used by the algorithms as weights when calculating the optimum transponder array positions.

After having calculated optimum positions for the array transponders, the APOS checks how the measured ranges fit with the calculated positions. Ranges that do not fit well have large range residuals, and these ranges may be measured anew or excluded before the calibration calculations are performed again.

The APOS calculates the uncertainties of the calibrated positions, and presents them as error ellipses around the positions.

Geographical calibration

The APOS uses positions of the vessel, simultaneously received from a DGPS system and calculated by the LBL system, as the basis for the geographical calibration. Only two DGPS / LBL position pairs are necessary to calculate the origin latitude, longitude and rotation, but up to many hundreds position pairs may be logged and used in the weighted least square error calculation. The calculation is over determined, and distance residuals are calculated for each position pair. The RMS value of these residuals indicate how well the position pairs match.

Each position pair has associated statistical information indicating its uncertainty. This information is used in the calculations, and it contributes to the statistical data giving the uncertainty of the origin calculated.

Positioning

During positioning the HiPAP / HPR system normally measures more ranges and SSBL directions than is necessary. After having calculated the position, it checks how well the measured ranges and directions fit with the position. Measurements obviously wrong may be automatically excluded when the position is calculated again.

The APOS calculates residuals of all measurements, and the uncertainty of the LBL position

The uncertainty of the local LBL position calculated, depends on several factors:

- The number of ranges and SSBL angles measured, and the geometrical crossings of the vectors from the transponders to the transducer.
- The accuracy with which the ranges and the angles are measured.
- The uncertainty of the sound velocity profile used. You insert this uncertainty in a menu.
- The uncertainty of the calibrated positions of the transponders in the array.

The local LBL positions calculated may be presented in geographical coordinates. In that case, the uncertainty of the origin is statistically added to the uncertainty of the local position before being presented.

Note *The graphical presentation on the screen is always in local coordinates. The printouts however may be in geographical coordinates.*

Transponder modes

Each transponder may be in one of the following modes.

- *SSBL mode.* The transponder enters this mode after power on and after reset. It must be in this mode when being interrogated as an SSBL transponder.
- *LBL calibration mode.* The transponder must be in this mode when performing the subsea range measurements during the Local calibration.
- *LBL positioning mode.* The transponders must be in this mode when measuring ranges from a transducer to the transponders. In this mode, the transponder is interrogated on an LBL interrogation channel, which is usually different from the transponder s channel. The transponder s reply frequency is decided by its channel number. This mode enables all the transponders in an array to be interrogated on the same interrogation channel, while replying on their individual frequencies.

In the LBL positioning mode, the turnaround delay is set individually for each transponder. This possibility is used to prevent the transponder replies being received at the transducer simultaneously.

Operation

The following paragraphs give an overview of the operations without going into details. For detailed description of the operation, refer to the APOS on-line help system.

Measure ranges

The transponders in the transponder array must all be in the Calibration mode before the subsea ranges are measured.

The local calibration is primarily based on range measurements between the transponders. They send the results up to the HiPAP / HPR system by telemetry. You may choose to request one transponder at a time to measure the ranges to all the others, or you may request all the transponders, one at a time, to measure the ranges to all the others. This operation will last for some minutes, depending upon the ranges and the number of ranges to measure. The second option should only be selected when the vessel has good telemetry communication with all transponders from a single position. In both cases only one telemetry function is performed at any one time in the water.

Execute the local calibration

Once the subsea ranges have been measured, the positions of the transponders in the array can be calculated.

When the APOS has completed the calculations, it displays the maximum and the RMS values of the range residuals. These indicate how well the calibrated positions fit with the measured ranges. If you are not satisfied with the residuals, you should identify the ranges contributing the most to the RMS value of the residuals. Ranges with large residuals should be measured again and the calibration calculations repeated. This iteration may need to be performed many times before the resulting residuals are considered to be small enough.

The left part of the screen is normally used to present graphical information. In the LBL local calibration process, it is better to use it to display the ranges. Then the display gives an overview over the ranges, the standard deviations and the range residuals. The ranges and the standard deviations are updated after each range measurement. The range residuals are updated after each local calibration calculation.

Position a vessel or ROV

When satisfied with the result of the local calibration, you can start the positioning operation. First the turnaround delays of those transponders in the array must be decided, then the transponders must be commanded to the LBL positioning mode.

Position a transponder

The transponders are able to measure the ranges to other transponders, and send the result, on telemetry, to the HiPAP / HPR system. This capability is used in the LBL transponder positioning mode. The transponder to be positioned is called the master transponder, and it is not part of the TP array. The master transponder measures ranges to transponders in a TP array, these other transponders being called the slaves. Up to six slaves may be used simultaneously by one master. The transponders in the TP array must be in the calibration mode. The master is commanded to be in a special TP range positioning mode, in which it knows the channels of the slaves to which it is to measure the ranges. The positioning sequence is initiated by the HiPAP / HPR system transmitting a short message to the master on telemetry. The master measures the ranges to the slaves, just as in calibration mode. Only one range is measured towards each slave. When it has finished, the master transmits the ranges, on telemetry, up to the HiPAP / HPR system, then waits for the next request to measure ranges.

The LBL transponder positioning mode is a flexible and simple solution for many applications. The drawback is the speed. Both the ranges and the request to measure are sent on telemetry, and the master transponder measures only one range at a time. The time used for a sequence depends on the number of slave transponders used, and if there are timeouts on the replies from the slaves. The positions may be updated as fast as once every 12 seconds, though more time may well be required, resulting in a slower update rate.

Geographical calibration

The geographical calibration requires that you position the vessel in local LBL coordinates and that the APOS reads the vessel position from a DGPS receiver simultaneously. An LBL position and a DGPS position, logged simultaneously, are named a position pair.

When logging the position pair, the vessel should be drifting to avoid noise and air bubbles from the thrusters and propellers disturbing the LBL measurements. 8 to 10 position pairs should be logged while the vessel is drifting in one position, then the vessel should be moved to another position and a new 8 to 10 position pairs should be logged. This procedure should be repeated at many positions, evenly distributed, in the area covered by the transponder array. Do not log only while located in the centre of the area as that will give a high uncertainty for the rotation of the local north axis.

When logging position pairs, attention should be paid to the ranges measured and the range residuals calculated. The best results are achieved when the position pairs are logged when many ranges are measured correctly and their residuals are small.

When enough position pairs are logged, the geographical calibration calculation is performed. Some position pairs will often have larger distance residuals than the others. In that case, you may exclude some of the position pairs with the large distance residuals and repeat the calculation. When performing the exclusions, be aware that the position pairs used in the calculation should be evenly distributed in the area.

SSBL PRINCIPLES OF OPERATION

For Super-Short Base Line (SSBL) information please refer to the *HiPAP / HPR 400 Product description* – section in the APOS HiPAP / HPR 400 Instruction manual.

INDEX

The next pages present the index of this manual.

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HPR 400 series

This document describes HPR 400 acoustic positioning systems. The HPR 400 series consists of HPR 410, HPR 408 and HPR 418 systems, which covers SSBL, LBL and combined SSBL and LBL modes of operation.

About this document

Rev	Date	Written by	Checked by	Approved by
F	20.02.08	GM	JEF	JEF
	Updated layout. Updated APOS list of functions. Minor corrections in the text. Implemented APC 1x.			

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Support

All Kongsberg Maritime products:
Phone 24 hour: +47 815 35 355
E mail: km.support@kongsberg.com

HiPAP, HPR, transponders and ACS:
Phone 24 hour: +47 992 03 808
E mail: km.support.hpr@kongsberg.com

Kongsberg Maritime AS

Strandpromenaden 50
P.O.Box 111
N-3191 Horten,
Norway

Telephone: +47 33 02 38 00
Telefax: +47 33 04 44 24
www.kongsberg.com
E-mail: subsea@kongsberg.com

KONGSBERG

Table of contents

INTRODUCTION

General

This document covers the HPR 400 series. It provides a general description of the systems, each module, the functions and technical specifications.

List of abbreviations

ACC	Acoustic Control Commander
ACS	Acoustic Control Subsea
APC	Acoustic Positioning Computer
APOS	Acoustic Positioning Operator Station
BOP	Blow Out Preventer
DGPS	Differential Global Positioning System
DP	Dynamic Positioning
GPS	Global Positioning System
HiPAP	High Precision Acoustic Positioning
HPR	Hydroacoustic Position Reference
LBL	Long Base Line
LF	Low Frequency
MF	Medium Frequency
MST	Mini SSBL Transponder
MPT	Multifunction Positioning Transponder
ROV	Remotely Operated Vehicle
SPT	SSBL Positioning Transponder
SSBL	Super Short Base Line
VRU	Vertical Reference Unit

HPR 400 systems

The HPR 400 series of acoustic positioning systems integrate SSBL, LBL and combined SSBL / LBL positioning principles on the same hardware and software platform. The systems can be configured to be one or a combination of the principles as follows:

- HPR 410 SSBL system - Uses SSBL type of transducer(s). Positions target(s) relative to vessel. It can be used with a selection of transponders. Acoustic telemetry is available.

- HPR 408 LBL system - Uses LBL type of transducer(s). Position surface vessel or ROV relative to local seabed transponder array. Provides data both in local and UTM coordinates. Can be used with a selection of LBL transponders. Uses acoustic telemetry for array calibration.
  – The HPR 408 LBL system can also be delivered with a subsea transceiver. This system may be used for Remotely Operated Vehicle (ROV) LBL positioning, as well as for any other subsea module positioning requiring LBL accuracy. Available subsea units:
- HPR 418 SSLBL system - Uses SSBL type of transducers. Combines features from both SSBL and LBL. Position surface vessel or ROV relative to local seabed transponder array and/or target relative vessel. Provides data both in local and UTM coordinates. Combined algorithm uses both ranges and directional measurements to compute the position. Can be used with a selection of transponders. Uses acoustic telemetry for array calibration.

HPR 400 portable system

The HPR 400 series also consists of a portable system, which has the same functionality as the above systems. The portable system has some limitations and is not for use with a Dynamic Positioning system. The portable system is not described here.

APOS

The HPR system is operated from the APOS, which is a Windows XP based software.

The APOS software can also be integrated with the Kongsberg DP system.

Sensors

The HPR system has a wide range of interfaces to sensors from different manufacturers. A gyro-compass and a vertical reference sensor will normally be interfaced to the system.

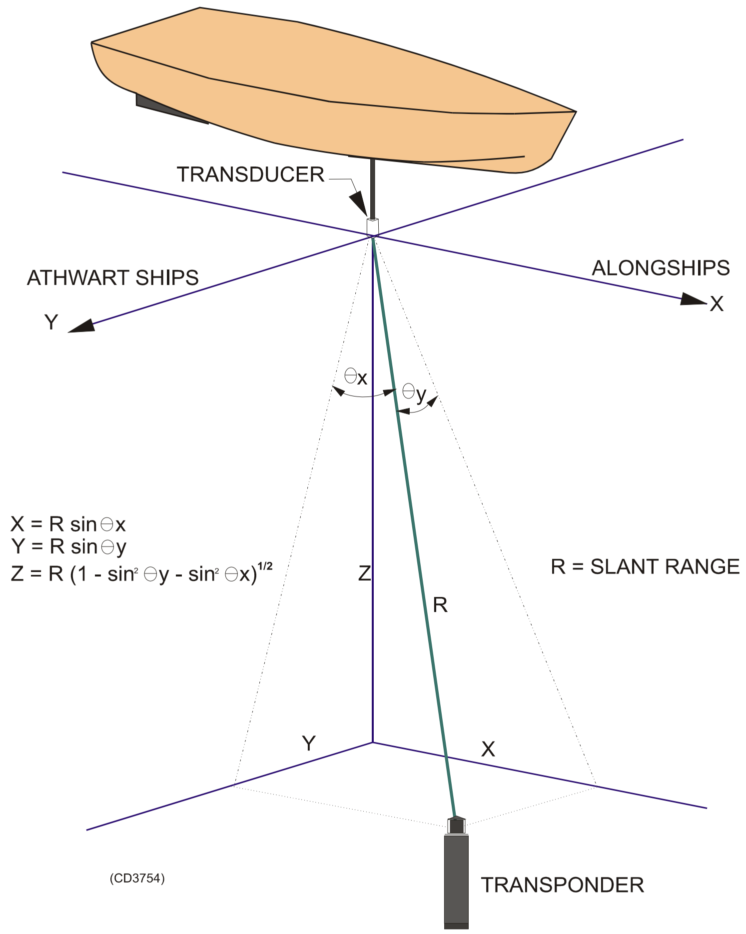
POSITINING PRINCIPLES

SSBL Positioning

In SSBL, the HPR system calculates a three-dimensional subsea position of a transponder relative to a vessel-mounted transducer. The position calculation is based on range and direction measurements to one transponder. The onboard transducer transmits an interrogation pulse to a subsea transponder, which then answers with a reply pulse.

- The onboard system will measure the time from interrogation to the reply pulse is detected and use the sound velocity to compute the range.
- The transponder position is presented both numerical and graphically on the operator station. Only one onboard SSBL type transducer is necessary to establish this position.

Using a pressure sensor in the subsea transponder can increase position and depth accuracy. The water pressure is measured and transmitted to the surface HPR system using telemetry. The depth is then used in the algorithms for establishing the 3D position. The system can also read the depth via a serial line input from a pressure sensor. Simultaneous use of many transponders is made possible by utilising individual interrogation and reply frequencies.



SSBL principle

LBL Positioning

Calibration

The LBL principle is based on one vessel-mounted transducer, and normally 4 - 6 transponders on the seabed. This seabed transponder array must be calibrated before LBL positioning operations can begin. The calibration shall determine the transponder's positions in a local geographical coordinate frame. The HPR 400 system supports two calibration techniques:

Baseline measurements

This technique uses automatic calibration functions in the HiPAP system. This allows all the ranges to be measured and made available by acoustic telemetry communication between the transponders and the vessel's system. Based on the baseline measurements and initial positions of the transponders, the calibrated transponder positions are computed.

Runtime calibration

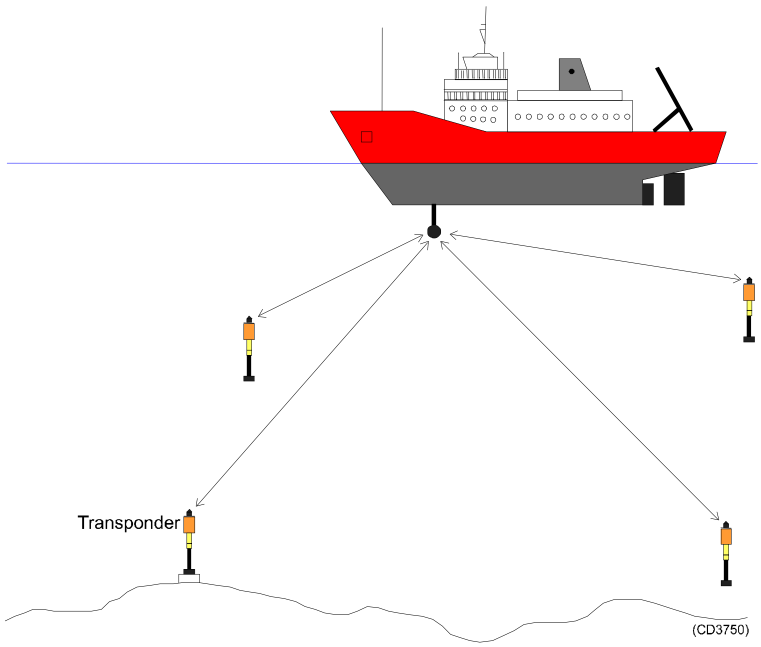
To use this technique, the system is run in LBL positioning mode, using the SSBL positions of the seabed transponders for the vessel LBL position calculation. The runtime calibration function logs the measurements, and based on this, new optimised seabed transponder positions will be computed. This technique makes the baseline measurements redundant. If the baselines measurements are done, they are also used in the calculations.

The calibration is performed only once prior to positioning operation, since the transponders will remain in the same location during the operation.

Positioning

When the transponder positions are known, positioning of the surface vessel can begin. All the seabed transponders will be interrogated simultaneously, and each will respond with its specific reply signal. The LBL system will then calculate the ranges from the individual transponders. By using the calibration data together with the calculated ranges in software algorithms, the vessel or an ROV can be positioned.

- The system can take the depth from an ROV-mounted pressure sensor via a serial line. By using this depth in the computation, it will increase the position accuracy of the ROV.
- The range capabilities of a medium frequency LBL system will be approximately the same as those of an SSBL system.
- LBL positioning is more complex to operate, it needs more transponders than the SSBL, but it will give better position accuracy at greater distances.



LBL principle

Combined SSBL and LBL positioning

The combined SSBL / LBL system uses an onboard multi-element transducer. The system may operate as an SSBL system and as an LBL system simultaneously.

As an example, the vessel may be positioned relative to the sea-bed using LBL while a SSBL transponder on a ROV is positioned relative to the vessel. The vessel is displayed relative to the LBL transponder array origin and the ROV relative to the vessel

The combined system will also use the measured angles together with the measured ranges in the LBL positioning. The combined measurement gives a robust system with increased accuracy. An LBL solution is achievable when only two transponder replies are detected.

Multi-User LBL positioning

Several individual vessels and ROV units can now position themselves using the same seabed transponder array. The system and principle has the following main advantages:

- Provides high position accuracy (comparable to standard LBL).
- A small number of transponders serve all vessels and ROVs.
- Secures high position update rate (down to approx. 2 seconds), which is essential in DP operations.
- Avoids transponder frequency collisions when vessels are working in the same area (all vessels are ”listening” only).

A transponder array is deployed and calibrated by use of subsea baseline measurements. One transponder is used as the Master in the positioning phase. The other transponders are called the Slaves.

The Master transponder acts as a beacon. It starts a positioning sequence by doing the steps described below. This is done regularly with an interval set by telemetry from one of the vessels.

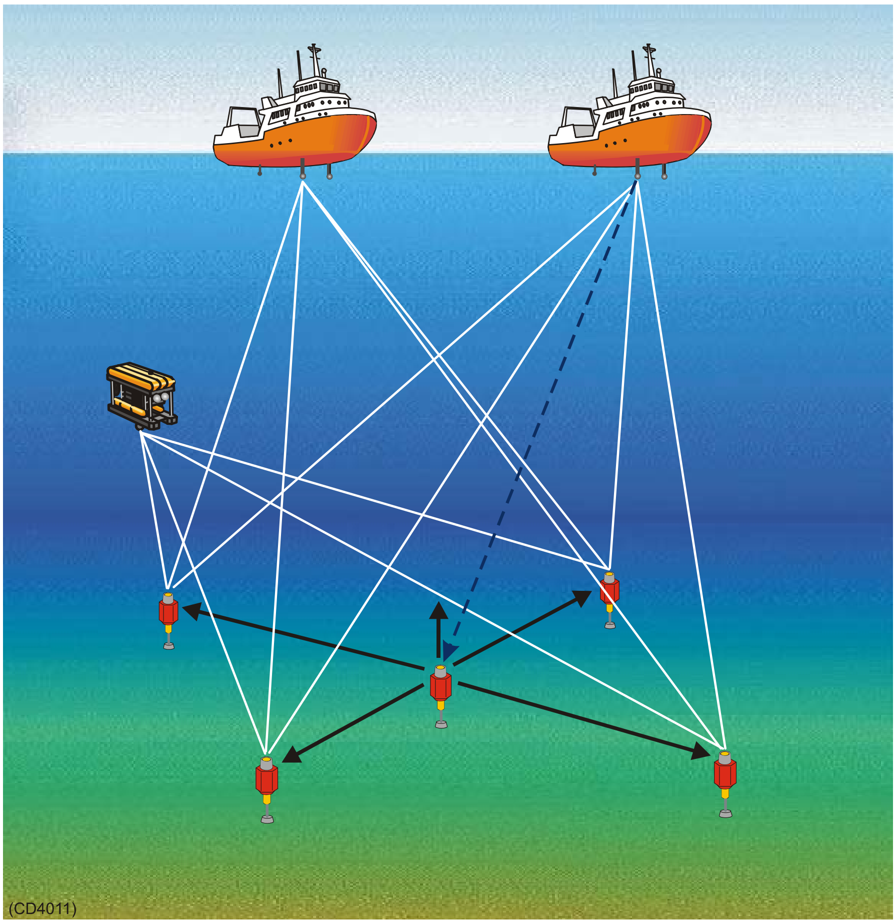
1 The Master interrogates the Slaves.

2 The Master transmits its individual transponder channel to be received by the vessels/ROVs positioning in the array.

3 Each Slave transponder receives the interrogation from the Master and transmits its individual reply channels after a turnaround delay.

A MULBL system positioning in the array, listens for the individual channels transmitted by the master beacon, and by the Slave transponders. When they are received, the system uses its knowledge about their positions in the TP array to calculate the differences in range to the transponders in the TP array. The time difference between the Master interrogation and the start of the reception of the pulses at the system is unknown. It has to be calculated together with the position of the vessel or ROV.

All vessels to use the MULBL array need the coordinates of the transponders and the channel numbers, which will be distributed of a file.



Multi-User LBL positioning

MEASUREMENT COMPENSATION

Roll - pitch - heading compensation

In order to compensate for the vessel roll/pitch/heading movements, vertical reference sensors and heading sensors are interfaced. Data from these sensors are used to compute position data that is relative to horizontal level and to north.

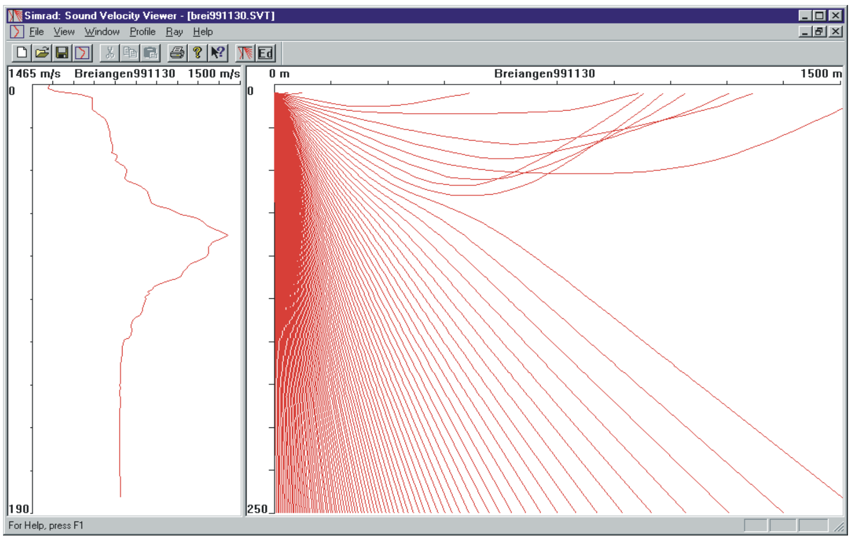
The absolute accuracy and the standard deviation of the position are very dependent of the roll/pitch/heading sensors performance. Especially when working at great waterdepths the roll/pitch/heading error contribution is significant and when working at long horizontal range the heading error contribution is significant. This compensation is used in all positioning modes.

The accuracy of the attitude data is of crucial significance for the total accuracy of the HPR system, and the error from the attitude sensor will add to the error of the HPR system.

As an example a roll or pith error of 0.25 degrees will give an error of 4.4 m at 1000 m depth, and an error of 13 m at 3000 m depth, while a roll or pitch error of 0.05 degree will give respectively 0.9 m and 2.6 m.

Ray bending compensation

Ray bending compensation is done in the Operator Unit. The positions calculated from the raw measurements are influenced by variable sound velocity through the water column. The system can correct these errors.



(Cd6087)

The sound velocity values may be measured by a probe and transferred to the system. If the depth of the target (transponder) is known either by depth sensor in the transponder or by an ROV depth sensor, these data can be transferred to the system.

The range calculation is compensated for the error caused by different sound velocities in the water column, and for the extra propagation path caused by the ray bending. The compensation is used in all positioning modes.

Transducer alignment

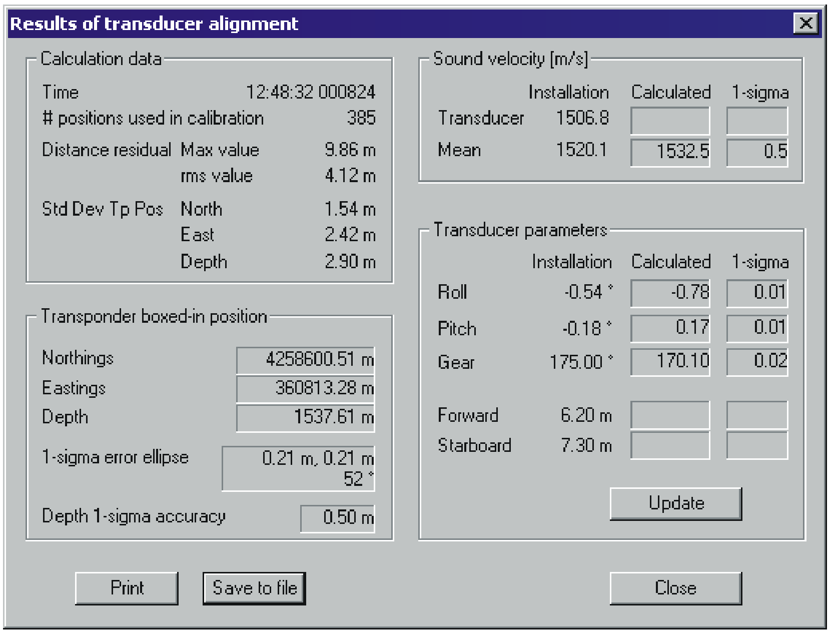
After the installation, it is necessary to determine a number of offsets between various sensor reference points and axes. These are:

- **Vertical angular** - The offset between transducer axis and roll/pitch sensor axis.
- **Horizontal angular** - The offset between roll/pitch sensor and heading reference.
- **Horizontal angular** - The offset between transducer axis and heading reference.
- **Horizontal distance** - The offset between transducer location and reference point.

The principles for these alignment adjustments are based on the position of a fixed seabed transponder relative to the vessel and the geographical position of the vessel.

In order to simplify and improve the quality of the alignment scenario, the alignment function in APOS is used. By logging the vessel position from DGPS along with the measured position of a seabed transponder, the program computes the alignment parameters. The normal procedure is to locate the vessel at four cardinal points and on top of the transponder with four headings.

Immediately the alignment parameters can be computed and automatically be transferred to the APOS alignment parameters. No manual transfer is needed. The results from the alignment are shown both numerical and graphically on the APOS. An example is shown in the two figures below.



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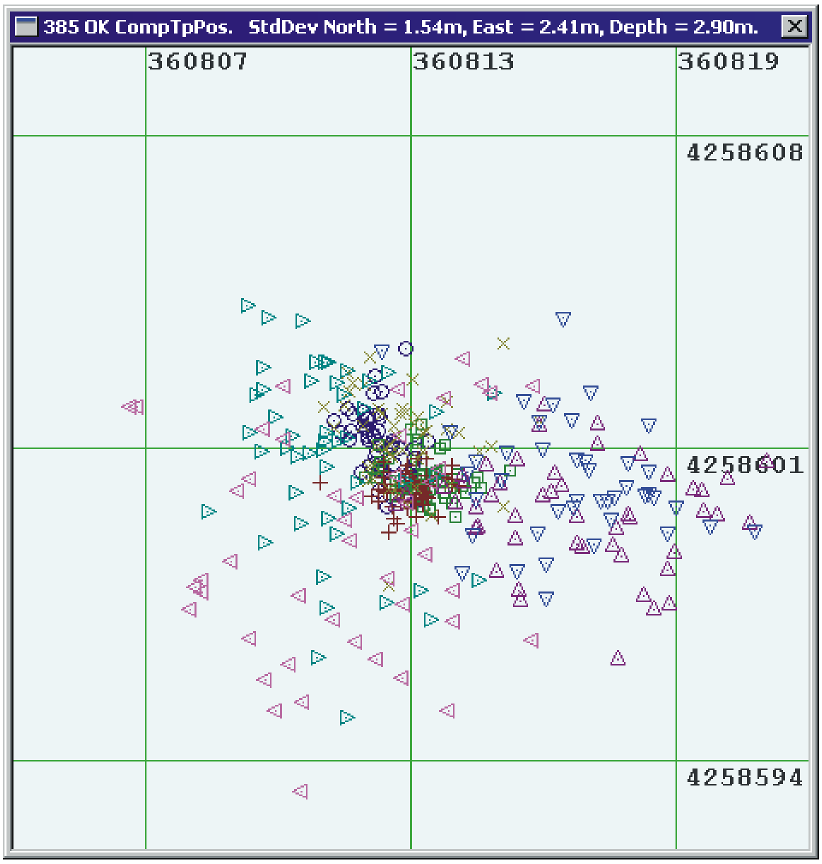
Result of transducer alignment – APOS presentation



(Cd5885)

Transponder positioning - APOS presentation

The figure shows the positions at the seabed transponder in UTM coordinates after the compensation values are determined and applied. The various symbols are used so readings from different locations easy can be separated from each other.

APPLICATIONS

Interfaces to the HPR 400 system

The HPR 400 can be interfaced to other computers allowing them to process the position data for various applications. The system is flexible in the way it interfaces other computes. Several binary and ASCII formats are available on serial line and Ethernet using UDP protocol. A dual Ethernet is available for secure DP operations. An accurate time-tagged position output is available if the system is interfaced to a DGPS and synchronised to 1PPS.

Dynamic positioning reference

The position data can be used by a Dynamic Positioning (DP) system as the reference signals for keeping the vessel in the desired position. High position accuracy and reliability ensure a secure and stable reference input to the DP systems. SSBL, LBL and SSLBL systems may be used.

Subsea survey and inspection

Positioning of ROVs carrying instruments for survey and inspection is another important application for the HPR systems. The ROV position relative to the vessel is integrated with the position from surface navigation to provide a geographical position of the ROV. In this application a responder is suitable.

Tracking towed bodies for similar applications may also be done. In survey applications, a best possible geographic position is wanted. To obtain this, sound velocity and pressure sensor input to the HPR may be used.

Rig monitoring

The HPR 400 systems can be used to monitor the drill rig position relative to the well/BOP. It can also be used with inclinometer transponders to monitor the BOP and riser inclination. Used with the ACS 400 it can be used for acoustic BOP control.

Acoustic Blow Out Preventer (BOP) Control

The HPR system is also used for transmitting and receiving acoustic telemetry command with high security. This is used for:

- Acoustic BOP control.
- Opening and closing of a valve governing the flow of crude oil to a tanker as on OLS.
- Monitor critical functions by reading subsea status information and sending this information to the operator onboard the vessel.

A separate system, ACS, is required on the BOP stack. A portable control unit, ACC, is also available.

Construction work and metrology

LBL Transponder positioning

A feature in the HPR system is to position one transponder relative to an LBL array. One Multifunction Positioning Transponder (MPT) is used to measure the range to other MPTs in an LBL array, and to transmit the ranges via telemetry to the surface HPR system. The HPR system computes the position of the transponder in the array.

The transponders may be interrogated simultaneously or in sequence. The ranges can be transmitted automatically after the measurement or on a controlled sequence from the surface HPR system.

The operator can control the speed of the telemetry link. A position update rate of 4 seconds is achievable. This function is ideal in applications like subsea construction and other object positioning where high accuracy is required and where there is no possibility to have an umbilical.

LBL High Accuracy Metrology

The MPT transponders have a High Accuracy mode, which has a very good range accuracy performance. It is possible to measure baselines with accuracy better than 0.05 m. The MPT’s are standard units that are operated by the HPR system.

The high accuracy and range capabilities obtained using MPT units in medium frequency mode reduces the need for high frequency transponders. High frequency transponders often need additional equipment to be installed onboard.

SYSTEM UNITS

Introduction

The HPR 400 system consists of 3 main units:

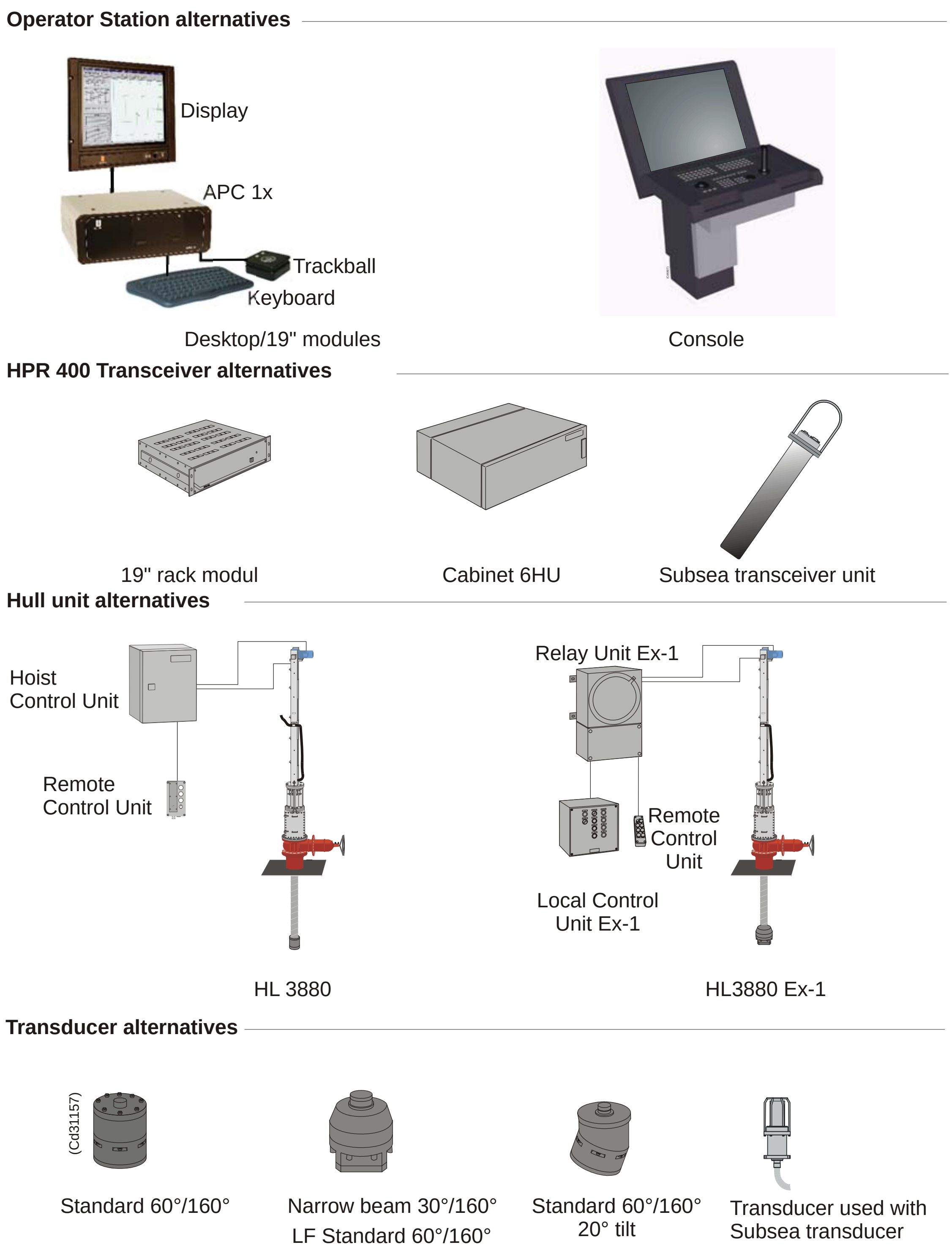
- Operator station
- Transceiver
- Hull unit with transducer and hoist control.

A system may be configured with one or several of these units. A gyrocompass and a vertical reference sensor will normally also be included in an HPR 400 system.

The units for Operator station alternatives are shown in system diagrams and in the “Outline dimensions” chapter.

The HPR 400 series may be supplied with several alternatives for transceivers, transducer and hull units. An overview of the available modules is shown in the figure on the following page.

HPR 400 series



Operator station

Introduction

The Operator station consists of:

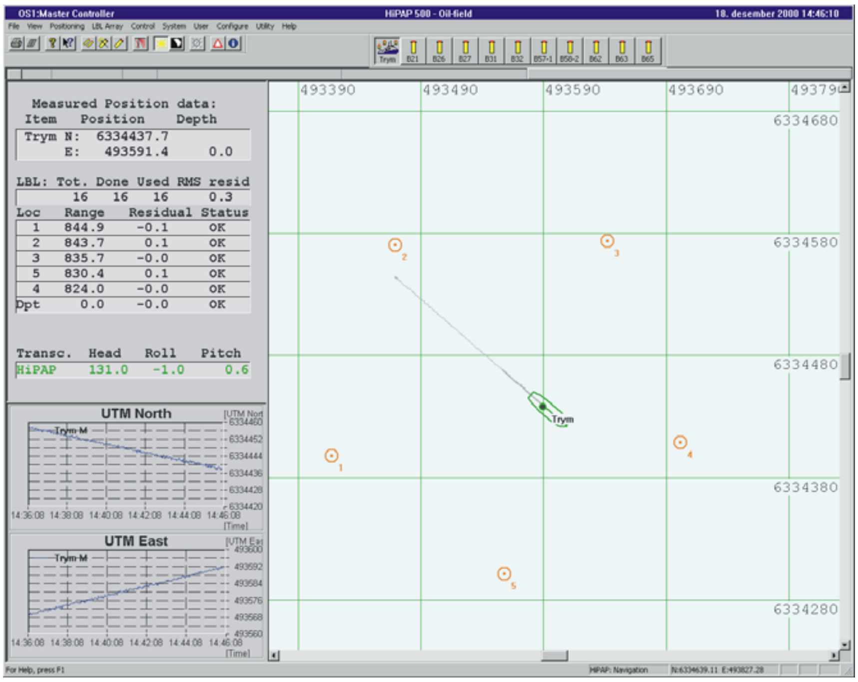
- APC 1x computer
- Keyboard and trackball
- Colour monitor

The computer runs on the Microsoft Windows XP operating system. The user interface is a graphical user interface, designed as a standard Windows XP application.

A Keyboard with numerical keys and a trackball controls the operation.

The screen is divided into 3 windows in which the operator can select several different views. Typical views are graphical position plot, numerical data, inclination and roll, pitch and heading. A normal display configuration is shown in the following figure.

One system may have one or several operator stations, which communicates on an Ethernet. One of the operator stations will be the Master. This is selected by the operator(s).



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One system may have one or several operator stations, which communicates on an Ethernet. One of the units will be the master, which is selected by the operator(s).

Operator station configuration

The HPR system may be configured with the operator station in tree ways:

1 Stand alone:
- Stand alone APC 1x computer
- LCD display
- Keyboard
- Trackball.

2 Operating Console

3 Integrated application on the same operator console as the Kongsberg Maritime DP.

Standard operator station

APC 1x - Acoustic Positioning Computer

The *APC 1x* is the computer in the HPR operator station. It holds all the operational software, and interfaces to display, keyboard, printers, network and other peripheral devices as required. The unit is normally fitted with a 3.5” floppy drive. The APC 1x may be mounted attached to the colour monitor, in a 19” rack or on a “desk top”.

LCD display

The LCD display is a general purpose, micro-processor based and digitally controlled display unit. The display can be installed in several ways; desktop, roof, panel or 19” rack.

Console monitors

The HPR system may be integrated in a console. The monitor will normally be supplied by the console manufacturer. It should be a 17” monitor or larger, able to operate with 1240x1024 resolution at 60Hz refresh rate.

Keyboard

The keyboard is a PS/2 keyboard. It is a QWERTY keyboard with US layout and includes back-lighting.

Operator console

The operator console integrates a 21” monitor, system controller and a keyboard. The console is identical to consoles used with the Kongsberg Maritime DP systems. The console is to be mounted on the deck.

Integrated operation with SDP XX

The integrated HPR and DP operation is available as two different solutions.

HPR and DP - one operator station

The operator must select whether the HPR or DP shall be viewed and operated. This is eligible from the menu. When the DP window is active, the HPR can be accessed from the menu selecting the HPR view or accessing a dialogue box for transponder operation. When the HPR window is active, the DP can be accessed from the menu selecting DP view.

HPR and DP - multiple operator stations

When several operator stations are available, the operator can view/operate the DP on one/several screen(s) and the HPR on another screen. The operation is the same as for a single operator console.

Units

Transceiver unit

Introduction

The HPR 400 Transceiver Unit processes the acoustic signals, calculates the transponder position(s), processes the acoustic telemetry data, and sends the information to the APC 1x. The unit is a 19”/3u rack module normally installed in a 6u cabinet for bulkhead mounting. It may also be delivered as a stand alone 19”/3u rack module. The main interfaces are:

- 2 SSBL transducers
- 2 LBL transducers
- 4 responders

- Roll, pitch and heading sensor.

The HPR 400 may be configured as a MF or LF system for all transducers. A combination of one MF and one LF SSBL transducer with one MF and one LF LBL transducer is also available.

The HPR 400 transceiver is also available in a subsea container rated for 3000 meters. It is designed for LBL positioning of ROVs. It is not further described here.

SSBL processing

The transceiver can operate two SSBL transducers with up to 56 transponders simultaneously. The unit measures the phase-difference between the SSBL transducer element groups, the propagation time and vessel roll, pitch and heading. From these measurements, the unit computes the X, Y and Z position of the transponder. The data is sent to the APC 1x.

The HPR 400 system is capable of handling both HPR 400 channels and HPR 300 channels.

LBL processing

The transceiver can operate 4 LBL transducers. Normally it uses 1 transducer and up to 8 transponders. The LBL processing can also be done with SSBL transducers. The unit measures the propagation time and computes the range to the transponders in the array. vessel roll, pitch and heading are also measured. The data is sent to the APC 1x.

Combined LBL and SBL processing

Combined LBL/SBL processing may also be used. Here up to 4 transducers may be used towards up to 8 transponders.

SSLBL processing

The SSLBL processing does both SSBL and LBL processing simultaneously, in which both ranges and direction to the transponders in the array are measured. It requires SSBL transducers.

Telemetry processing

The transceiver can operate 4 LBL transducers for telemetry. Simultaneously, it can use one transducer and communicate to one transponder. The telemetry processing can also be done with SSBL transducers. The unit transmits acoustic telemetry messages, and receives and decodes the acoustic telemetry message from the transponder. The data is sent to the APC 1x.

Transducers

A standard transducer (medium/wide/narrow beam) is mounted on a hull unit installed in the keel of the vessel. The transducer has a multi-element array of transmission/reception elements, enabling both pulse and phase measurement for the calculation of the range and two axis angles to the transponder(s).

Hull units

Introduction

An important factor for good acoustic communication to transponders is the high quality hull units on which the HPR transducers are normally mounted. These hull units allow the transducer to be lowered, under either local or remote control, through the vessel's hull to a depth sufficient to minimise the effects of noise and air layers below the vessel.

The hull unit is installed on top of a gate valve, which can be closed during service and maintenance of the transducer. The hull units also hold the guide arrangement for keeping the transducer exactly aligned with the vessel.

Available hull units

The HL 3880 is the standard hull unit available for the HPR 400 systems.

The descriptions in this document also apply to the following hull units:

- HL 1030
- HL 1530
- HL 2300
- HL 3100
- HL 6230

These hull units are based on the same design as the HL 3880 Hull Unit system, but differ in total height, transducer design and transducer depth.

Hoist control unit

This unit holds the power supplies and control logic for the hoist and lower operation of the hull unit. It also has a local control panel for local control of the hoist/lower operation.

Remote control unit

This unit is normally mounted close to the display unit in the operation room. It allows remote control of the hoist and lower operation of the hull unit.

Gate valves

There are two different gate valves available with 500 mm aperture and 350 mm aperture. The valve is hand-wheel operated, delivered with electrical interlock for prevention of lowering the transducer into the gate.

As an option the gate vale can be delivered with an electrical actuator (electrical gate valve operation).

Mounting flange

There are two different flanges available with 500 mm aperture and 350 mm aperture. Standard height is 600 mm. Optional length is available on request.

It is equipped with the following sub units:

- Local control unit
- Remote control unit

The HL 3880 Ex-1 is the hull unit prepared to be fitted in explosive zone 1. It is equipped with the following sub units:

- Local control unit
- Remote control unit

EXTERNAL INTERFACES

Attitude sensors are a common definition for roll, pitch, heave and heading sensors. The HPR 400 system has a wide range of interfaces to sensors from different manufacturers.

Vertical Reference Unit (VRU)

The Vertical Reference Unit (VRU) is interfaced to the HPR 400 Transceiver Unit. The system can thereby automatically compensate for the vessel's roll and pitch movements. The HPR system can use the same VRU as the Dynamic Positioning (DP) system (if one is fitted).

The Vertical Reference Unit may or may not be a part of the Kongsberg Maritime delivery. In any case, the unit is documented separately by the applicable manufacturer.

Gyro compass

The gyro compass supplies the HPR with the vessel's heading relative to north. The HPR may then provide transponder coordinates relative to north. It is also used to update the position filter as the vessel changes heading.

Integrated attitude sensors

These sensors integrate rate gyros, accelerometer and GPS to provide an accurate roll, pitch, heave and heading output. These sensors are superior to traditional gyros and VRUs. The HPR may be interfaced to such sensors.

Interface specification

The HPR has several interface formats available. These are described in "Attitude formats description".

Refer to APOS on-line help

SYSTEM CONFIGURATIONS

Introduction

The HPR 400 system may be configured in several different ways, from a single system to a redundant system with several operator stations. Some configurations are described below.

Single HPR 400 system

The single system includes the minimum units for a fully operational system. The communication from operator station and HPR 400 transceiver is a serial line. The data output from the system is also serial line. A system like this can be a HPR 410 or a HPR 418. See following system diagram.

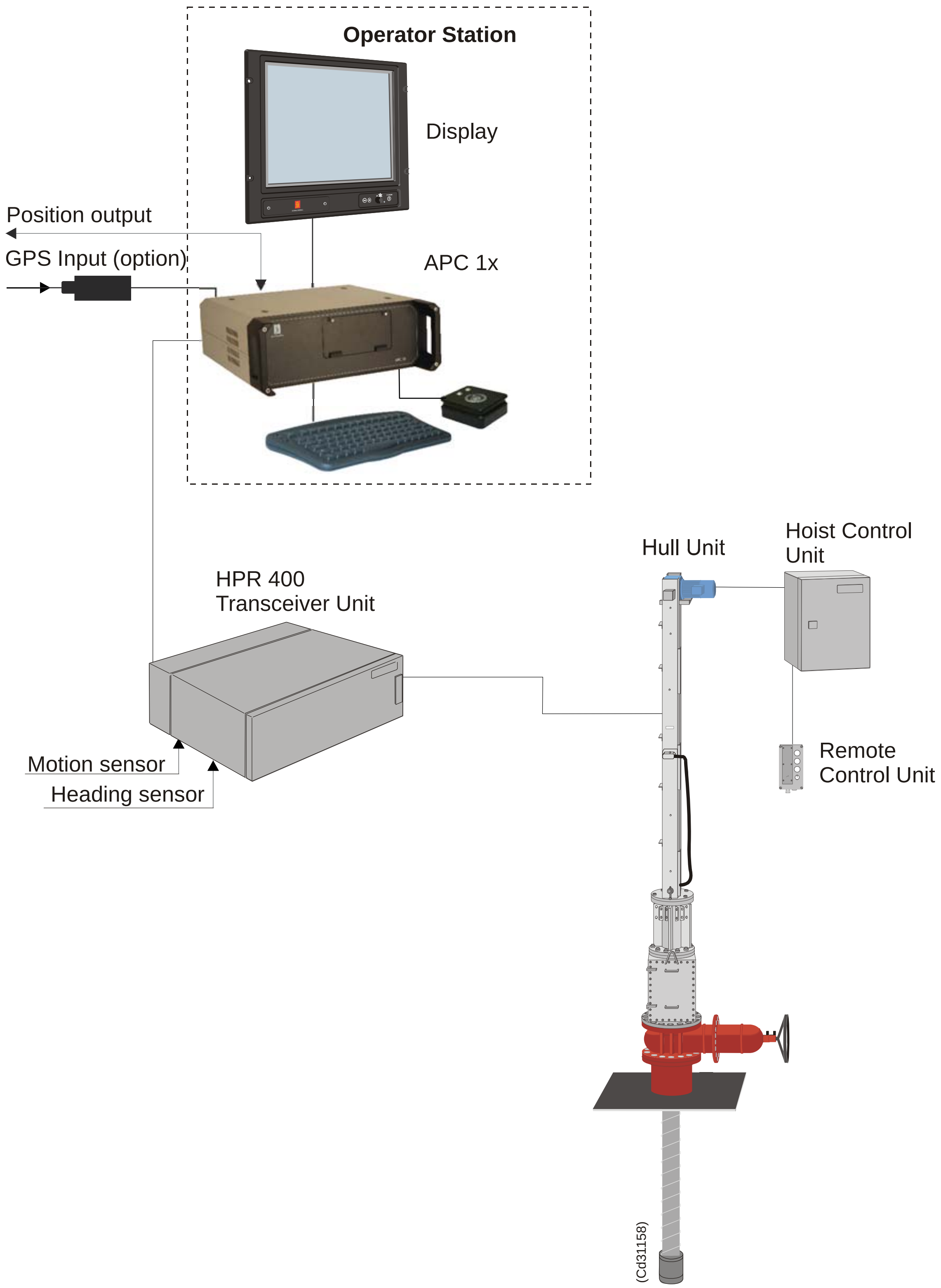
Redundant HPR 400 system

The redundant system has two of each unit to secure continuous operation even with a single failure. This system has communication between HPR 400 transceiver and operator station on a dual Ethernet, which secures control of both transducers if one operator station breaks down. The communication to other computers may be via Ethernet or via serial lines. See following system diagram.

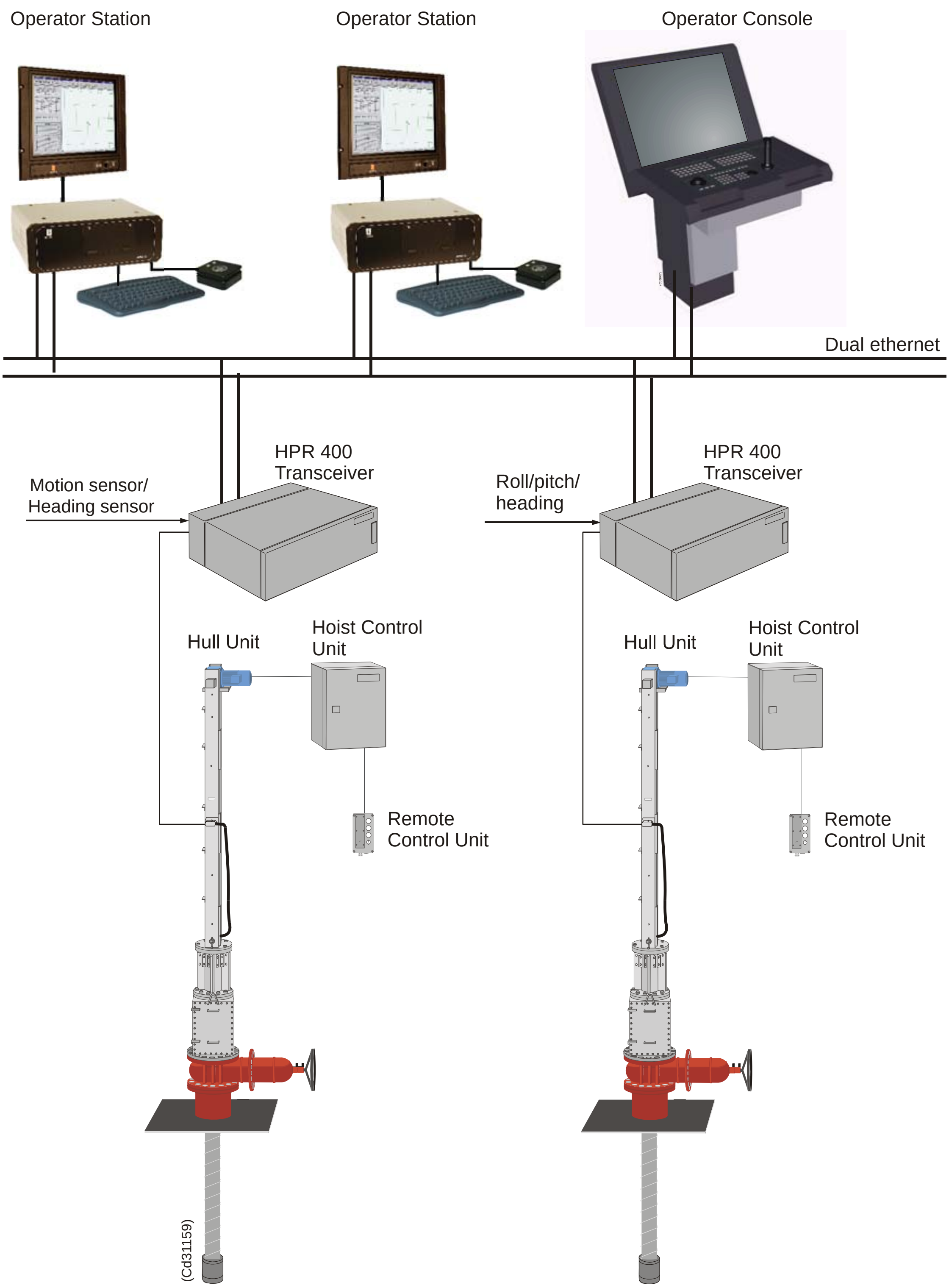
Combined HiPAP and HPR 400 system

A combined configuration uses the common operator station or consoles to operate both HiPAP and HPR 400 systems. Existing HPR 400 system may be upgraded to a combined system by adding the HiPAP Hull unit and transceiver. The operator can control both systems by using one operator station/console.

Single HPR 400 - system diagram



Redundant HPR 400 - system diagram



Transceivers

The system may be configured with from 1 to 4 transceivers. All transceivers are accessible from one operator station.

Transducers

The HPR 400 system may be configured with the following transducers:

SSBL MEDIUM - Standard MF SSBL transducer with 160/60º beam. The software algorithms keep narrow beam within 110º.

SSBL NARROW - Narrow beam MF SSBL transducer with 160/30º beam. The software algorithms keep narrow beam within 45º.

SSBL 15 kHz - Standard LF SSBL transducer with 160/60º beam. The software algorithms keep narrow beam within 110º.

LBL - Simple transducer for LBL and telemetry, available with different beam patterns.

LBL 15 kHz - Simple transducer for LBL and telemetry, available with different beam patterns.

TRANSPONDERS

General

The position calculation is based on range and/or direction measurements from the onboard transducer to the subsea transponder(s). The various transponder models have different depth rating, source level, lifetime, beam pattern and function.
The following transponder series are available:

- MPT - Multifunction Positioning Transponders
- SPT - SSBL Positioning Transponders
- MST - Mini SSBL Transponders

The MPT / SPT transponders are available with 1000 and 3000 m depth rating.

MPT transponders for 6000 m depth rating are also available.

The MST is available with 1000, 2000 and 4000 m depth rating.

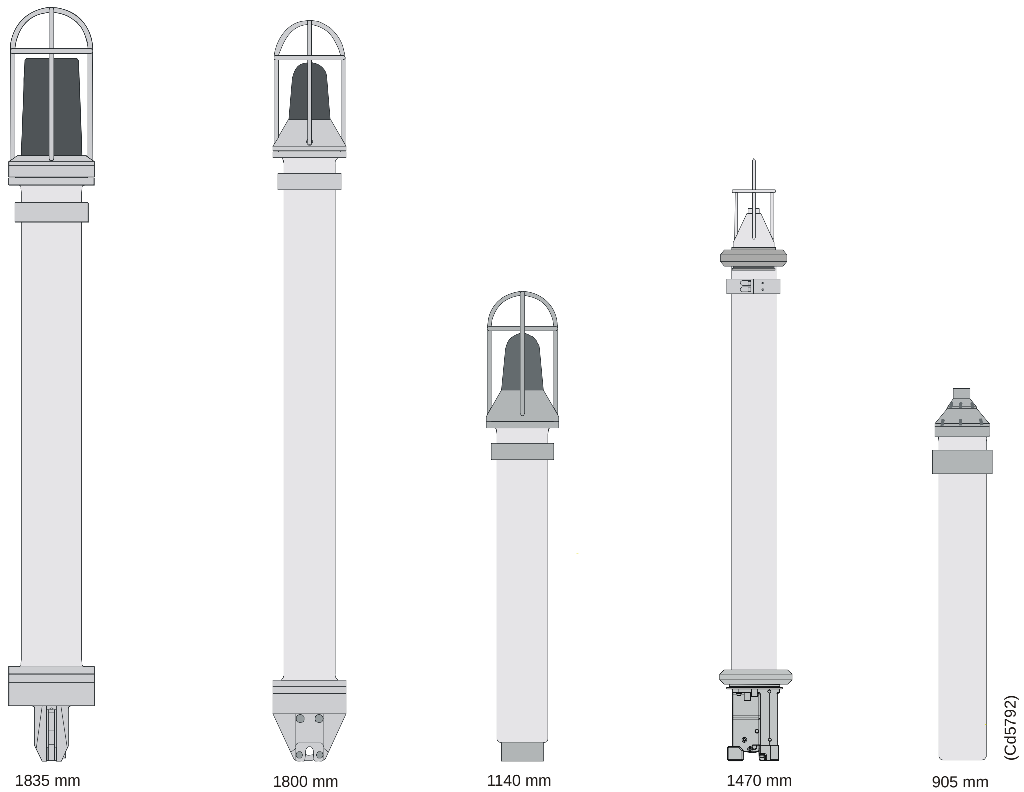
The MPT and SPT transponders do all have acoustic telemetry included. By use of acoustic telemetry from the HPR system several parameters can be controlled:

- Read battery status
- Enable/disable
- Transmitter power
- Receiver sensitivity
- Change channel - frequency
- Read sensors, if any
- Acoustic release

For details, see the *Product Specification* for each of the models.

MPT series

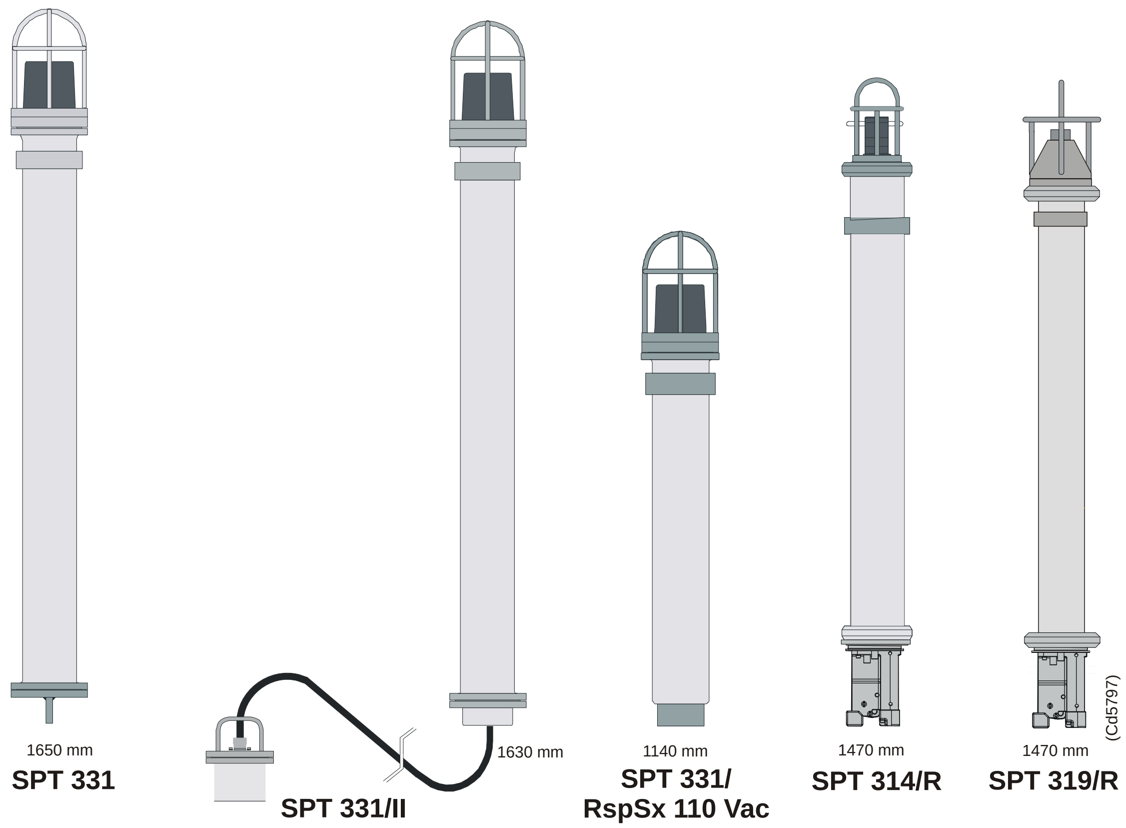
The MPT series consists of a wide number of transponders all suited for SSBL and LBL use. Depth rating, beam pattern, release mechanism, pressure and temperature sensor are among the options/choices available.



MPT 331/DTR DuB **MPT 339/DTR** **MPT 339/ R 110 Vac** **MPT 319/R** **MPT 316/DT EEx**

SPT series

The SPT series consists of a wide number of transponders. All suited for SSBL use. The SPT has the same hardware as the MPT, but only the SSBL functionality. Depth rating, beam pattern, release mechanism, inclinometers, pressure and temperature sensor are among the options/chooses available.



MST series

The MST is an SSBL mini transponder suited for ROV operation and where the size of the transponder can be a limiting factor. The transponder models cover various water depths. The MST series consists of the following models:

- MST 319 - rated for 1000 m water depth
- MST 324 - rated for 2000 m water depth
- MST 342 - rated for 4000 m water depth

All units have a rechargeable battery, can operate in responder mode and be externally powered.

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SYSTEM FUNCTIONS

Introduction

The HPR system consists of a wide range of functions. A function is selected by the operator. The basic systems have standard functions included, to ensure normal operation. The systems may be delivered with additional options selected from the system option list.

Main functions

General

The main functions in the HPR system are described below. The system may be configured with one or several of these functions. They will appear in the systems main menu.

List of main functions

The list below shows which functionality each of the functions includes. The ”reg. no” is the unique identification for this function.
Example; the reg. no for APOS Base version is 886 - 212745.

Reg. no	Description
886-212745	**APOS base version** *APOS - Acoustic Position Operator Station* Base for running all applications, includes: • Sound velocity profile function • Ethernet interface for position data • Serial line, RS-422 for transceiver interface • Serial line, RS-422 for position data Transponder telemetry for SPT / MPT transponders including: • Set transmit power level • Set receive sensitivity • Set Pulse length • Change channel • Enable/Disable • Transponder release • Read battery status • Read sensor data, if any Position and angle alarm: • APOS software for HiPAP or HPR 400 providing alarm for transponder position and riser angle alarm. APOS Depth sensor interface: • APOS software for interfacing a depth sensor for depth compensation of position. Suitable for ROV or Tow fish positioning.

<table>
<tr><th>Reg. no</th><th>Description</th></tr>
<tr><td>886-212747</td><td>HPR 400 SSBL function
APOS software for HPR 410 SSBL operation includes:
• Transponder positioning
• Responder positioning
• Use of MF or LF transducers
• Interface for one synchro GYRO
• Interface for one analogue VRU
• Interface for one serial GYRO or attitude sensor
• SSBL simulator for training
A responder controller pcb is required for responder use.</td></tr>
<tr><td>886-212748</td><td>LBL function
APOS software for LBL operation using HiPAP / HPR 400 includes:
• Calibration of transponder array in local grid
• Positioning of vessel/ROV in LBL array
• Necessary transponder telemetry
• LBL simulator for training
• Geographical position output if tp origin are entered in geo coordinates
This function requires that the system already has the “APOS Base Version”, reg. no: 212745, reg.no: Dependant on model.
Positioning of an ROV in LBL requires an HPR 400 Subsea Unit.</td></tr>
<tr><td>886-212749</td><td>HPR 410P SSBL function
APOS software for HPR 410P SSBL operation includes:
• Transponder positioning
• Responder positioning
• Use of PMT 301 Transducer w/ internal roll/pitch inclinometers
A responder controller PCB is required for responder use (Reg. No 382-089372).</td></tr>
</table>

Reg. no	**Description**
886-212750	**MULBL function** APOS software for HiPAP / HPR 400 system MULBL operation includes: • Calibration of transponder array in local grid • Positioning of vessel in MULBL array • Necessary transponder telemetry It requires HiPAP SSBL and LBL, reg. no.: 212746 and 12748.
886-212751	**MULBL transponder array data** APOS files containing transponder array data for MULBL.
ADDITIONAL OPTIONS	
886-212752	**Beacon Mode** APOS software for HiPAP / HPR 400 beacon and depth beacon operation.
886-212753	**Inclinometer Mode** APOS software for HiPAP or HPR 400 inclinometer transponder operation.
886-212754	**Compass Transponder** Mode APOS software for HiPAP / HPR 400 compass transponder operation.
886-212755	**GEO LBL Calibration** APOS software for HiPAP / HPR 400 for calibration of LBL array in geographical coordinates. In positioning mode the position may be reported in geographical coordinates.
886-212757	**LBL Transponder Positioning Mode** APOS software for HiPAP or HPR 400 for use of MPT transponders to be positioned in an LBL network. (old name was Tp Range Pos).
886-212759	**APOS Master Slave function** An extra copy of the functionality of the master operator station for installation on additional operator stations. The operator can select which station shall be the master. Can be used both for HiPAP and HPR 400 systems.

Reg. no	Description
886-212760	**APOS Upgrade software** Upgrade from HSC400 software to APOS software, including old functionality. This may require an new monitor and a APC 1x computer and keyboard.
886-212761	**APOS External synch** APOS software for synchronising HiPAP / HPR 400 transceivers to external equipment.
886-212762	**APOS DUAL Ethernet** APOS software and hardware for use of SDP dual Ethernet. Requires one Ethernet.
886-212764 KIT-212572	**HPR 400 Transceiver DUAL Ethernet** An SDN 400 module mounted in HPR transceiver cabinet for interface to dual Ethernet.
886-212765	**APOS ACS BOP function** APOS software for telemetry to ACS 400 or ACS 300 system used on BOP. Telemetry to ACS 300 only available on HPR 400 systems.
886-212766	**APOS ACS OLS function** APOS software for telemetry to ACS 300 system used on OLS. Telemetry to ACS 300 only available on HPR 400 systems.
886-212767	**APOS STL function** APOS software for HiPAP / HPR 400 system for STL fields special functions including: • Scanning of MLBE depth and position • Positioning of STL buoy • Scanning of transponder battery status • Graphics showing STL connection point
886-215836	**APOS Anchor Line Monitoring function** APOS software for HiPAP / HPR 400 system. Scanning of up to 9 transponder(s) installed on Anchor Lines/Anchor Line Buoys, presenting individual: • Depth • Position • Scanning of transponder battery status

Reg. no	**Description**
886-215837	**HiPAP Transponder Relay Function** Enables use of relay-function, relay-transponder frequency allocation, operator interfaces and displays functionality.
886-215939	**SAL Tension & Yoke monitoring** APOS software HiPAP or HPR 400 systems for showing Tension and Yoke including: • Graphical presentation of yoke-angle • Graphical presentation of tension • Table for converting inclination angle to tension
886-212768	**APOS Field transponder array data** APOS files containing transponder array data for offshore loading fields.
881-217543	**APOS Trainer - HPR 400 Series** The product is suitable for training, planning and demonstration purposes. Features: • A CD containing full APOS software with all options except OLS. Defined with one HiPAP / one HPR 400 transceiver • APOS instruction manual Includes Sound velocity ray-trace calculation with displaying of deflection based on velocity profile input. Includes Long Base Line array planning tool. Includes data output for testing telegram interfaces to external computers (transmits standard HiPAP / HPR telegrams). The APOS can be operated as a normal HPR and a simulator replaces transceiver and transponders. The program requires a computer with CD-ROM player, a running NT4.0 program, a monitor with minimum 800x600 resolution, a network card, and a TCP-IP protocol needs to be defined.
	APOS Software for EMGS's interface with CTL The software is an optional feature to any HiPAP / HPR 400 system. This option can only work on the Master Operator Station.
	APOS Extension For Audible Alarm Position and angle audible alarm extension. APOS software for HiPAP / HPR 400 system providing alarm for transponder position and riser angle alarm. Gives an audible alarm using the windows sound system. Includes a sound card and a small speaker.

TECHNICAL SPECIFICATIONS

SSBL Accuracy

HPR 400 Standard transducer 20-32 kHz

Wide beam ±80°	≤5 % of slant range
Narrow beam ±55°	≤2 % of slant range

HPR 400 Narrow beam transducer 20-32 kHz

Wide beam ±80°	≤5 % of slant range
Narrow beam ±22.5°	≤1 % of slant range

HPR 400 Standard transducer 10-15 kHz

Wide beam ±80°	≤5 % of slant range
Medium beam ±55°	≤2 % of slant range

Note *The specification is based on:*

- Line of sight from transducer to transponder
- No influence from ray bending
- Signal to Noise ratio ≥ 20 dB. rel. 1μPa
- No error from heading and roll/pitch sensors

LBL accuracy

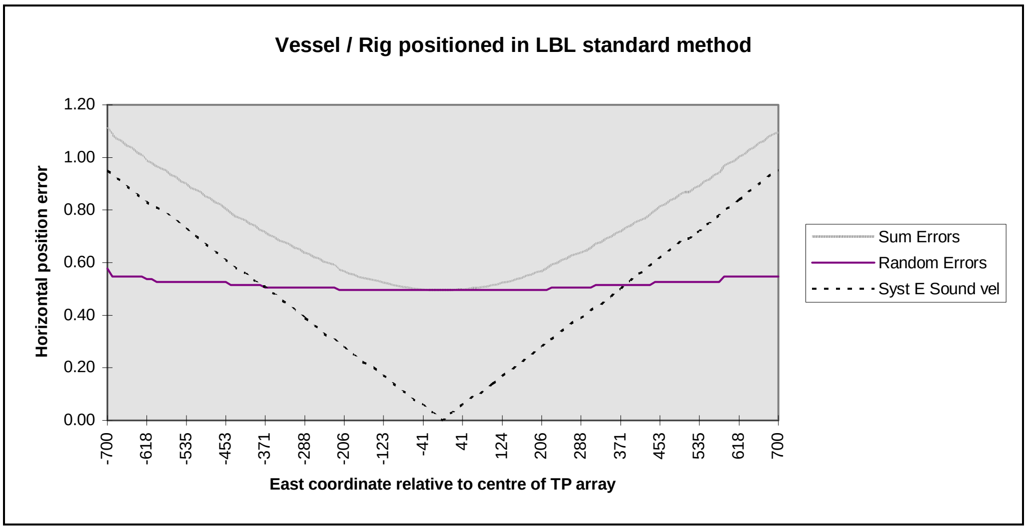
The position accuracy for LBL operation is very dependent on the transponder array geometry, sound velocity errors and signal to noise ratio. However, simulations can show the accuracy.

The following "one sigma" error contribution to the range measurements are assumed (20-30) kHz system:

- Range reception with 20dB S/N: 0.15 meter
- Range reception in the transponder: 0.15 meter
- Range error due to Tp movement: 0.10 meter
- Range error due to rig movement: 0.20 meter

The random errors are added as Gaussian noise to the measurements.

The figure shows the error in the horizontal position when the Rig moves within the transponder array. The simulations are done with 4 LBL transponders placed on the Seabed in a circle with radius 636m. The water depth is 1200 m. The error is showed as a function of the East coordinate. The north coordinate is zero, and the East coordinate zero is consequently the centre of the array. We have assumed that the wide beam of the Rig transducer is used, and that the S/N when receiving the transponder replies is 20 dB. The effect of a systematic error in the Sound velocity of 1 m/s is also showed. When being in the centre of the array, that error causes no position error. When being in the outer parts of the array, that error causes a significant systematic error in the position.



Range capabilities

The range capabilities depend on the vessels noise level, transponder signal level and transponder type. Ray-bending effects may also reduce the operating range. The figures are based on 20-32 kHz systems and are approximate values for guidance.

Standard transponder:

w/ 188 dB rel.1μPa ref.1m...................Typical 1000 m - 1500 m

High power transponder:

w/ 195 dB rel.1μPa ref.1m...................Typical 1500 m - 2000 m

High power transponder:

w/ 206 dB rel.1μPa ref.1m...................Typical 2500 m - 4000 m

(Based on 115 dB detection level)

Note — *The specification is based on:*

- Line of sight from transducer to transponder
- No influence from ray bending
- Signal to Noise ratio ≥ 20 dB. rel. 1µPa
- No error from heading and roll/pitch sensors

Unit specifications

APC 1x computer

Unit for desktop installation:	17 kg
Unit for rack installation (including rails and side plates):	17 kg
Colour graphics resolution:	Eligible max. 1600 x 1200
Video output:	15 pin, analogue VGA
Floppy drive:	3.5″
Printer interface:	parallel
Electrical interfaces:	RS-422, RS-232, Ethernet

Power supply

Voltage:	180-264 Vac/ 90-132 Vac
Frequency:	50-60 Hz
Max Inrush current:	80 A
Nominal:	80 W

Temperature

Storage:	-40° C to +70° C
Operating:	+10° C to +55° C

Humidity

Storage / operating:	85% / 95% relative

Vibration

Range:	5-100 Hz
Excitation level:	5-13.2 Hz ±1.5 mm, 13.2-100 Hz 1 g

Telegram formats

Serial lines	Ethernet
- Binary HPR 209/309:	- Binary HPR 400

- Binary HPR 400- BCD code:	- Proprietary NMEA
- Proprietary NMEA:	

Keyboard

Weight:	3 kg
Cable length:	2 m
Degree of protection:	IP 64

Trackball

Weight:	1.5 kg
Cable length:	2.8 m
Degree of protection:	IP 64

Display

→ *For information, refer to separate manual supplied with the display.*

HPR 400 transceiver unit

Power supply, voltage:	185 – 264 Vac
Power supply, frequency:	50-60 Hz
Power supply, consumption max:	55 W
Temperature, storage:	-20 to +60° C
Temperature, operating:	0 to +55° C
Degree of protection, in 6U cabinet:	IP 54
Humidity, storage / operating:	90% / 80% relative

Heading reference:

- HPR 400 S31 - This is a MF system, and is deep water rated to 1000 meter.
- HPR 400 S33 - This is a MF system, and is deep water rated to 3000 meter.
- HPR 400 S16 - This is a LF system, and is deep water rated to 6000 meter.

- This unit holds the power supplies and control logic for the hoist and lower operation. It also has a local control panel for local control of the hoist/lower operation.
- This unit is normally mounted close to the display unit in the operation room. It allows remote control of the hoist and lower operation.
- This unit is normally mounted close to the hull unit for local control of the hoist and lower operation. This particular version is designed for use in explosive zones.
- This unit is normally mounted close to the display unit in the operation room. It allows remote control of the hoist and lower operation.
- Synchronous
- Serial RS 422 SKR format
- Serial RS 422 STL format
- Serial RS 422 NMEA format
- Serial RS 422 Seatex MRU or Seapath
- Serial RS 422 DGR format (Tokimec DGR 11)
- Analogue Sine ± 90° ±10 V
- Analogue Sine ± 15° ±10 V
- Analogue linear ± 60° ±10 V
- Analogue Seatex MRU ± 20° ±10 V
- Serial RS 422 Seatex MRU or Seapath
- 2 SSBL MF and 2 LBL/Telemetry MF
- 2 SSBL LF and 2 LBL/Telemetry LF
- 1 SSBL & 1 LBL/Telemetry MF and 1 SSBL & 1 LBL/Telemetry LF

Roll and pitch reference

Transducer frequency combinations

Transponders in use:	max. 56
Transponder channels:	HPR 300 and HPR 400

Hoist control unit

Weight:	12 kg
Degree of protection:	IP 54

Power supply

Voltage:	230 / 440 Vac 3 Phase
Frequency:	50-60 Hz
Consumption max:	1100 W

Temperature

Storage:	-20° C to +60° C
Operating:	0° C to +55° C

Humidity

Storage / operating:	80% / 90% relative

Remote control unit

Power supply

The Remote Control Unit is supplied with 24 Vdc from the Hoist Control Unit.

Weight:	1.5 kg
Voltage:	240 Vdc
Frequency:	50-60 Hz
Consumption:	6 W
Degree of protection:	IP 54

Temperature

Storage:	-20° C to +60° C
Operating:	0° C to +55° C

Humidity

Storage:	10 - 90% relative
Operational:	30 - 80% relative

Flange

Certificates

Lloyd's and DNV certifications are standard, others on request.

Dimensions

Standard height:	600 mm
Optional height:	Specified by customer
Diameter, internal / flange:	500 mm / 670 mm
Wall thickness:	20 mm
Weight, standard:	90 Kg

Gate valve

Certificates

Lloyd's and DNV certifications are standard, others on request.

Dimensions

Type:	DN500
Height:	350 mm
Length (from centre):	1335 mm
Diameter, internal / flange:	500 mm / 670 mm
Weight:	510 Kg

Hull units

Power supply, voltage:	230 / 440 Vac 3 Phase
Power supply, frequency:	50-60 Hz
Power supply, consumption max:	1100 W
Temperature, storage:	-20° C to +60° C
Temperature, operating:	0 ° C to +55° C
Degree of protection:	IP 54
Humidity, storage / operating:	90% / 80% relative

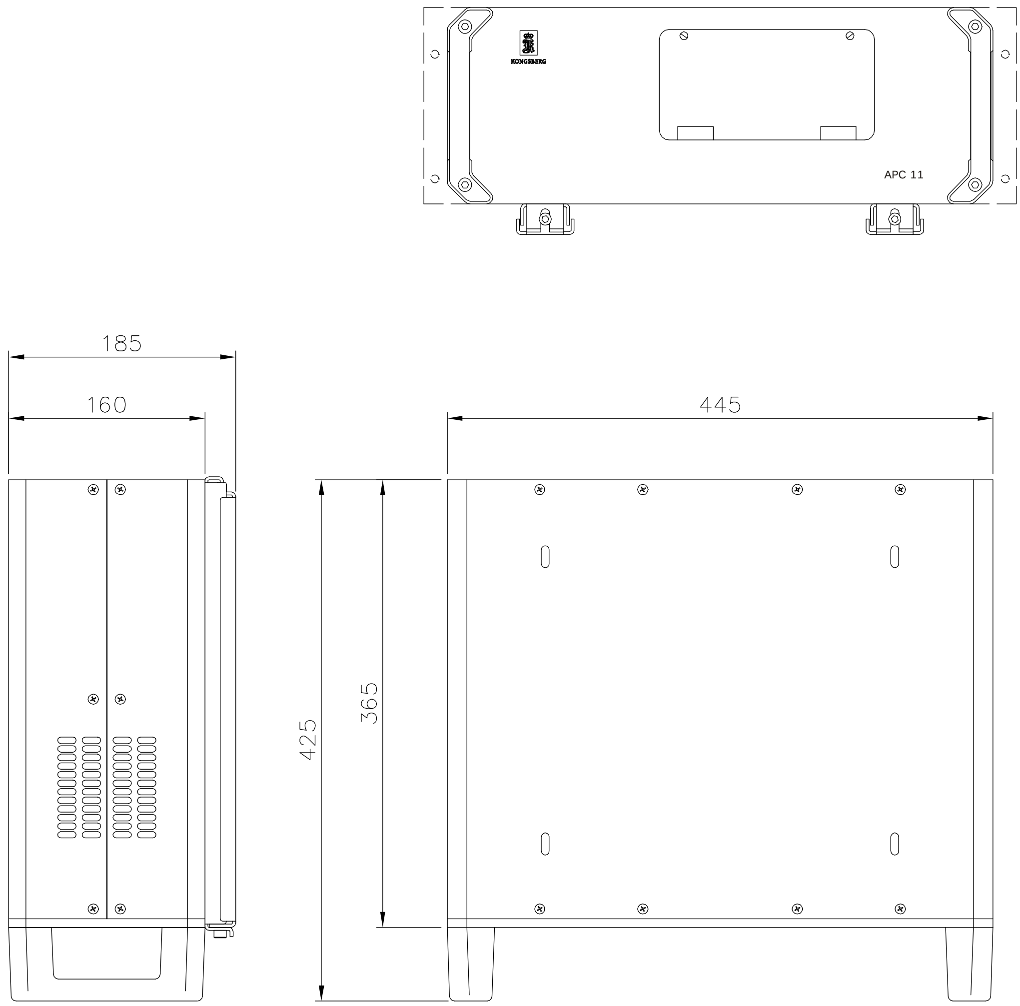
Weight

HL3880:	1225 Kg
HL3100:	1261 Kg
HL2300:	1161 Kg
HL1530:	1061 Kg
HL 3380 Ex-1:	1336 Kg

Outline dimensions

The outline dimensions shown in this section are for information only and must not be used for installation or manufactory purposes.

APC 1x - outline dimensions



Note:
All measurements are in mm.
The drawing is not in scale.

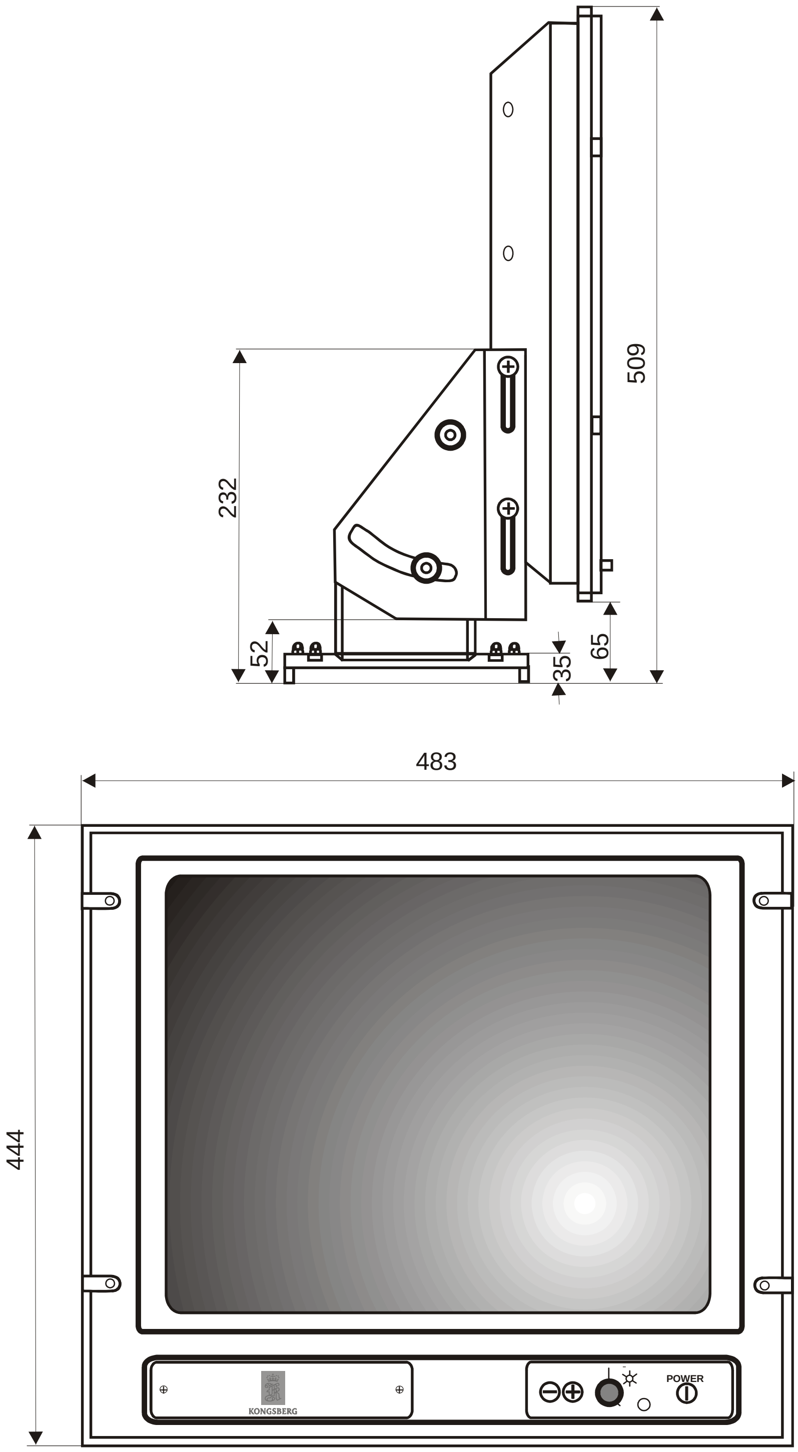
Cd31082x Page 1 o 1
210400 Rev.B

Keyboard and trackball

Note:
All measurements are in mm.
The drawing is not in scale.

Cd31400x Page 1 of 1
N/A

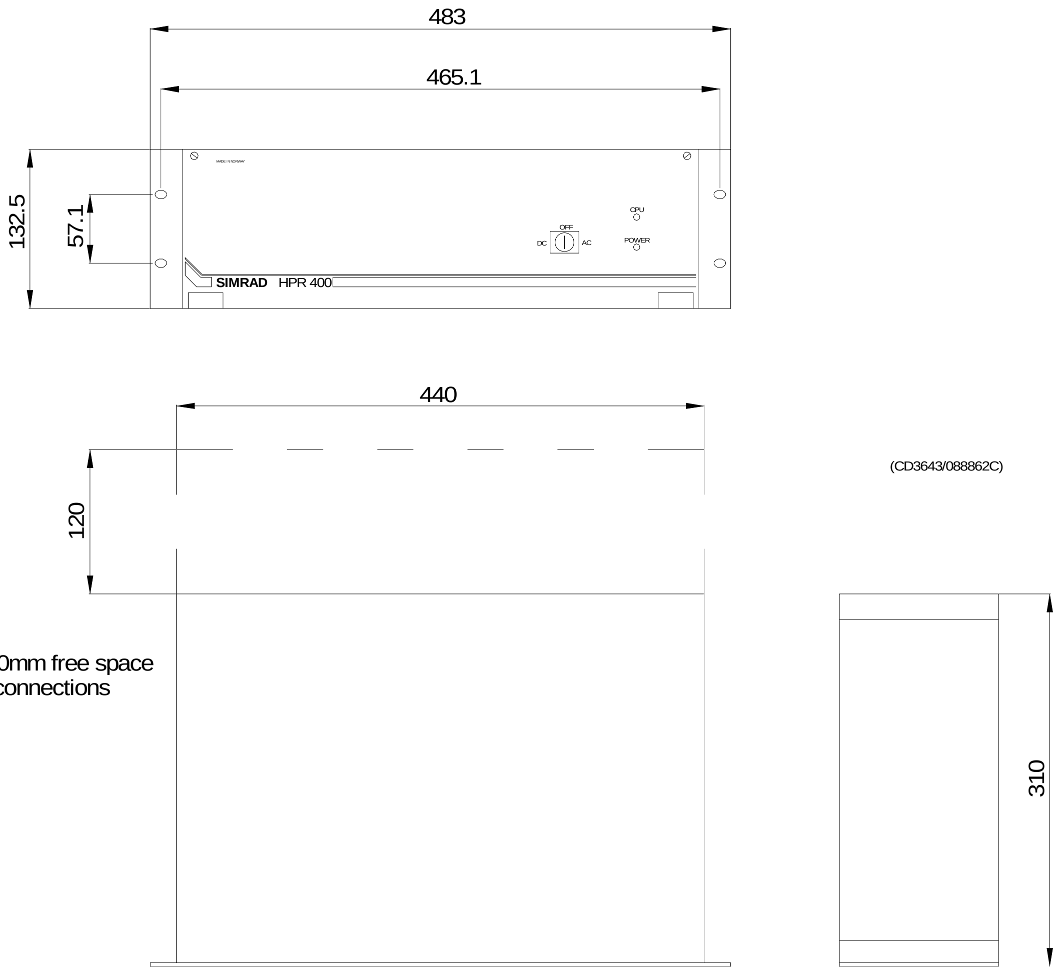
19“ display - outline dimensions



Note:
All measurements are in mm.
The drawing is not in scale.

Cd31022x Page 1 o 1

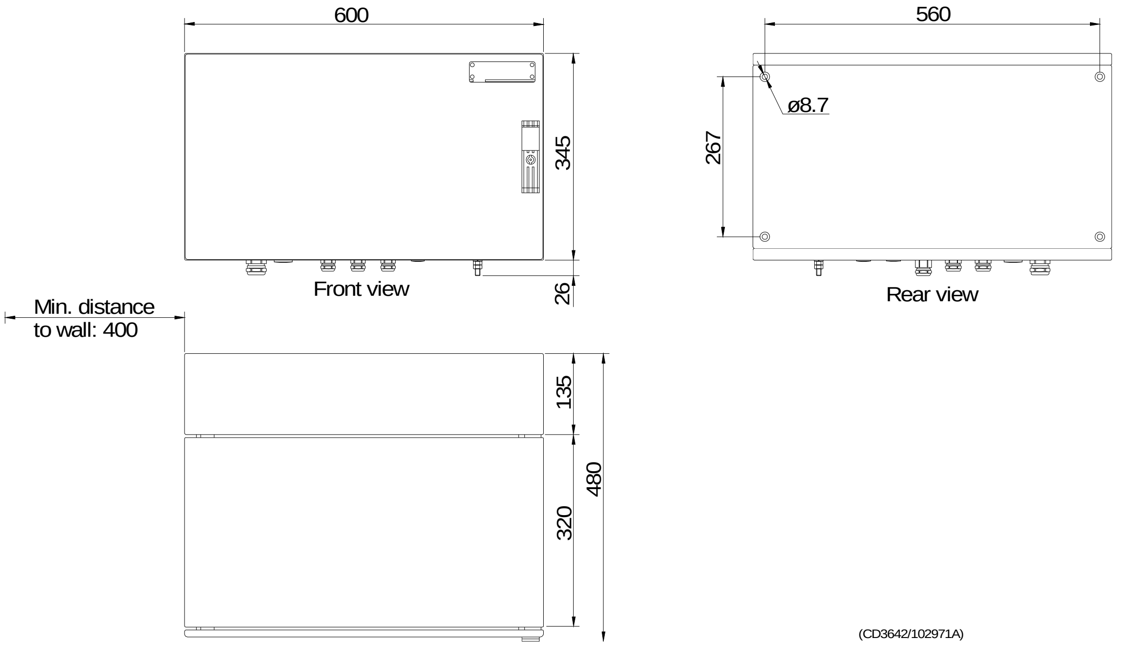
HPR 400 transceiver – 19” rack



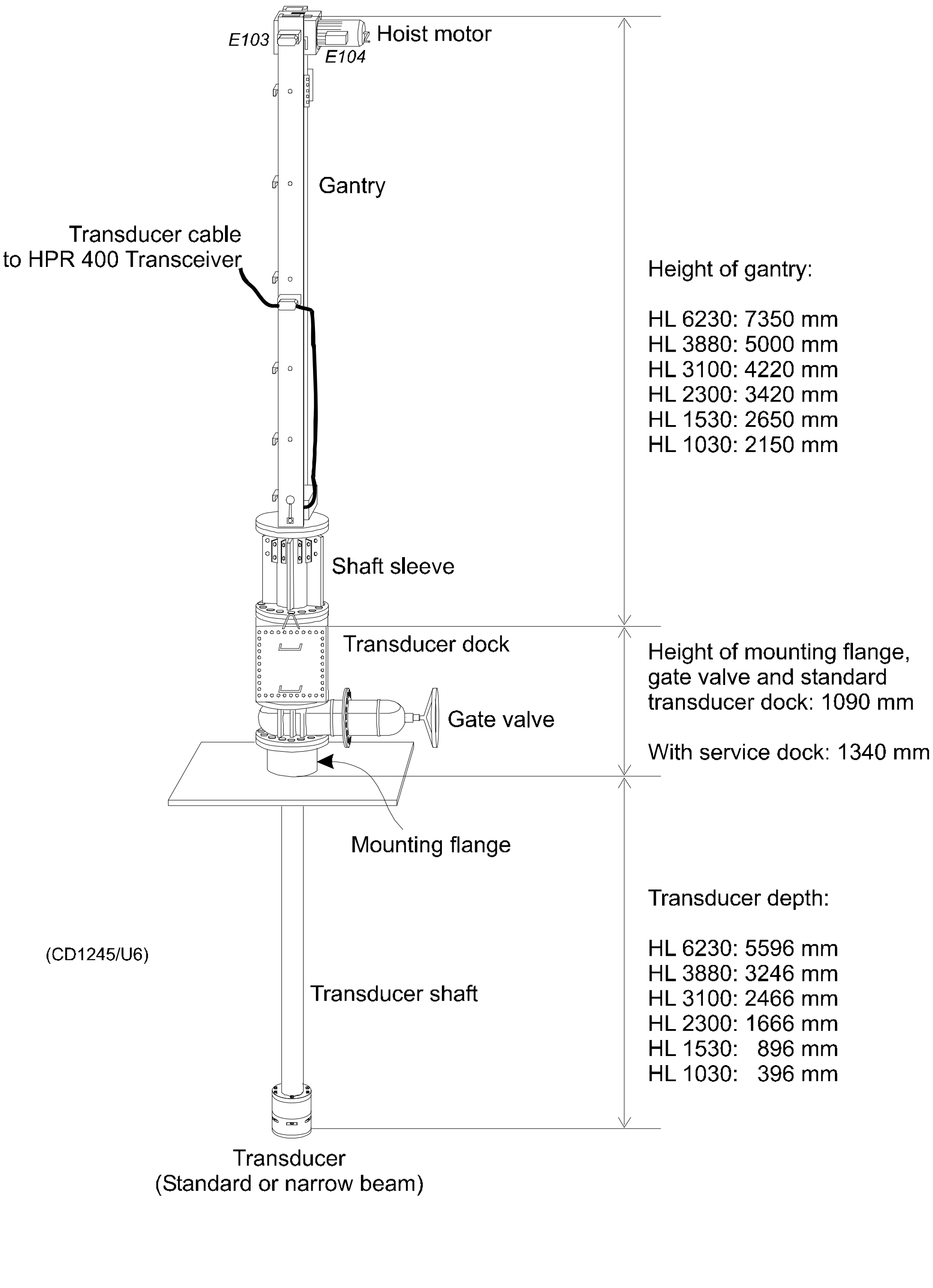
Allow 120mm free space
for plug connections

(CD3643/088862C)

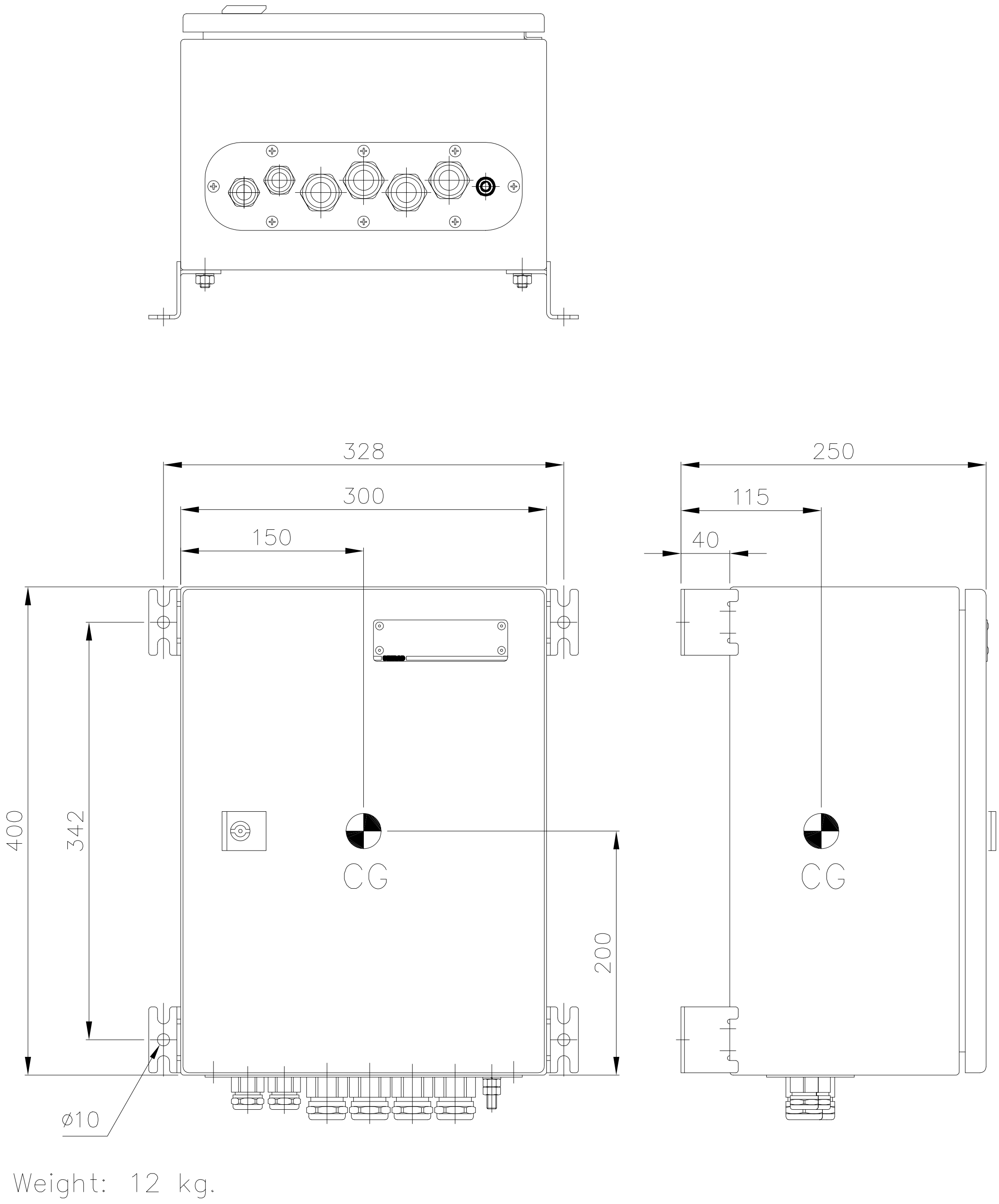
HPR 400 transceiver – 6u cabinet



HL3880 / HL3100 / HL2300 / HL1530



Hoist Control Unit – outline dimensions



Note:
All measurements are in mm.
The drawing is not in scale.

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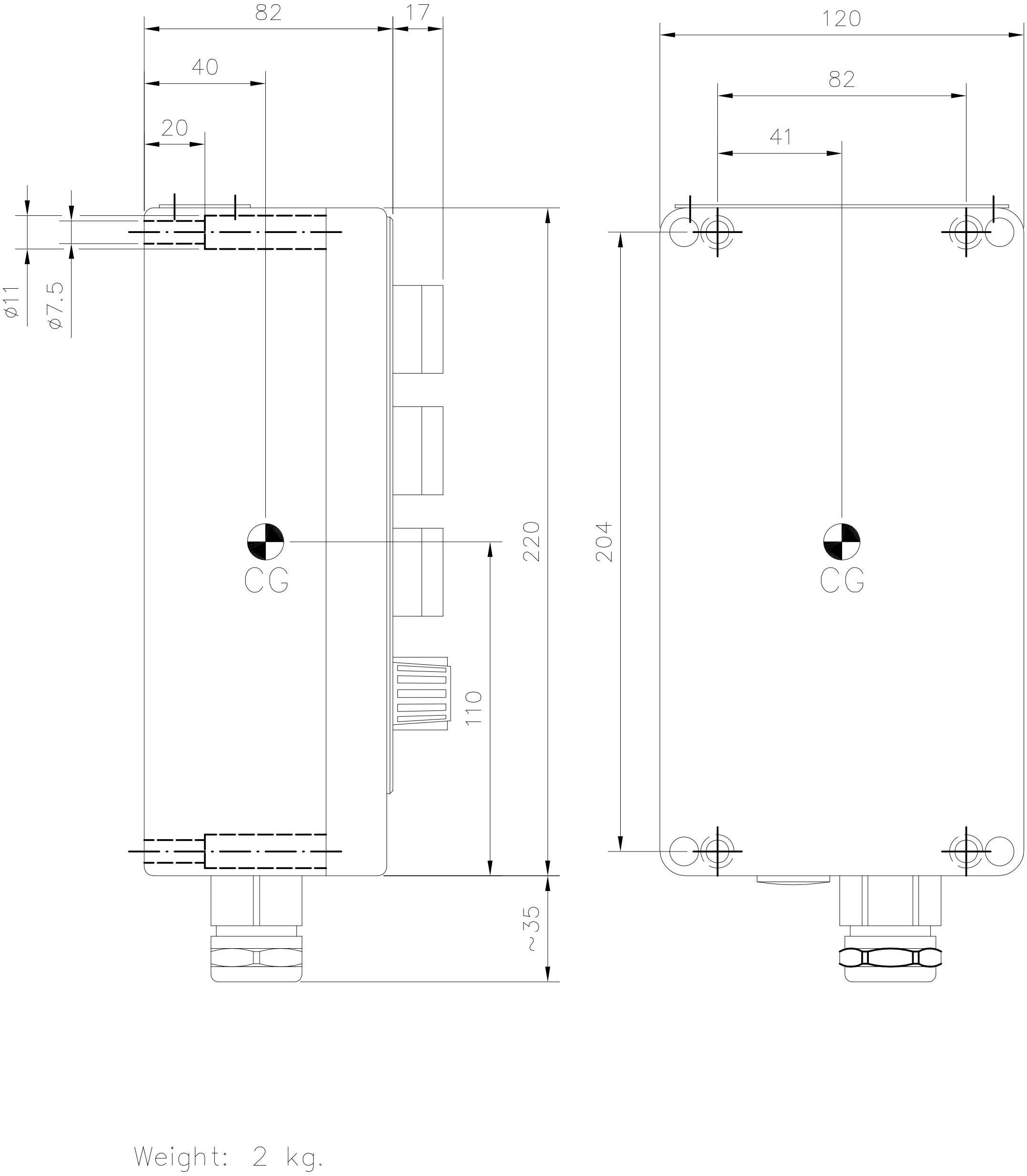
830-102887 Rev.D

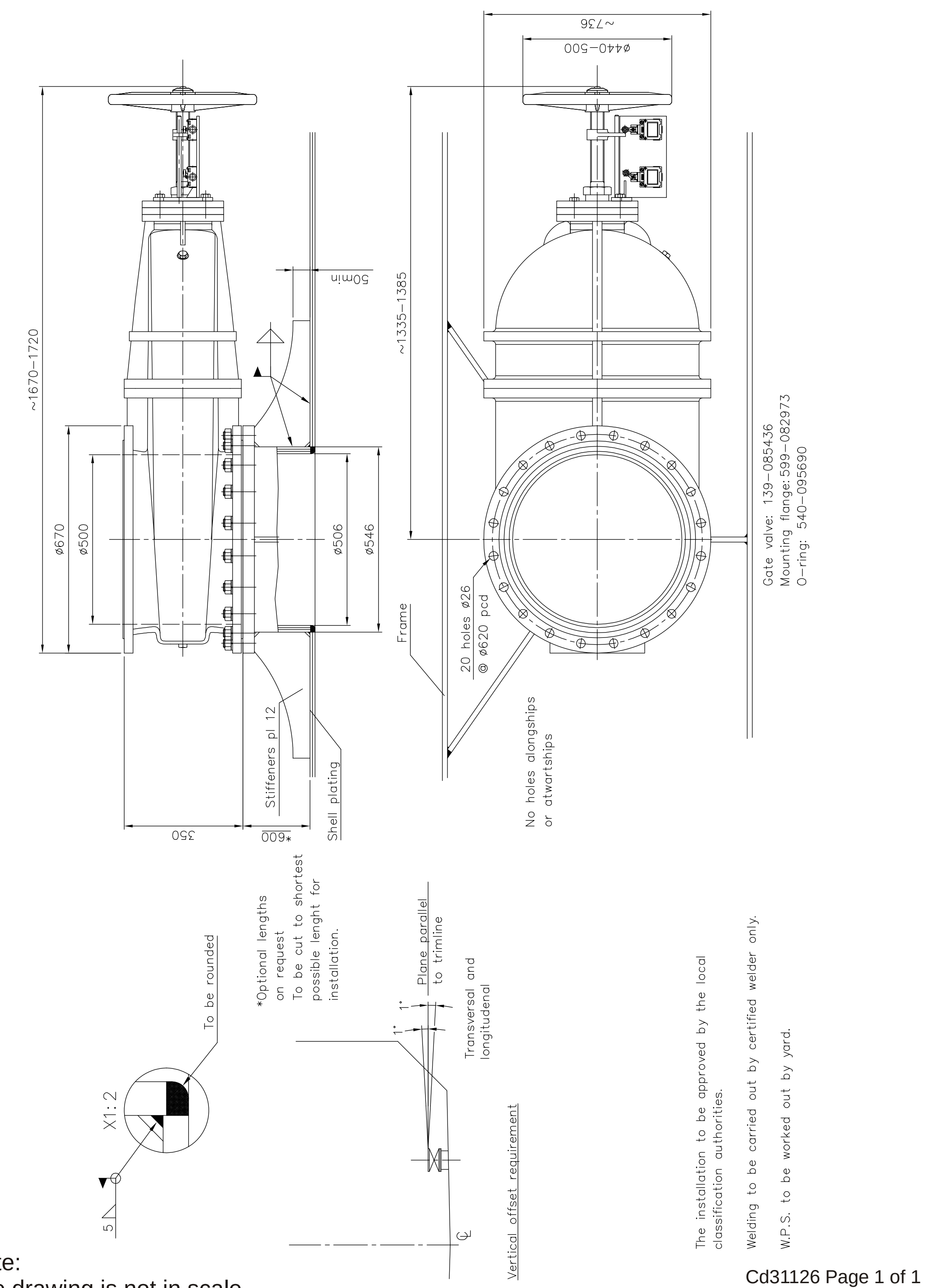
Remote Control Unit – outline dimensions



Note:
All measurements are in mm.
The drawing is not in scale.

Cd31029 Page 1 of 1
830-103012 Rev.B

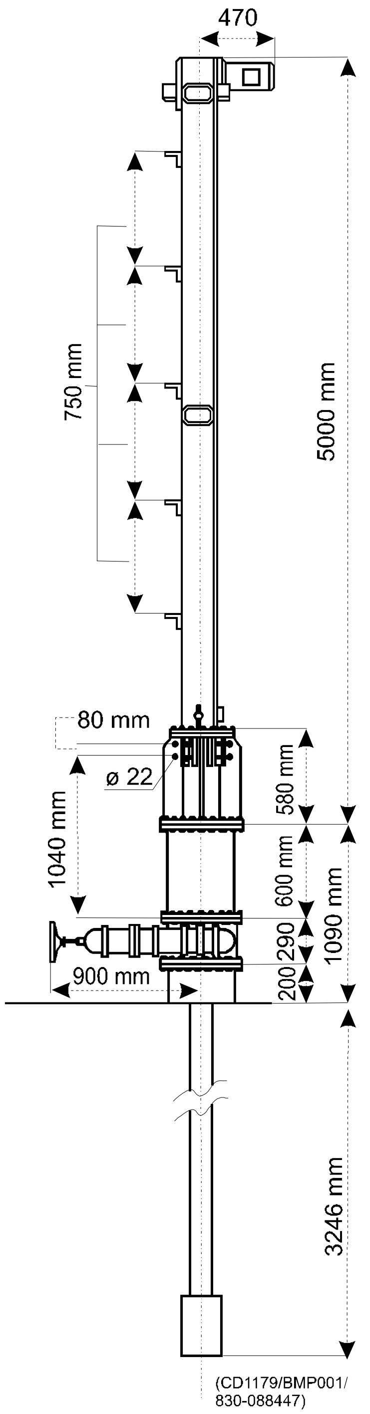
DN 500 mounting flange w/gate valve



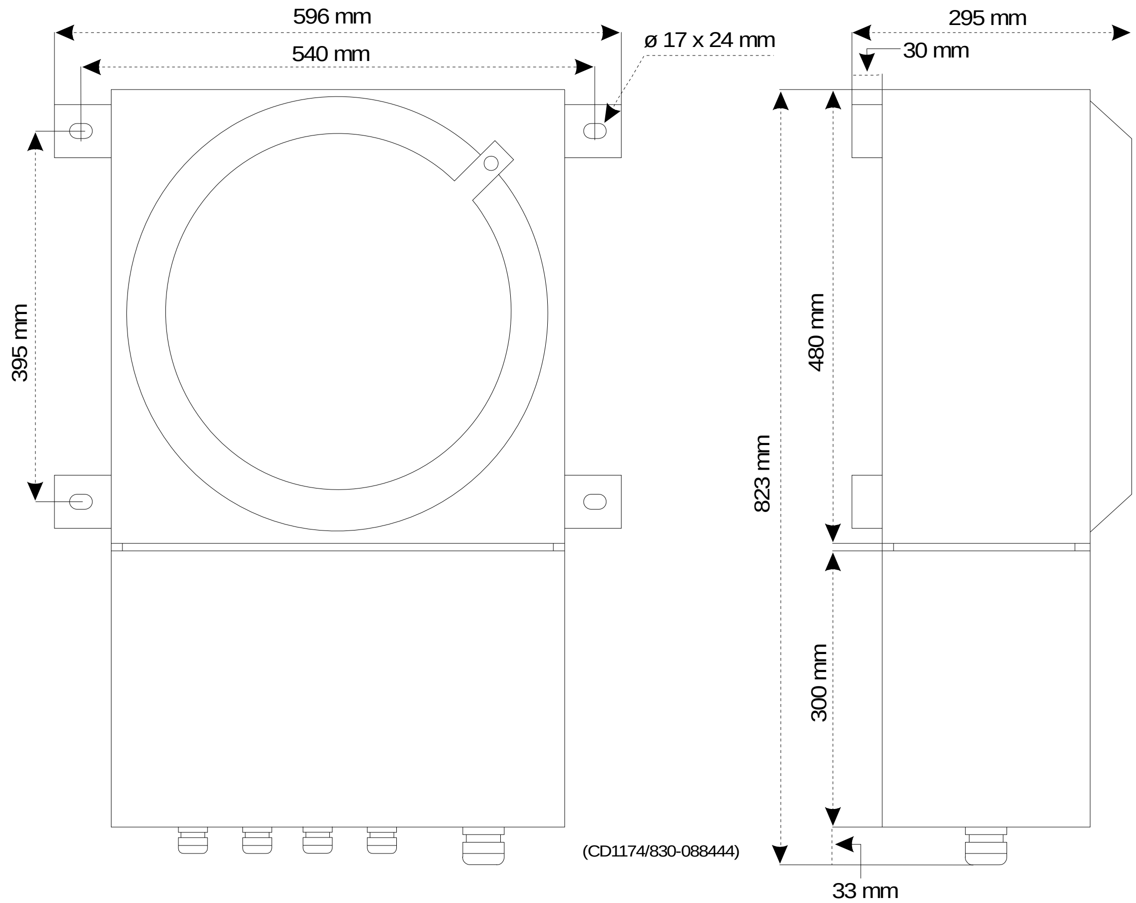
Note:
The drawing is not in scale.

Cd31126 Page 1 of 1
830-083045 Rev.F

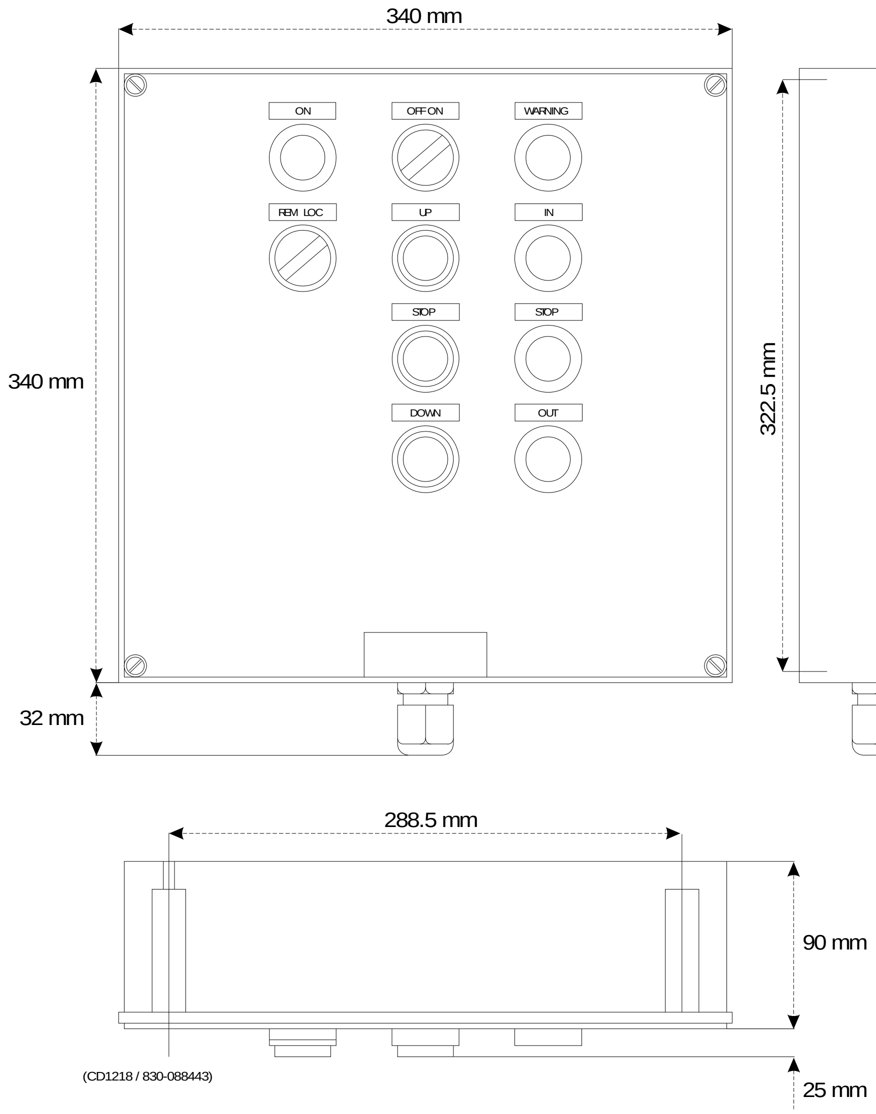
HL 3380 Ex – 1


470
750 mm
5000 mm
80 mm
ø 22
580 mm
1040 mm
600 mm
1090 mm
290
200
900 mm
3246 mm
(CD1179/BMP001/
830-088447)

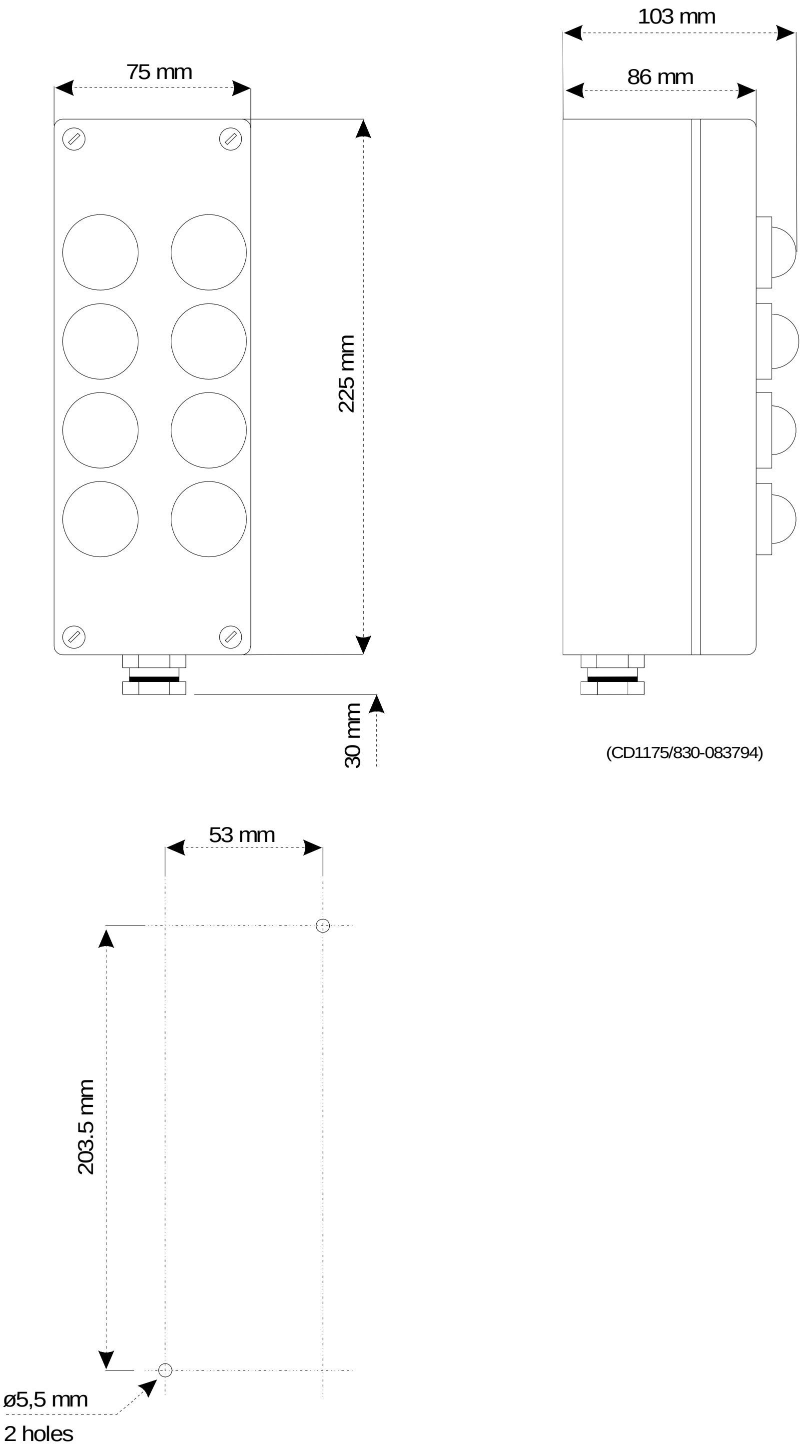
Relay unit Ex – 1



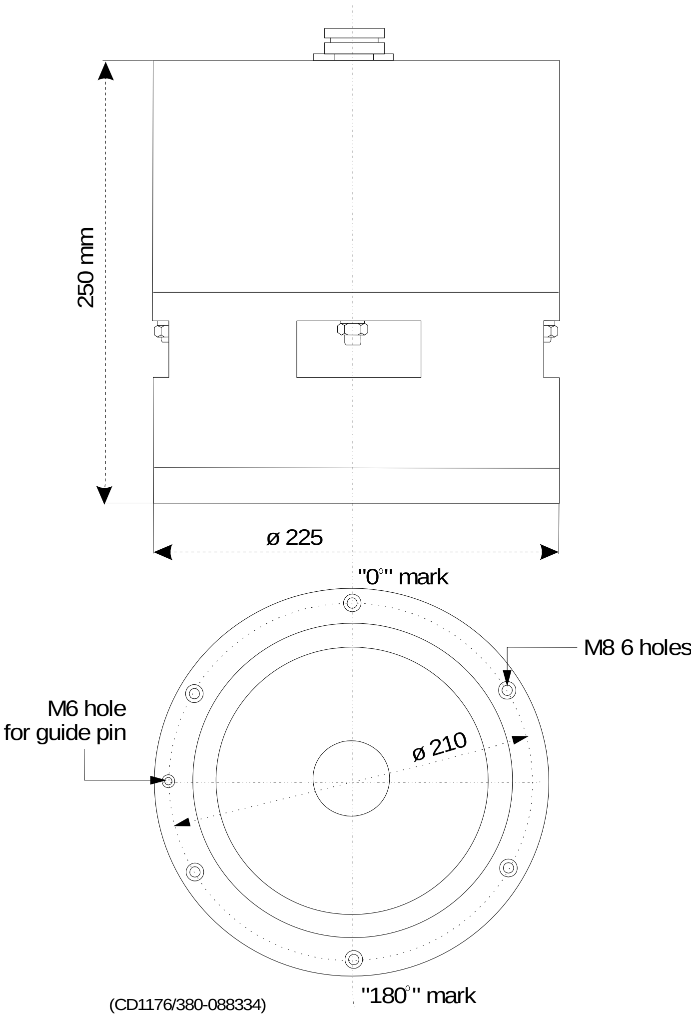
Local control unit Ex – 1



Remote control unit Ex – 1

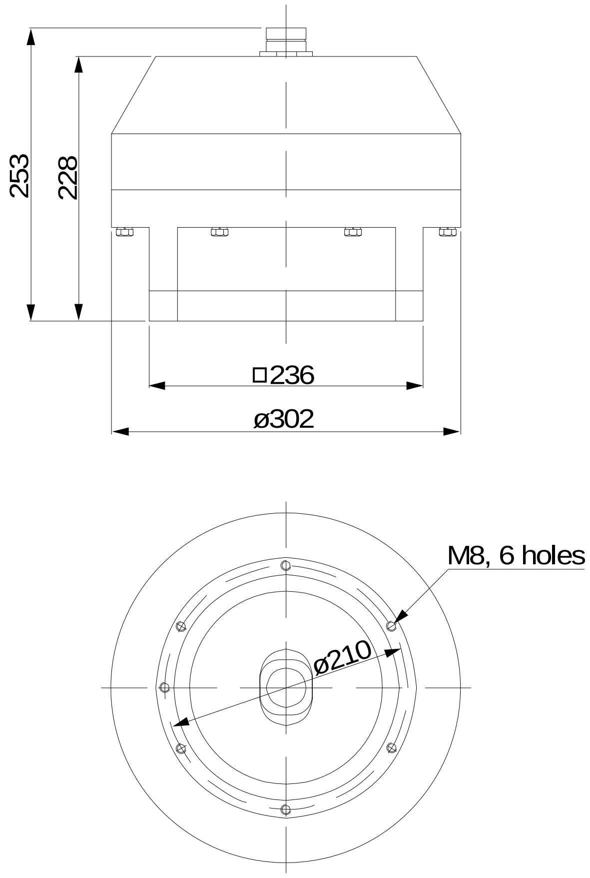


Standard transducer



(CD1176/380-088334)

Narrow /LF Medium beam transducer



(CD1177/830-082498)

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