Chapter 7 : Infrastructure

This chapter describes the infrastructure required to power and control the offshore installations and to provide accommodation for monitoring, data acquisition and onsite personnel. This includes the onshore civil engineering (Shore Station and Power Hut), the Main Electro-Optical Cable (MEOC) providing the electrical power link and optical-fibre data link between the detector and the shore, and the power distribution system.

The MEOC and the JB present single-point-failure risks for the ANTARES detector. The reliability of these systems is therefore an issue of the highest importance. A Failure Mode and Engineering Criticality Analysis (FMECA)carried out using available reliability data, indicates a failure probability of < 3% over the 10 year design lifetime of the detector, well within the design specifications.

Infrastructure Overview

The ANTARES detector array, located in deep water offshore, must be supplied with electrical power, controlled and monitored from land, and must transmit physics and calibration data to onshore facilities for storage and analysis. The infrastructure required to achieve this includes:

- onshore accommodation for power supplies, detector control and data management;
- communication between the onshore support devices and the detector, provided by the Main Electro-Optical Cable (MEOC);
- a power distribution system satisfying the power and voltage requirements of the various detector components.

The onshore accommodation consists of two separate buildings, a Shore Station housing control and data management infrastructure and providing space for onsite personnel, and a Power Hut devoted to power distribution requirements. The Power Hut must be located at the point where the MEOC comes onshore; the Shore Station will be housed in an existing structure about 4 km away and connected to the Power Hut by a fibre optical cable.

The Power Hut will supply power to the MEOC at about 4500 V/ 50 Hz AC. This will be converted to 500 V/ 50 Hz by the main transformer housed in the Junction Box, rectified to 400 V DC and converted to the voltages required by individual components using DC/DC converters.

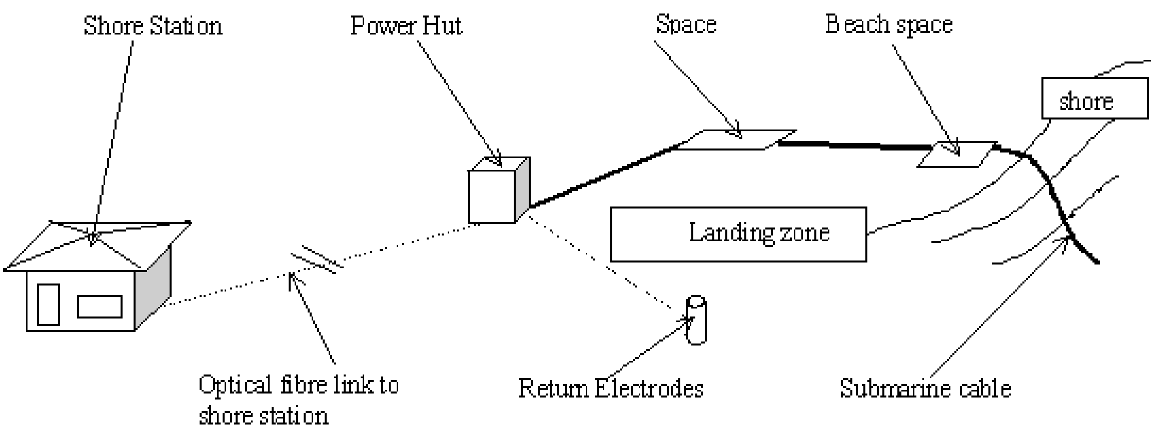
Shore Station and Power Hut

Definitions

The shore station gathers in the same structure the space necessary for ANTARES (data management, control and personnel needs).

The Power Hut needs to be located on the site of the landing of the submarine cable. It is distant from the shore station to which it is connected by a 4.3 km fibre optic cable. The ends of the cables are collected in the power hut. The conducting parts of the return current electrodes should be buried in the vicinity of that hut.

Schematic diagramme of the Power Hut and Shore Station



Provisions for the Power Hut

- protected room LV : 5 kV AC
- electrical distribution EDF: 60 kVA, 400V three-phase
- telephone line
- room protected against bad weather, lightning, animals, sand,...
- reliable ventilation system
- anti trespassing system
- 24 hours access with authorisation
- useful surface area: 10 to 12 m^2 Height: 3m
- permanent load on soil: 750 kg/m^2

Equipment

- Electrical board 60kVA 400 V
- Transformer 400/4000 V (2+1)
- Coupler

- Self inductor
- Power control rack
- MEOC to shore link rack

Personnel present in normal operation : 0

Proposed location for the Power Hut

- MEOC landing on the Sablettes beach.
- Use of existing France Telecom underground infrastructure

Provisions for the Shore Station

The shore station has four rooms dedicated to the operation of the ANTARES experiment: a computer room, a control room, a service room and a meeting room.

General specifications for the shore station

- access control
- fire safety
- heating and air conditioning
- parking (4 cars)
- permanent authorized access
- utilities

Computer room

- computer room air conditioning, second-floors, fire safety...
- controlled access
- 100 PC farm, circulation rack, and system console
- Useful surface area: about 20 m^2
- Heat to dissipate: about 8 kW

Personnel present in normal operation: 0

Control room

- This room contains the control, clock and the electrical power interface racks.
- A tape storage unit
- Access to high speed external network
- 4-5 work stations (desk + console)
- useful surface area: about 50 m^2

Personnel present temporarily during operations: 5-6 maximum

Service room

- Contains the general electrical power distribution board: 18 kVA 400V
- Cooling production group (about 20 kW)
- An inverter and backup batteries of the machine room

- Fire safe ventilation system
- Controlled access
- Useful surface area: 10 m^2

Personnel present during operation: 0

Meeting room (optional)

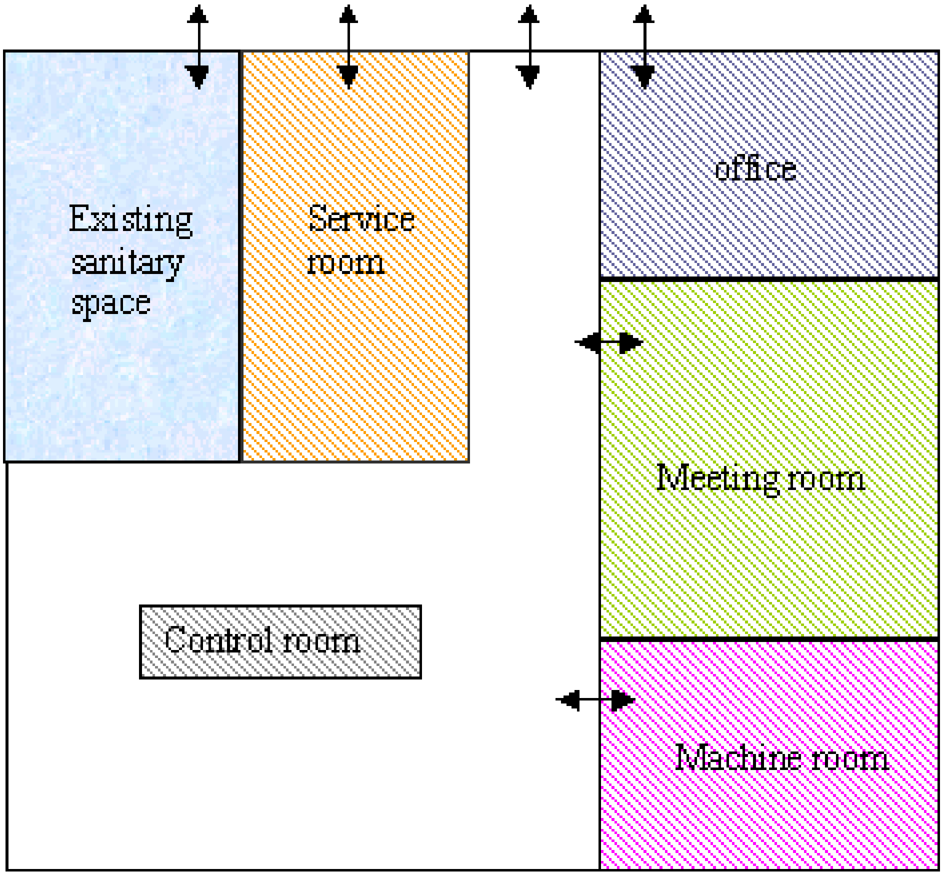
- Furniture for meetings and discussions (10-12 people)
- Useful surface area: 20 m^2

Total useful surface of Shore Station : 100 m^2

Shore Station Location

- Installation in the old shipyards in La Seyne-sur-Mer
- Terrestrial distance from the MEOC: 4.3 km

Projected Layout of the Shore Station



The machine room houses the PC computer farm.

Reference : STT 00 00 B Station Terre

The Electrical Power System

List of References

- [1] D2-OEC-1003/D A.Calzas
- [2] 3 ENE 01-05/A A. Calzas

Introduction for Electrical Power

The requirements and options regarding electrical power have been stated in the technical note D2-OEC-1003/D [1] and in the Conceptual Design Report (CDR) of ANTARES. In figure 7.1, a schematic diagramme of the Electrical Power System (EPS) is shown. The EPS comprises the following sub-systems:

- Power Hut on shore - Transformer and infrastructure
- Main Electro-Optical Cable (MEOC) and its termination
- Junction Box (JB)
- Interconnecting Link Cable from JB to String Power Module (SPM)
- String Power Module (SPM) - AC / DC conversion
- Electro Mechanical Cable (EMC) - Links the SPM to six Master Local Control Modules (MLCM)
- DC/DC converter in Local Control Module (LCM) power box.

Specifications of voltage and power dissipation in the sub-systems are summarised in Table I. Voltage values are shown for two cases - no load and full load (i.e. 15 fully-equipped strings).

The power distribution is designed to use the highest possible voltage at every stage. This maximises energy efficiency and stability and results in the lightest possible cables.

Electrical power is carried by a 45-50 km long Main Electro- Optical Cable, a product of ALCATEL, from the Power Hut at shore as ~ 4500 V / 50Hz to the JB, located at 2500 metres depth.

This voltage is reduced in the JB by means of a transformer to the highest voltage compatible with the deep-sea operated Electro Optical Connectors - 500 V - and is transported via a circuit breaker and the Interconnnecting Link cable to the SPM.

The arrival voltage at the SPM is reduced by transformers and rectified to the highest voltage compatible with the input specifications - 400 V - of the DC / DC converters located in the LCMs. The latter voltage is reduced in the LCM to 24 V.

Ancillary transformer outputs and converters provide the power needed for local use in the JB and SPM and the nearby String Control Module (SCM). The transformer, rectifier, remote diagnostic system and overcurrent protection, located in the JB, represent a single point failure risk.

This system consequently has to satisfy extremely demanding specifications where reliability is concerned. A failure of the MEOC, the main transformer, the electrode or the JB container would cause the loss of operation of the entire detector. A failure of the JB control system would have no immediate consequence on detector operation. However, the JB parameters would be unknown, and it would not be possible to reset the output circuit breakers. Recovering the JB means disconnecting all outputs via a submarine intervention and dredging the JB frame. This is a delicate, cumbersome and costly operation. Therefore, a recovery of the JB from the deep sea is only foreseen as a last resort.

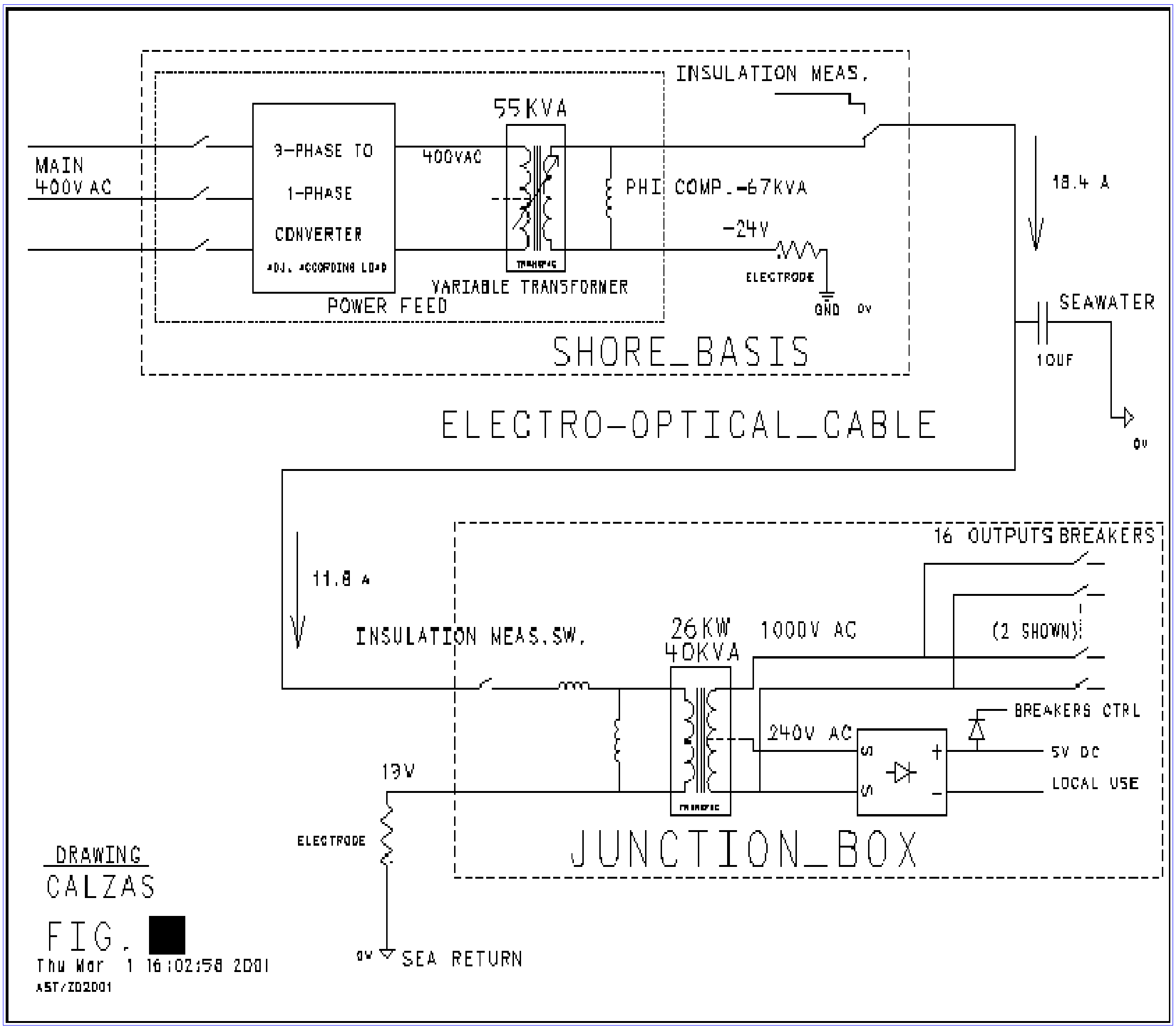


Figure 7.1 **Schematic diagramme of the Electrical Power system**

The objective set for the reliability of the JB power system is a probability of failure less than 10% during the 10 year design lifetime of the detector.

In this chapter, the engineering solutions are described for the various sub-systems of the electrical power system. Test procedures, to be applied both before and after immersion, of the MEOC and JB are described. A Failure Mode, Effect and Criticality Analysis (FMECA) has been made and a failure probability of the electric power system of the JB is estimated to be less than 3% during its 10 years lifetime, well within the design specifications (cf Annex).

Energy System Power Parameters

Anticipated Values for normal operation range (from TDR version 0.3) document.
These values will be confirmed after integration tests.

Value	Min Volt age	Max Volt age	Max Current	Installed Medium (*1) Umax*Imax	Available Power Umin*Imax	Thermal dissipation (*2)	Notes
Symbole (unit)	Umin (V)	Umax (V)	Imax (A)	(VA)	(W)	(W)	ISO units are used
Main to Power Hut	380	420	87 installed per phase	60 kVA	not pertinent		3 phase 400v 50Hz
Power Supply				37 kVA input		~2 000	The redundancy parts are not counted
Power Supply to Balancing Inductor/ MEOC	~2500 @start-up ~4000 @normal	4200	8	35 kVA	35 000		the balancing inductor is in parallel with the MEOC
Balancing Inductor to MEOC	not pertinent	4200	10 (in quadrature)	66,6 kVA (reactive)	not pertinent	~1 000	tap adjustable weight=400kg
Power Hut to MEOC	~2500 @start-up ~4000 @normal	4200	13 (8 in phase)	55 kVA	not pertinent		50Hz. The sea return losses are negligible
42km MEOC						4 200 total 0.1w/m	@10A
MEOC to JB	3400 @Imax	4400	8 in phase	37 kVA	27 200		Power Factor=1
JB						<1200 for transformer +<750 for ancilliaries	the transformer losses depend on current and temperature (click for transformer)

the table continues...

...continuation of the table

Value	Min Voltage	Max Voltage	Max Current	Installed Medium Umax*Imax	Available Power Umin*Imax	Thermal dissipation	Notes
Symbole (unit)	Umin (V)	Umax (V)	Imax (A)	(VA)	(W)	(W)	ISO units are used
JBtrans to all ILs	750@Imax	1000	33	33 kVA	25 000		33A Imax due to transformer limits
JB trans to ancilliaries	180@Imax	240	4.2	1 kVA	750		due to transformer limits
JB to one IL	750@Imax	1000	2.2	2 200	1 650		set for 15 equal loads
IL			2.2			~66	4% loss @ Imax
IL to SPM	720@Imax	1000	2.2	2 200	1 540		50 Hz
SPM							see TDR 5-7
SPM to EMC	>380-5%	<380+5%	?	?	6*180+50		DC
EMC						~40	total
EMC to LCMs	?	420			1035		DC (*3)
LCM						~10	
LCM to OMs and inst.					?		

Notes
(*1) The physical size of the installed media is proportionate to the Umax x Imax product.
(*2) For any given device the thermal dissipation is $a*Ueff^2+b*Ieff^2+c*Ueff*Ieff$, the third term is usually small.
(*3) figure from B.Brooks as 5 Apr 01: MLCM 47.3; SLCM1 35.8; SLCM2 31.6; SLCM3 28.9 W typ.

Power System on shore

On the shore, the following sub-systems are located:

- The MEOC arrival port, the ground-return electrodes and the land around the electrodes,
- The 60 kVA power supply, connected to the mains electricity network
- A shelter -- the Power Hut.

The optical-fibre part of the MEOC terminates in the Power Hut and is subsequently forwarded to the Shore Station, located at a distance of approximately 4 km.

The power supply and the control and diagnostic system of the Junction Box are controlled and monitored by the Slow Control (SC) system. An independent, autonomous monitor ensures that the power is disconnected in case of a malfunction of a cable, the sea electrode or ground electrode.

The power supply consists of three 18 kVA units with a two-out-of-three hot redundancy, a synchronising device and an inductor. The inductor provides the reactive current to compensate for the capacitive effect of the cable. The ground electrodes have a resistance of approximately 2 ohms and can sustain a maximum current of 12 A. The electrodes are surrounded by an area that is large enough to adequately limit the stray current. The power supply takes 36 kW from the mains electricity net and delivers 32 kW with the full load of 15 complete detector strings connected.

Main Electro-optical Cable

The Main Electro Optical Cable (MEOC) provides the electrical power link and the data link, the latter through 48 monomode optical fibres, between the shore station and the detector. The selected cable, a standard telecommunications type, satisfies our environmental and mechanical criteria such as temperature tolerance, bending radius, mechanical strength, etc... Full specifications are given in a technical note [1].

Characteristics of the MEOC include:

- 21.5 mm diameter for the unarmoured part.
- 58 mm diameter for the doubly-armoured part.
- 35 kN permanent tension acceptable
- 4.1 N/m weight in water
- 1 ohm/km copper conductor specified at 50 A max
- 48 monomode pure silica fibres embedded in a stainless steel tube

The specifications on the optical fibres are the following:

- Optical power loss: 0.182 dB/km.
- Dispersion: 21 ps/nm.km at 1550 nm wavelength.

The expected failure probability of the MEOC, computed from manufacturers figures is around 4.10^{-3}, in 10 years. This does not distinguish between cable failure and fibre failure for two reasons:
1) when a commercial fibre breaks, the whole cable is repaired
2) when a cable suffers an external damage, all fibres are considered broken.

Cable-laying and test procedures

The MEOC will first be connected to the shore station and then launched, away from the shore, by a specialized cable-laying ship and crew. The part in shallow waters (15 km) down to a depth of typically 1000 metres, is armoured to resist anchors, fishing devices and the like.

ALCATEL will take responsibility for laying the cable, following a track prescribed by the ANTARES Collaboration, towards the best possible site in terms of flatness of the sea bottom and the absence of obstacles.

Surveys by a Remote Operated underwater Vehicle (ROV) have been carried out to select the site. Before the boat departs, the cable will be tested for optical and power transmission. During the journey towards the target site, the cable is tested, at regular intervals, for correct optical transmission and insulation properties. Current characteristics will be tested when the cable is completely unwound with the shore station connected and an electrode dipped into the sea.

The cable termination is then closed by a deep sea plug and optical transmission and cable isolation will be measured at the Shore Station. The MEOC, linked to a dragging tail and two acoustic beacons (meant to guide future recovery operations) is positioned next to the site. In the MEOC-JB connection operation, the dragging tail is used to raise the cable termination to the deck of the ship and connect it to the JB. Extensive tests of the JB will then be performed, including a full power test with a load equivalent to 15 detector strings.

Connection of MEOC and Return Electrodes

MEOC connector

The cable termination interfaces with the JB container via a penetrator mounted in an intermediate chamber - the Pre-Junction Box (Pre-JB). The intermediate chamber is necessary because:

- A hole in the main container cannot exceed 40 mm diameter (local stress/pressure restriction)
- A 90 degree axis change is required for the cable to fit in the JB frame.

The MEOC is equipped with a stress-relief device (operation stress 35 kN, breakage stress 100 kN) and the bending restrictor blades (radius of curvature 1 m) mounted on the JB frame.

Return Electrode

The iridium-coated return electrode has been extensively tested and should have a lifetime of 20 years under full load conditions. It will be positioned on the JB frame in such a way that the electrode is nowhere closer than 2 metres to a conductive part. The electrode interfaces with the JB container by means of a dry-mateable connector with three contacts.

List of references

[1] 3LSM0203/A Marché de l'Etat et ses établissements publics - Liaison sous-marine. Cahier des clauses techniques particulières. Calzas. 26/6/00

Junction Box Power

The JB is a pressure resistant container made from titanium, held in the JB Frame (JBF) (cf the relevant section in the Mechanics chapter). The JB and JBF provide the following facilities for electrical power:

- Connection for the MEOC and the return electrode.
- Power transformer housing.
- String overcurrent protection system.
- Remote diagnostic system.
- Sixteen penetrators for connections to SPMs. These penetrators are connected to the bulkhead sockets - the female part of a connector - mounted on the JB frame.
- In the JB frame, sixteen electro-optical (EO) bulkhead sockets. Here the link cables, providing connection to the SPMs, will be plugged in.

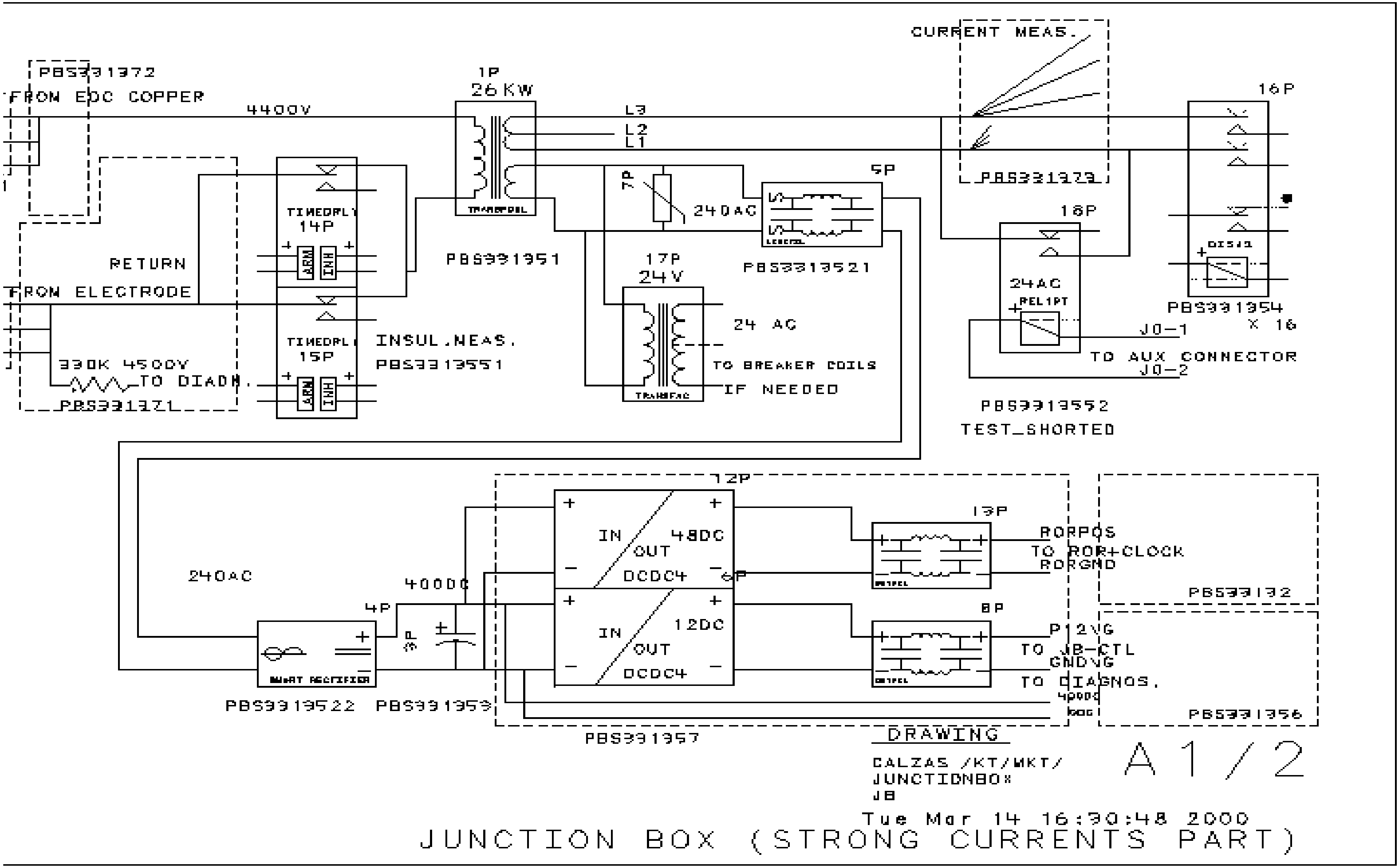
Power conversion, overcurrent protection and remote monitoring use most of the volume of the container. In addition to electric power functions, the JB contains electronics to combine and distribute read-out requests and the clock signals (cf section in Electronics chapter) .

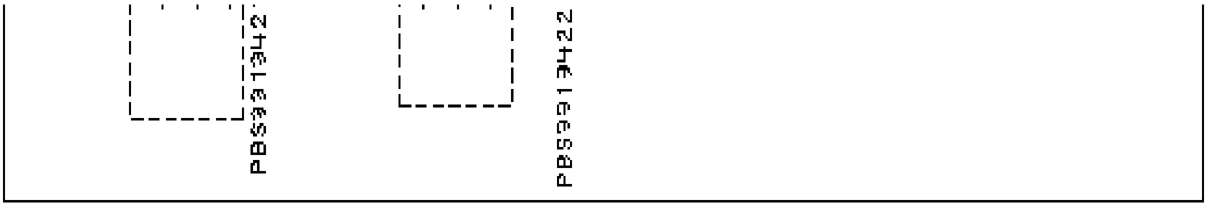
Power transformation system

A diagramme of the Electrical Power System in the JB is shown in figure 7.2, below.

The specifications of the power transformation system include:

- maximal input voltage 4400 V, corresponding to an output voltage of 500 V at no load and 750 V at full load.
- maximal output current at full load 33.3 A


PBS331372
FROM EDC COPPER
4400V
RETURN
FROM ELECTRODE
330K 4500V
TO DIADM.
PBS331371
TIMEDPLY
14P
ARM
INH
TIMEDPLY
15P
INSUL.MEAS.
PBS3313551
1P
26KW
PBS331351
L3
L2
L1
7P
240AC
5P
PBS3313521
17P
24V
24 AC
TO BREAKER COILS
IF NEEDED
CURRENT MEAS.
PBS331373
16P
24AC
REL1PT
J0-1
TO AUX CONNECTOR
J0-2
PBS3313552
TEST_SHORTED
16P
PBS331354
X 16
240AC
4P
400DC
3P
PBS3313522
PBS331353
12P
IN
OUT
48DC
DCDC4
6P
12DC
PBS331357
13P
RORPOS
TO ROR+CLOCK
RORGND
PBS331132
8P
P12VG
TO JB-CTL
GNDVG
TO DIAGNOS.
PBS331356
DRAWING
CALZAS /KT/WKT/
JUNCTIONBOX
JB
Tue Mar 14 16:30:48 2000
A1/2
JUNCTION BOX (STRONG CURRENTS PART)



The main components of the JB power system are:

Main transformer

The transformer provides the maximum voltage compatible with the connectors (500 V). An additional secondary winding followed by a rectifier and a converter deliver the voltage - 48 V - needed locally for the JB electronics. The transformer is rated at 40 kVA with an efficiency of 97% at full load. At full load the output is 750 V. The size of the transformer is approximately 480*350*320 mm^3, its weight is 200 kg. Cooling is provided by a naphtalene oil bath. The failure rate of the transformer is among the lowest of the entire detector, i.e. better than 1.1 10^{-8} per hour.

JB rectifier

This device, that provides 400 V DC, derives its input from a secondary coil on the main transformer. It contains a bridge and an active rectifier sinking a sinusoidal current (no harmonics). In order to improve reliability a two-fold redundancy is implemented for this system.

JB DC Storage A capacitor is used with a failure rate per hour of DC storage of 2 $*10^{-8}$ @ 45° C and $3*10^{-8}$ @ 60° C.

JB Low Voltage Supply This device includes DC/DC converters and overcurrent limiters. It provides 5 V,12 V and 24 V. The failure rate computed on the basis of manufacturer data is better than 5 10^{-6} per hour. In order to improve reliability, a two-fold redundancy is implemented for this system.

Power in SPM, EMC and LCM

The String Power Module (SPM) at the bottom of each line, receives power from the JB and distributes it to the LCM. It is described in a dedicated page that is printed with the Electronics section.

The voltage drop at the JB output with full load is 24%. In order to have nearly the same voltage on all the SPM inputs, the voltage drop on the Interconnecting Link cable should not exceed 4%. The same holds for the vertical Electro-Mechanical Cable (EMC), the backbone of a line. The power system is specified for a 1800 W maximum load per line.

The voltage at the output of the SPM has been chosen to match the LCM converter range: 250-415 V (425 V for less than one second). This range is reduced by the voltage drop (not exceeding 4 %) in the EMC. Taking a 10 V safety margin both ways, the voltage at the output is 326 V with full load and 415 V at no load (a partial drop compensation is provided for by the SPM).

The Electro Mechanical Cable contains one individual wire per sector and three return wires. This arrangement allows one to switch off a sector in case of cable damage or a LCM flood. A special wiring diagram is used in order to enhance the efficiency of power transmission.

The input voltage of the power converter in the LCM varies between 315 and 425 depending on the load of the SPM.

In order to safeguard against possible short-duration overvoltage due to electromagnetic interference (e.g. when a LCM is stored on the quay prior to launching), inductive effects, power-load changes and feedback-loop interference (due to the common return wires in the EMC), a device is implemented in the LCM to dissipate half the nominal power of the LCM, if the voltage approaches the maximally allowed level.

Pre and post-immersion tests

The shore power supply, the JB and at least one SPM will be tested together before the MEOC laying.

The MEOC will be replaced by discrete components to simulate its resistance, capacitance and inductance. For a 50 km long cable, these values are 50 ohms, 26 mH and 9 microfarads, respectively.

The sea return will also be simulated by discrete components.

The final connection procedure will be rehearsed using a cable termination mounted on a 80 m long cable segment with a 1000 kg dead weight attached:

1. A dragging tail will be fixed close to the cable termination by means of the stress relief device in the same way as for the real operation.
2. The segment, weight and tail will be immersed to a depth of 400 m.
3. The tail will then be hauled onboard .
4. The MEOC will be connected the pre-Junction Box.
5. After this operation, the terminated cable segment will undergo hyperbaric tests on shore.

Full-power tests

The cable cannot (because of thermal limitations, absence of the return electrode and safety reasons) withstand full power before it is positioned on the sea bottom. Such a test would anyway not be meaningful because the main risks suffered by the cable are from the laying operation itself. The full power tests will be conducted at the time that the JB is connected to the cable. We will also connect to the JB as many Interconnecting Link cables as needed to fully load the JB. This means that the JB outputs will be used to pass more power than in normal conditions but still within the manufacturer's specifications. The outputs will be tested in sequence (possibly some at the same time) for optical and electrical performance.

Power ON/ power OFF procedures and overcurrent protection

Power-on and power-off procedures are as follows:

1. The cable voltage is increased gradually under Slow Control command.
2. When the JB secondary voltage reaches V1hi(*), the local power supply is activated. This amounts to less than 4% of the total possible load. The local power supply has an hysteresis so that it will continue to operate even if the voltage goes down to V1low.
3. When the voltage received at the SPM reaches V2hi, the SPM power supply is activated. There is a prescribed variance among the V2hi values from one SPM to another SPM so the SPM power supplies are activated in sequence. At this time, the supply only feeds the SPM Slow Control. Each SPM Slow Control represents less than 1% of the total possible load. The SPM power supply has an hysteresis - so even if the voltage goes down to V2low, the supply continues to operate correctly.
4. When the voltage reaches Vnlow, all the Slow Control functions are in operation. Each sector is now under command of SC. Each sector represents less than 2% of the total possible load. Slow Control is responsible for sequencing the powering up (or down) of each sector. For this, the shore Slow Control must check that the JB voltage is within Vnlow and Vnhi and possibly adjust it.

   (*) $V1_{low}$ < V1hi < V2low < V2hi ;
   V2low < Vn low < Vnom < Vn hi
   Precise values will be assessed (not critical).

Overcurrent Protection

Shorts can occur if an output is damaged or if a SPM is flooded. The worst case is when the short occurs close to the JB. The current is limited by the combination of the MEOC inductance, the transformer short current until the thermo-magnetic circuit breaker trips. When the short is removed, the charge stored in the main cable is transferred in the holdup capacitors with a current, limited by the Metal Oxyde Varistances. In case of a "weak" short (the default-current value is not very important) the magnetic breaker does not trip, but the thermal breaker does. In case of an abrupt switching-off of all the loads, the voltage rises in the worst case to a value below the allowed maximum in the various relevant elements of the system. The shore power supply is automatically switched off for an amount of time needed for all components to reach a quiescent state (e.g. the transformer temperature).

The overcurrent protection system from the shore station up to and including the LCM power converter is organised as follows:

- At the shore station, the available power is limited. A sensor with a 20 A threshold switches off power should an over-threshold value persist for more than one cycle of 50 Hz.
- A thermo-magnetic circuit breaker is mounted on each of the 16 output channels of the JB. These breakers are designed to disconnect JB outputs when a short or other failure occurs downstream, or when commanded by the slow control system.

The circuit breakers must sustain the short-circuit current during the MEOC discharge time of 0.9 ms and the subsequent power delivered by the main supply (200 A behind the transformer for 2 ms). They are ***not*** designed to

- be remotely closed or opened with full load present (downstream electronics must be powered down first).

- be closed or opened more than 100 times.

Remote resetable breakers or switches (breaker plus open/close feature) will be used.

In the SPM, the input is protected with a 3.15 A fuse. The outputs of the SPM are monitored and can be actuated by SC. In the LCM, the input of the power box will be protected by a voltage limiter and a fuse.

ANNEX: Reliability of the Electrical Power System

A functional analysis of the electric power system (EPS) has been performed in reference 1. With the help of a FMECA analysis, the initial design concepts were modified such that reliability was substantially improved. An upper limit of the failure probability of all components contributing to essential functions was established, based on data provided by the manufacturer of components. Since the part of the EPS on-shore is accessible, the calculation of failure probability is most pertinent where the sea-borne parts (MEOC and JB) are concerned.

The reliability of mechanical functions, in particular the water-tightness of penetrators, connectors and O-rings was not taken into account in the analysis for lack of quantitative data of MTBF for these components. The analysis demonstrates that the cumulative failure probability is essentially the sum of individual component failure probabilities. The key result of the current reliability analysis is, in summary: **a smaller than 3% probability of failure in the lifetime of 10 years.**

Several entries of the reliability calculation are shown in the tables displayed below.

NODE	Failure Probability in 10 years (%)	Replacement cost
MEOC	< 0.4	high
Junction Box	< 2	high

JUNCTION BOX	Failure probability in 10 years (%)	Replacement delay (week)**
Container leak	Not known	16
Transformer including cabling	<1	16
Feed-through short	<1	12
Sea-return electrode	<1	20
MEOC - discharge switch system remaining open	<1	12
Common Cabling	<1	12

**Data apply from the moment a ship is available and weather permitting.

Node in Junction Box	Failure prob. in 10 years (%)	Replacement delay (week)	Effects
Low voltage supply	2.6	12	no breaker reset, no sensor measurement, no JB trigger
Oil in electronics compartment	<1	16	in worst case: the same (*)
MEOC discharge switch system closed	10		no EOC insulation measurement
Trigger Box	not known	16	no JB trigger

(*) breaker reset, sensors, SC electronics and trigger are not tested against oil.

List of references

- [1] D2-OEC-1003/D A.Calzas
- For further details of the reliability analysis, cf technical note 3ENE0105

Power objects

PBS 6.*

- **PBS6.1 Power Hut**

PBS6.1.1	55kVA Power Supply
PBS6.1.1.1	*Tri/mono converter*
PBS6.1.1.2	*Variable voltage transformer*
PBS6.1.2	20 kVA self
PBS6.1.3	Hut (building)
PBS6.1.4	Cable and optical platine
PBS6.1.5	Electrodes
PBS6.1.6	Shore power cupboard
PBS6.1.7	Remote control cupboard
PBS6.1.8	Slow Control node

- **PBS6.2 Shore station**
- **PBS6.3 Link from shore to sea**

PBS6.3.1	Main ElectroOptical Cable (MEOC)
PBS6.3.2	Terminations
PBS6.3.2.1	*Shore termination*
PBS6.3.2.2	*Sea termination*
PBS6.3.2.3	*Stress relief device*
PBS6.3.2.4	*Link for tests (50m with plug)*

- **PBS6.3 Link from shore to sea**

PBS6.3.1	Main ElectroOptical Cable (MEOC)
PBS6.3.2	Terminations
PBS6.3.2.1	*Shore termination*
PBS6.3.2.2	*Sea termination*
PBS6.3.2.3	*Stress relief device*
PBS6.3.2.4	*Link for tests (50m with plug)*

- **PBS6.4: Junction Box (Power part)**

PBS6.4.1	Penetrators and bulkhead receptacles
PBS6.4.2	Power components
PBS6.4.3	Power Remote diagnostic
PBS6.4.4	Very Low Voltage Power Supply
PBS6.4.5	Cabling and Connections
PBS6.4.6	Sensors
PBS6.4.7	Remote Control

- **PBS6.5 Sea electrode**

PBS6.5.1	Electrode and its cable
PBS6.5.2	Electrode support