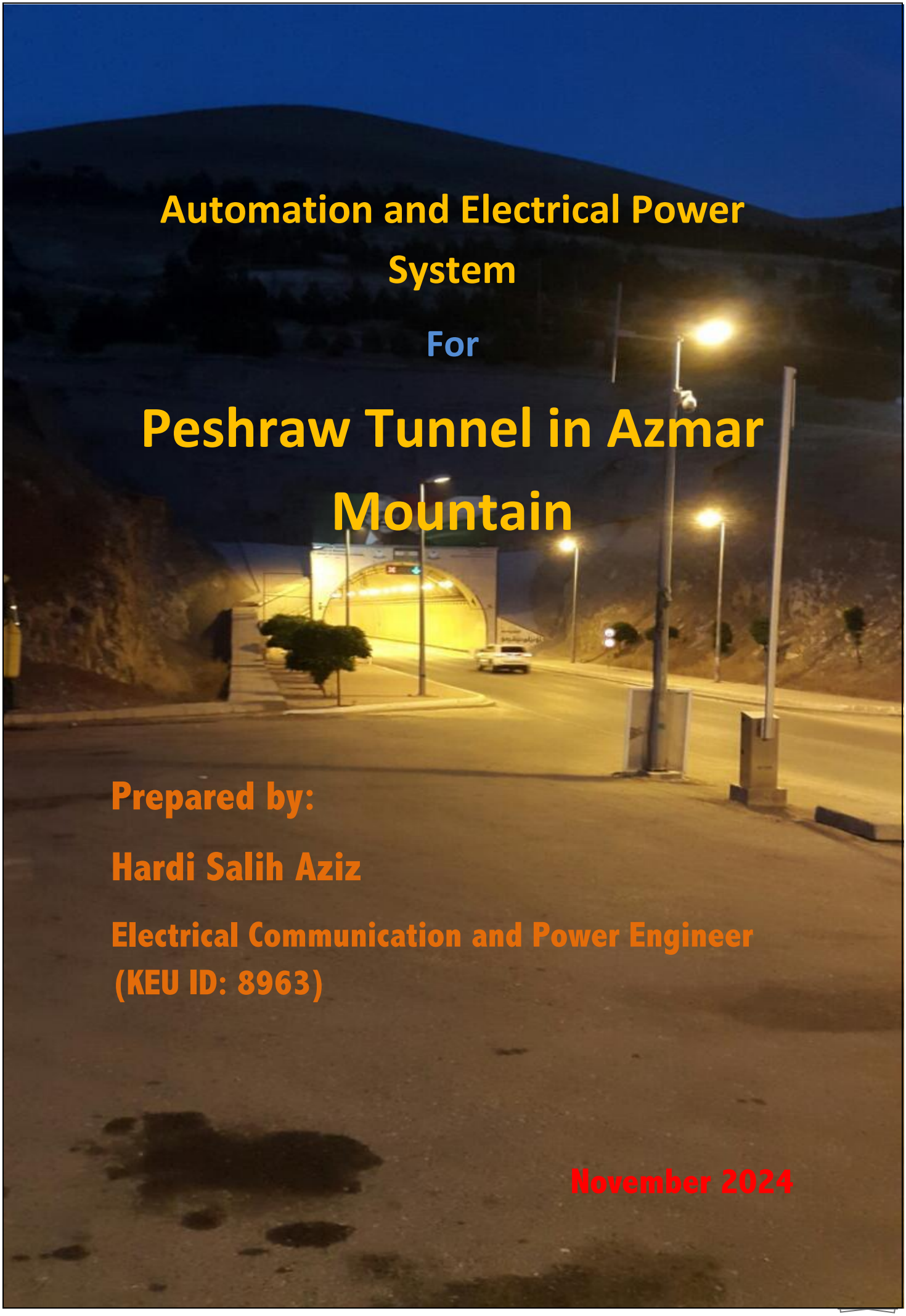

Automation and Electrical Power System

For

Peshraw Tunnel in Azmar Mountain

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Electrical and Automation System Design with Equipment's Installation Report

ABSTRACT

Azmar tunnel is one of longest tunnel in Kurdish region –north Iraq, it was civil constructed From 2005, one tube two way direction without any shoulders and lay- bye, aim to have SIL2 as possible, Power system (LV, MV, TR, and cabling), fault tolerant integrated system, hot standby redundant, two control centers, SCADA system modular scalable architecture.

- The electrical system in tunnel is subdivided into below main part:

1. SCADA and Automation System including tunnel control and management system (Low current System).

2. Electrical Power System (LV, MV, TR, Cabling, and Lighting).

The aim of electrical system equipment's inside tunnel, to installing safety systems such as emergency phones, air quality sensors, fire detection sensors, automated systems to help fighting fire and avoid the smoke to remain inside the tunnel in case it happens when you are stuck in a queue, incident detection systems and a dedicated redundant control room with trained operators to monitor that everything just run smooth and fine.

Electrical and Automation System Design with Equipment's Installation Report

Content

Azmar tunnel:

One tube bidirectional traffic motorway tunnel, tunnel is 2389 meters long, 7.65 meters high, and 8.5 meters' traffic way, with a 0.765m pipeline and 1.385m walkway, Iraq – Kurdish Regional, Sulaimanyah, the project will shorten the 15 km mountain route to a straight 8 km, facilitating vehicle passage, particularly during winter when the mountain is covered in snow, linking Sulaimanyah city with the Sharbazer area, greatly helping citizens. Its alternative name is Peshraw, in honor of the Civil engineer who deceased when he worked in.

Length: 2389m

Width: 10.835 m

Altitude: 1250m above sea level

Shoulders: No

Lay bys: No

Ceiling: Semi circle 7.65m height

Mountain Tunnel

There is substation near each portal, each substation supplies power to half tunnel equipment, each one has CCR (control center room) these CCRs act as hot standby redundancy with: (Fig.1: CCR Control Room)

Main CCR: Sulaimanyah side

Slave CCR: Sitak side

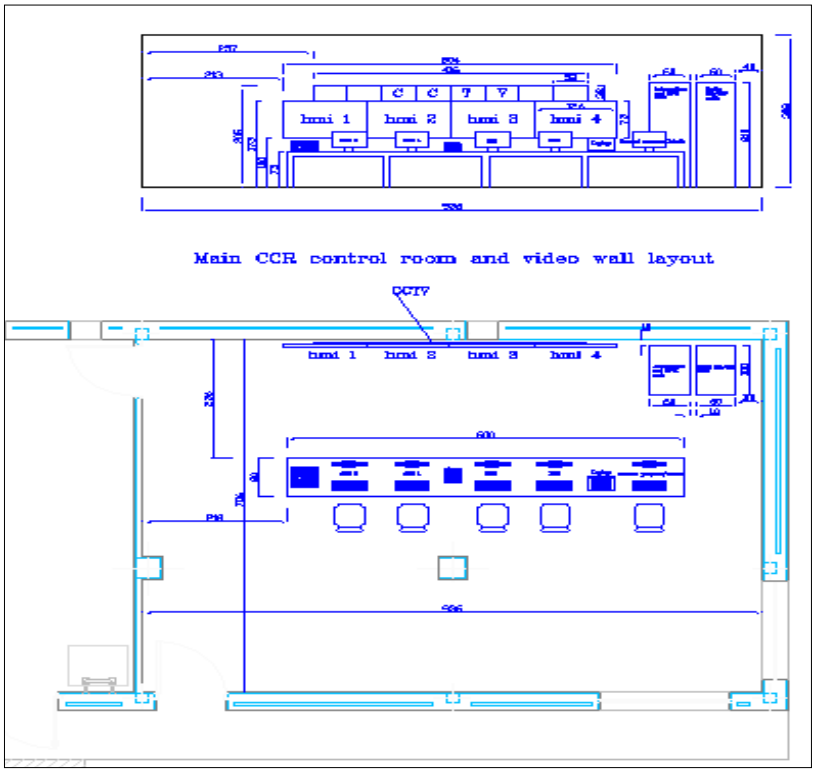


Figure.1-A (Main CCR Control Room)

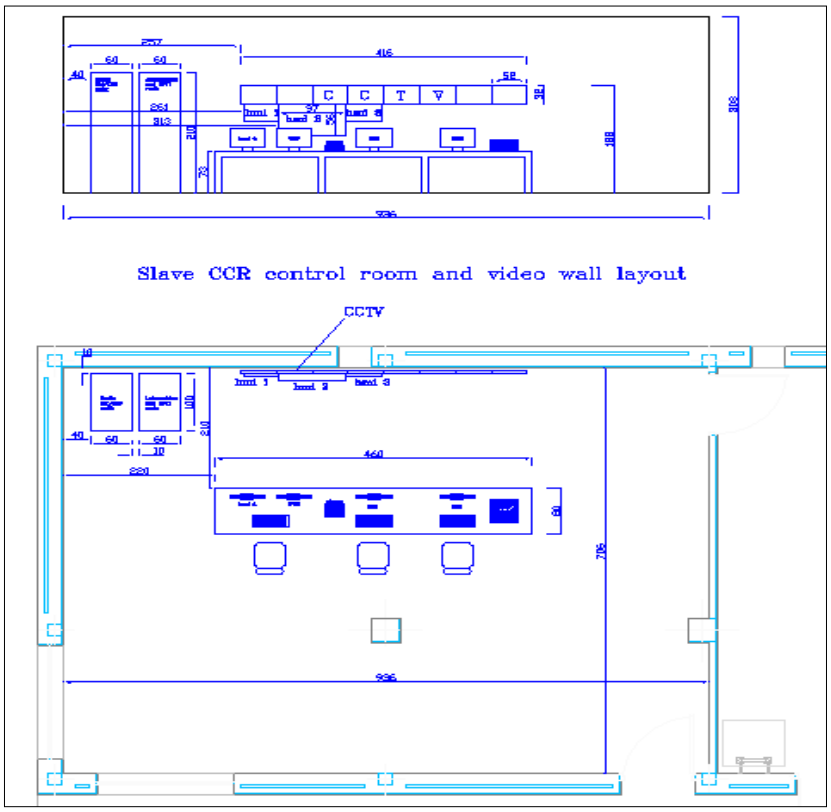


Figure.1-B (Slave CCR Control Room)

1. The Automation System (Low current System):

Comprehensive range of Automation and electrical subsystems are provided with azmar tunnel to ensure safe operation, these systems are guidelines and regulation:

-**PIARC guidelines**

-RABT 2008

-Directive 2004/54/EC(EU)

-BD78/99 UK

-NFPA-502,USA

The following are the main systems to be monitoring and controlled by automation and SCADA system: (**The followings are electrical power system will be explaining with drawing in detail in power system**) [Shown in Fig.2]

A-electrical distribution (two substations each with 11kv/400v transformer 1600kva and 730kva diesel generator)

A.1- The medium voltage switch board (MV) [Schneider Brand]

A.2- Low voltage motor control centers [ABB Brand]

A.3- Low voltage distribution and services [ABB Brand]

A.4- Power factor correction [ABB Brand]

A.5- Diesel emergency FG WILSON P730E

A.6- UPS [ABB Brand]

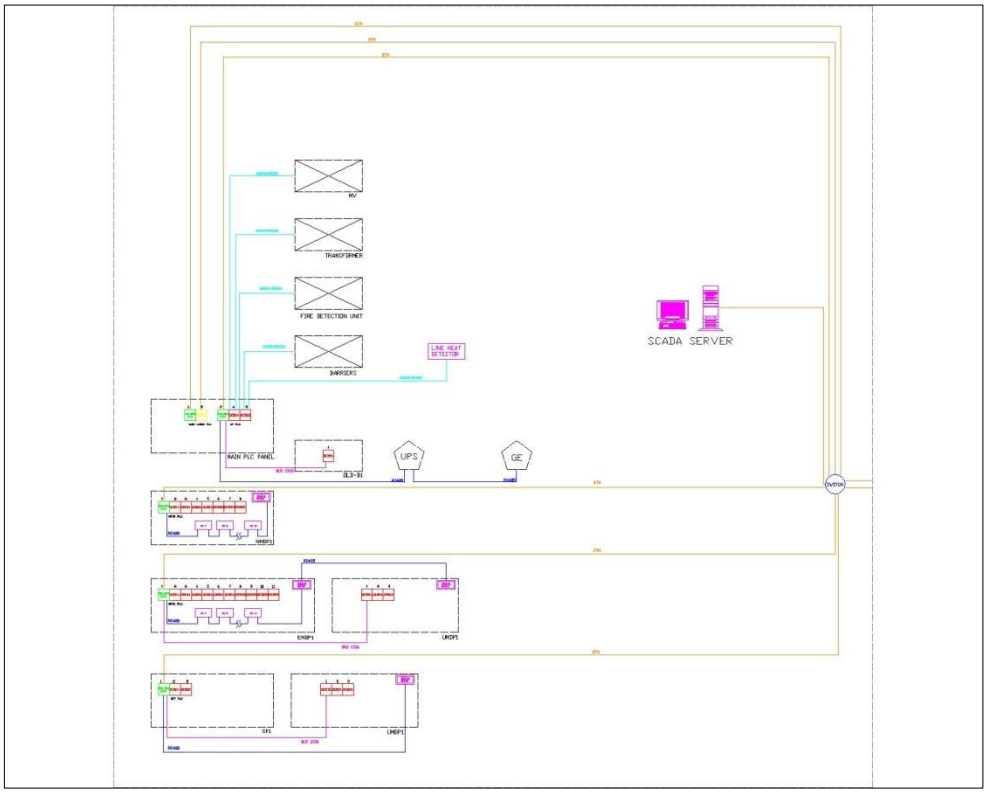


Figure.2-A (PLC Architecture Main Substation)

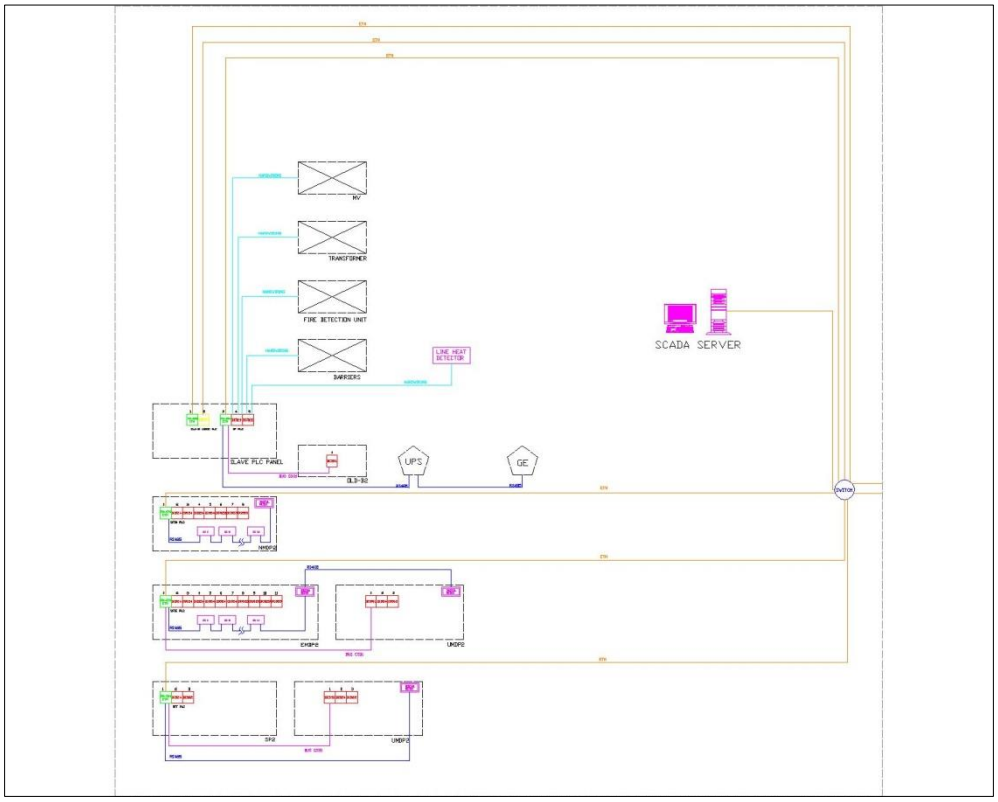


Figure.2-B (PLC Architecture Slave Substation)

- SCADA system input/output for electric power supplies (substations):

A- Status monitoring of circuit breakers such as:

- Local/remote

- Open/close

- Breaker position (operating, test)

- D.C voltage presence/AC power presence

- Trip

- Emergency stop

B- Commands control such as:

- Open/close

- Forward/reverse for jet fan VFD (Frequency inverter)

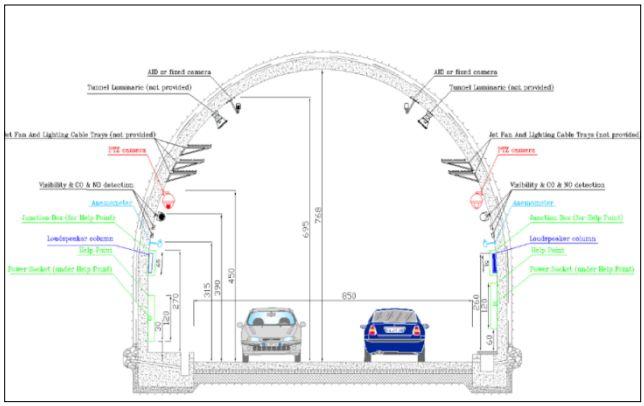
- Diesel and ATI ,1250A,load transfer panel with motorized switch FG WILSON.

C- Monitor the measurement and status for IED devices

- Voltages, currents, frequency, and power factor

- Kw, Kvar and energy Kw-hour consumption -power factor correction on stages d-alarms data for protection relays

Tunnel Equipments in Section



1.1- Fire detection:

Four separate methods of fire detection in azmar tunnel were installed:

A- Linear heat detector fiber optic type (AP sensing) for reaching predefined temperature first threshold at 65c, the second at -85c. (Fig.3)

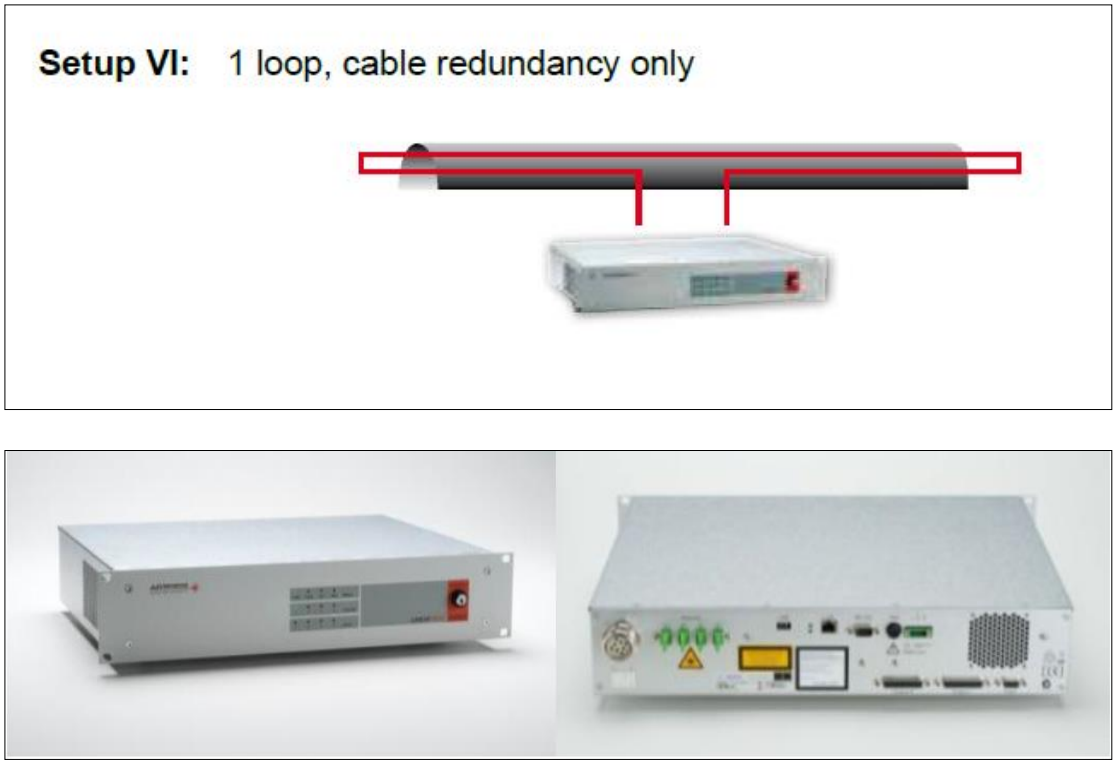


Figure.3 (Linear Heat Detection)

B- Alarm push buttons (included in emergency phone boxes) with CCTV verification.

C- AID video incident detection system (smoke, flame, CCTV)

D- Visibility detectors about (6-10) m bath transmission method, in conjunction with (CO/No) fluctuation. (Fig.4)

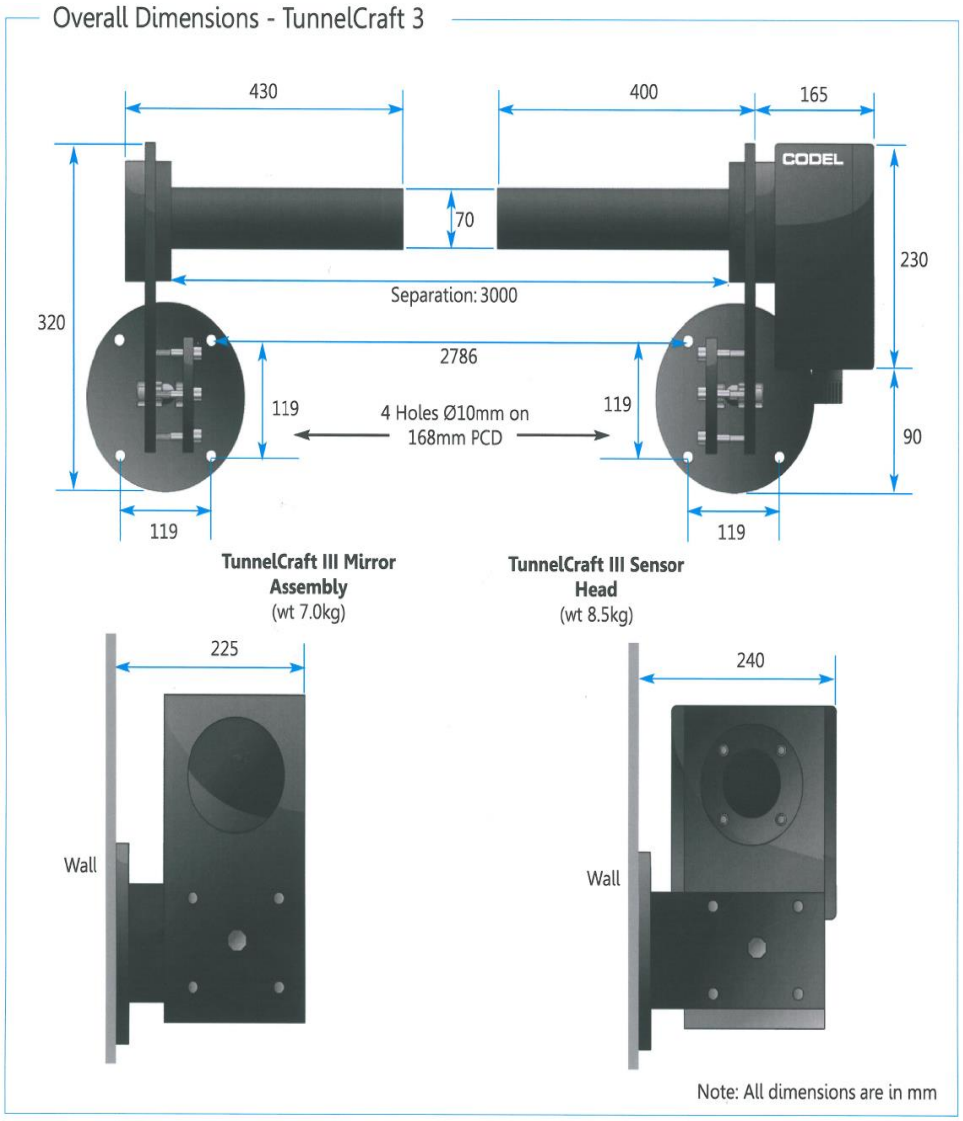


Figure.4 (Visibility & CO & NO detector)

1.2- Fire Fighting:

Two pump stations (500GPM) are distributed among substations, dry type pipe system, in each substation:

- Two electric pumps

- One diesel pump

- One jockey pump

- Deluge valve

Control system monitoring:

- Pump status

- Deluge valve status -tank level analog signal -fuel level float alarm,

- Fuel pumps status

- Flow measurement analog signal

- Network connection with pump panel controllers (data, status) Fire pump Controller(for each pump)

-operation sequence for pumps -deluge valve opening

1.3- Tunnel lighting control:

About 698 luminaries (Thorn, type 7824B) are distributed in tunnel; they are supplied from the substations.Tunnel control system to have luminance meter (See Fig. 5) at each portal and accordingly will control the luminaries operation in tunnel

Control depends on Switching and L20 measurement at each portal, besides night and emergency situation, we arrange the luminaries to be three level switching (night and low luminance, medium, sunny)

Figure.5 (Luminance meter)

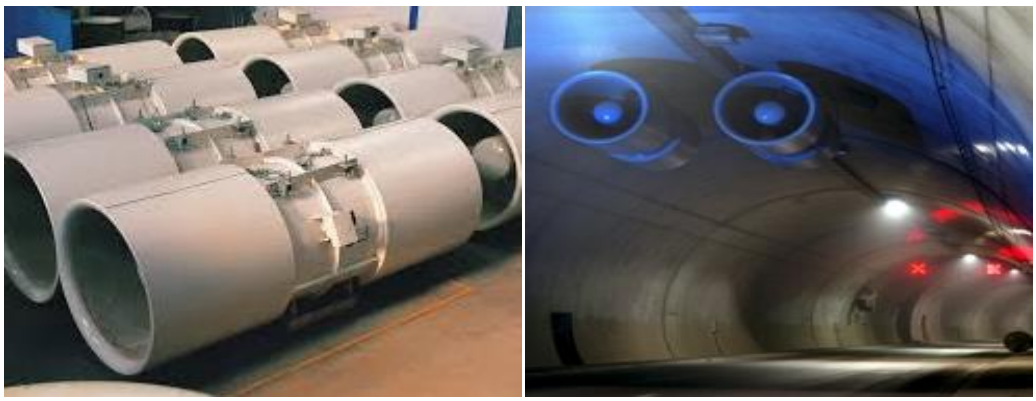
1.4- Ventilation and pollution control:

Forced ventilation is provided with in azmar tunnel by forty two (42) jet fans 30kw reversible (Zitron type JRZ-12.5), longitudinal Ventilation their function:

- Dilution of pollutants in tunnel

-Traffic data and congesting

- Fire protection



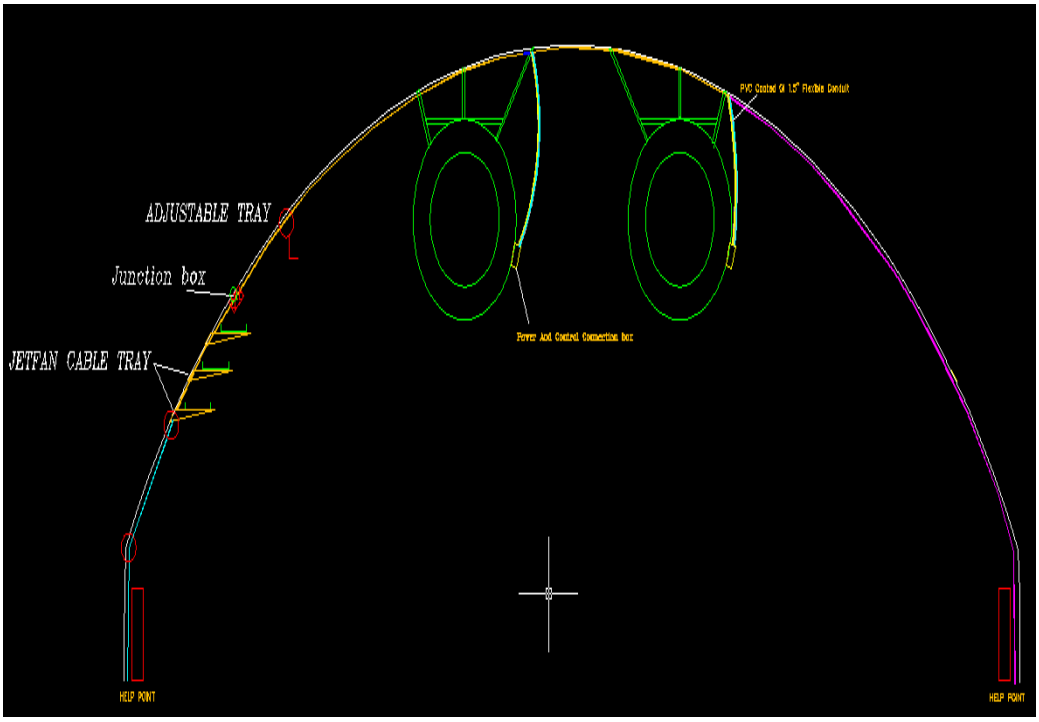
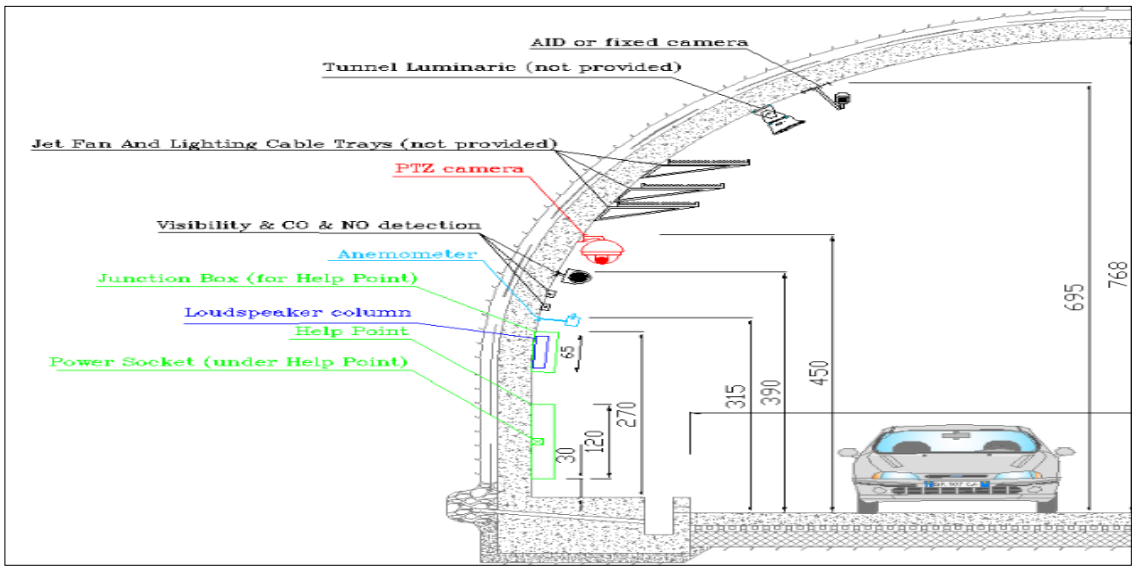


Figure.6 (Jet Fan Ventilation)

Various sensors (Visibility, Cox, NOx, Wind speed, and Temperature profile of tunnel) are distributed along tunnel.



A- Visibility, CO, and NO (CODEL Brand) transmission ≤500m apart to detect smoke for fire detection. (See Fig.4)

B- Air flow, Ultrasonic anemometer and direction at three positions in tunnel to measure the velocity and direction of air in outside and inside tunnel.

Figure.7 (Air Sensors)

Jet fans VFD PLC data to include but not limited to:

·14.1 - Digital input data:

- Running/Stop
- Reverse/Forwards
- Starter alarms
- Remote/local
- Emergency stop
- Winding temperature alarm
- Bearing temperature alarm

- Control voltage, and power supply presence

- Heater on

1.4.2- Digital out:

- Start/Stop

-Reverse/Forward

-Reset fault

- Emergency condition

1.4.3 - Analog and numerical data:

- Vibration mm/sec

- Current/Voltage/Kw/PF/frequency

- Hours accumulated

- Number of starts in the last hour

The incidents were taken as account for the ventilation control is listed below:

- Fire alarm .
- Opacity Alarm
- Visibility, CO, and NO (VCN) sensor alarm.
- Traffic congestion
- State and alarms of the fans .
- Fire push button pressed .
- Excessive smoke detection including AID system .
- Manual Control performed by the operator .

The TMCS continuously monitors the tunnel traffic conditions via fixed IP cameras distributed along the tunnel, from this data, an average speed (km/hr) and throughput (veh/hr) for the tunnel can be determined, and used to trim the operation period of jet fans.

Also ventilation program ordered:

•By the system, if the control of the ventilation is in automatic mode .

•By the operator, if the control of the ventilation is in manual mode. Predefined plans (during emergency, fire...) for automatic operation regimes to integrated in SCADA system

1.5 - CCTV and incident detection system:

The camera system of tunnel as bellow:

- Twenty nine fixed IP (GLOBAL PROOF Brand) cameras to cover the tunnel about 75m spacing.

-Seven DOME cameras for vision redundancy and verification (300m)spacing

-Two PTZ cameras (SIQURA Brand) at portals take full coverage for tunnel entrances (CCTV system only)

The Conway housing, which is manufactured to weatherproof level IP66, camera stainless steel grade is 316 and lens assemblies maximum protection from fumes and other contaminants as well as reducing the risk of corrosion, accessories for increase working temperature, sun shields, multi streaming ,so suitable F.O network infrastructure were used.

AID incident detection is from Traficon modular system has the following cards:

-VIP/IP cards for IP cameras

-VIP/T cards for Dome cameras

-VIP/D cards for outside tunnel fixed cameras

- Communication cards

- Power supply

-Suitable racks

-Two PC work stations with flux view software.

Incident detection has cover:

A- Traffic events: Stopped vehicle, inverse direction, Speed drop, Traffic Congestion, Wrong-way drivers.

B- Non traffic events: Smoke, Fallen object, Pedestrian, flame detection.

C- Technical Alarms: Bad video, No video, Power Failure, Communication Error, Redundant power, I/O expansion, Reboot.

D- Traffic data: Such as Traffic volume, Traffic speed, Occupancy and Level of service.

F- Automatic recording of pre and post incident image sequences (Fifteen minutes)

- Module software integrated in tunnel control system to cover DAI algorithm that can video analysis as same as Traficon system, in any case multi streaming cameras can send their videos to SCADA and Traficon system, the network protocols, band width to bear that.

The following modules are typical but not limited to:

A- Module of management of video matrices.

Locking of images in monitors, vision of video in an operator position, act on cameras (movement, zoom control, focus ...), define and execute prepositions, create and run camera sequences, record and reproduce digital videos, record photos…,

B- Incident detection module (DAI)

C- Traffic data Collection:

Includes the calculation and presentation of levels of service in the road map, with detail of direction, traffic data details, and tunnel control system to communicate with Traficon system

For status, alarms, cameras location, movement, zooming recording, virtual matrix, diagnostic

Cameras are store fifteen minutes before and after alarm activated by AID or SCADA systems, these stored data can't be edited for security.

Traficon software client to save data in the main enterprise servers

HMI Server (Historical data servers)

1.6 - Traffic control system:

Advanced tunnel management system (ATMS) has been provided as:

A- Variable message signals LED type (CT electronica brand):

Three lines x17 characters each , multi colors, auto luminance Text and graphic (EN 12966) and external area is 5460x1685mm (Fig.

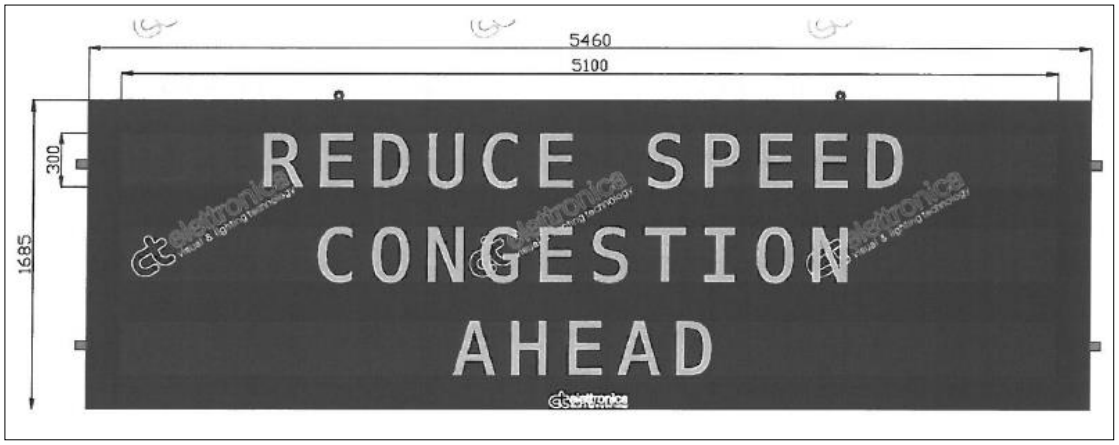


Figure.8 (Large VMS)

B- Lane and speed signs (CT electronica brand are LED (light Emitting diode) matrix signs that Display either a downward Pointing green arrow or a red Cross. Available in single Version, the display matrix, with a (50) mm pixel pitch in a sign 700x700mm, optical performance meets EN 12966.

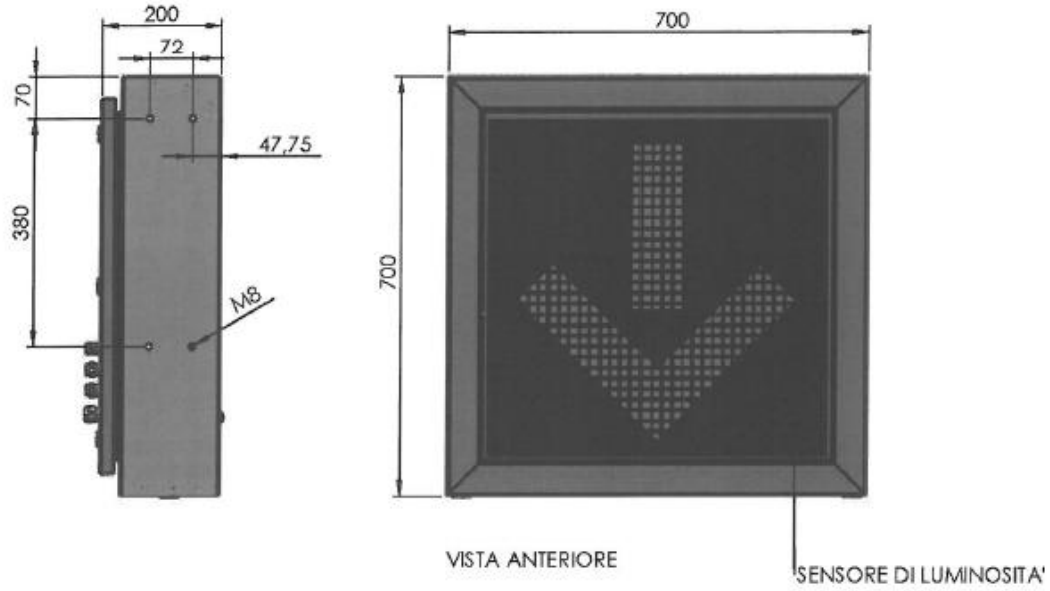


Figure.9 (Lane Sign Control)

C- One and two aspect traffic lamps (CT electronica brand) at portals and at barriers.

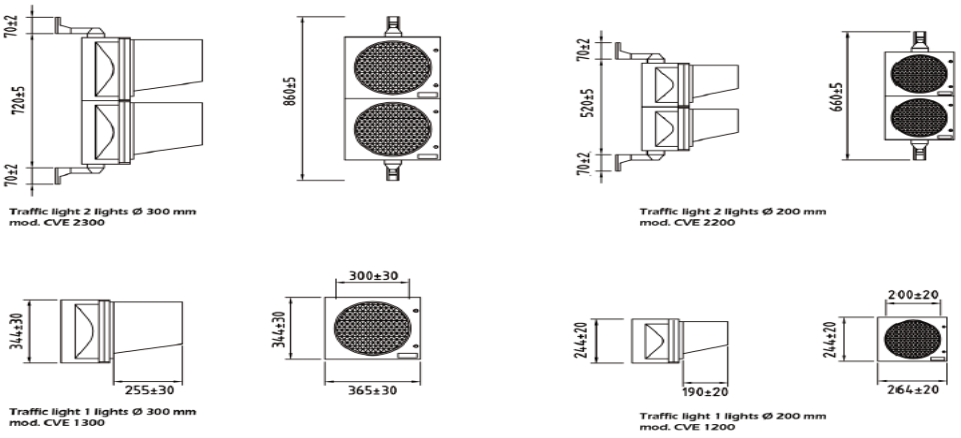


Figure.10 (One and two aspect traffic Light)

D- Over height detector (OHD) RAM20:

RAM 20 has been developed to detect moving objects passing over the allowed height (in our tunnel allowed height is 4.5m). RAM 20 is also able to measure the distance of the object from the sensor and therefore to give information about the lane in which the object transited and it is based on a laser scanner with 4 planes of detection, install (500m) from each portal.

Figure.11 (OHD RAM20)

E- Automatic and manual barriers (FADINI Brand), install (50m) from each portal.

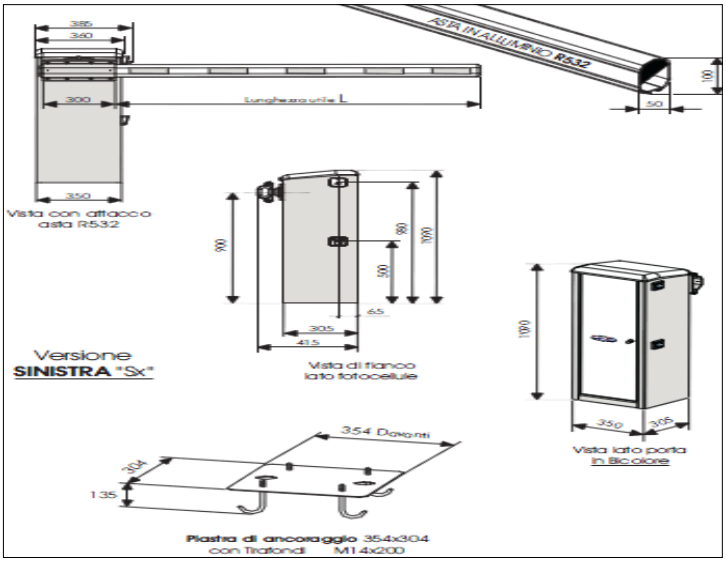


Figure.12 (Barrier)

F- Fixed road signs (local) it has tunnel information such as (tunnel name, height, length, tunnel cameras monitored, FM channel, telephones SOS)

Figure.13 (Fixed Road Sign)

G- Small VMS color text two lines, 12 character /line, 50mm pixel width, with flashing, 1100x650mm.

Figure.14 (Small VMS)

1.7 - Emergency telephones:

This product is designed to ensure the safety and comfort for the tunnel, where is very important for everybody to make emergency calls or simple calls for information. Communications can be started by pressing the button on the SOS panel (two buttons for emergency situation).

The communication with the centre is hands-free, which are only needed to start the call by pressing either key. The communication is very clear and very easy, talk and listen directly on the front panel, SOS device also allow broadcasting an audio announcement from the center by two 50W amplifier inside the unit.

Emergency call boxes were Installed spacing ≤150m at each tunnel wall side, the control boxes have also:

- Fire verification bush buttons with glass.

-Fire brigade sockets(16 amps single phase).

Communication is established through F.O network. A user may answer, hold, hang up or transfer a call coming in from the field. A user may also call out to a particular phone.

1.8 - Radio System:

A- FM (88-108) MHZ rebroadcasting for drivers radio system will permit motorists traveling through the tunnel to receive local radio station signals. The rebroadcast system will be capable of receiving local stations and retransmitting them with a reception level equal to that outside the tunnels without the need for adjusting vehicle volume control. The system also provided for interruption of normal broadcast reception (FM) to provide pre-recorded messages to motorists in Tunnel in the event of an emergency, FM break in can be connected with PA system. The tunnel coverage system is (Leaky Cable) along the tunnel.

Antenna

Combiner

Duplexer

B- Full duplex low VHF (66-88) MHZ four channels

C- Full duplex high VHF (150-200) MHZ at least two channels

D- Full duplex UHF (400-470) MHZ at least one channel

E- Internet connection system that supplied:

- ADSL

- SAT

System security to be achieved (VPN, HTTPS, IP filtering, Fire wall, Passwords…)

G- Redundancy between the two controls rooms (hot standby)

H- Hand held mobiles provided (20 set).

1.9 - PA (Public Address) System:

-1.9.1- Public Loud Speaker:

Loud Speaker is designed to give information for drivers inside and outside tunnel in such cases like (Car accident, Fire, Bad weather, Instruction for driver ….. ECT), and the system is covering the following zones:

A- Substation buildings

B- Portals

C- Four zones inside tunnel

Distance between Loud speakers around (50m).

Figure.15 (Loud Speaker)

-1.9.2- Alarm Horns:

These horns has installed in tunnel for emergency alarms.

Full system connection with:

A- SCADA

B- FM break in

And also has control desks, amplifiers, CD and radio player, PC, software

1.10 - Networks:

This system in Peshraw tunnel has the following specifications:

A- The system is using double fiber optic ring type Ethernet single mode, and with cables LSFH (Low Smoke Free of Halogen) and IEC-332 flame resist.

Figure.16 (Hirschman Network Switch)

Redundant network with fast recovery time using standard redundancy protocol RSTP or any open fast standard (less than 300 msec), managed switches, hubs, and the network to be of high security, SCADA can manage communication routes, multi casting, configuration, and diagnostics.

B- All equipments inside tunnel are industrial type (-40c to 75c) and reside in fire, vibration resistant, ip66, ik09, hard environment resist, tunnel junction boxes.

C- Remote I/O module considered as well

D- The network system on tunnel also include: Diagnostic, monitoring, alarming and management, SCADA system, HMI screen, besides fault

E- Any failure in communication link for any system, the system in safe operation mode (like default program regime, continue operating in last program...) before the operator takes.

F- Operator can perform scada functions from any network node with pass word access this covers configuration data.

1.11 - Public Telephones:

We have 20 pair public telephone (IP/PBX) provided with HP inside tunnel, to main substation external MDF, and PBAX exchange with accessories has connected to our LAN network to reach second standby control room.

The system that includes:

A- Two desk telephone in each control room

B- Five wall mounted telephones in each substation

C- Six telephones for emergency rescue (fire, police, and traffic men)

Public IP/PBX telephone inside control Room and substation

1.12 - Control Room Console:

Peshraw tunnel have two control room (Master CCR and Slave CCR), that will control whole system inside and out site the tunnel via a SCADA system (MOVICON Software).

Figure.17 (Control Room of Peshraw Tunnel)

The Control Room contains:

A- Radio communication Board, FM interruption, PA, Switch and server rack, Main PLC, Video wall and CCTV cameras monitor (See Fig.17)

B- Telephone console (emergency and public) switchboard (See Fig.18)

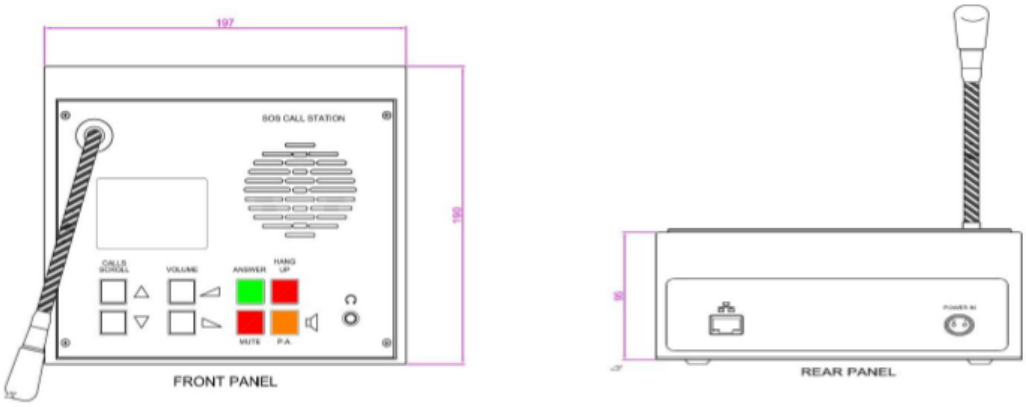


Figure.18 (Operator Consoles)

1.13 - PLC Main Control:

ABB PLC (AC500) full redundant, SIL2, hot plug in module replacement by using either S7-400H somatic.

Figure.19 (PLC AC500)

Tunnel PLC system have the PLC , modules, racks, marshalling cabinets, communication links, RO modules, junction boxes, …. to operate the system with hot redundancy.

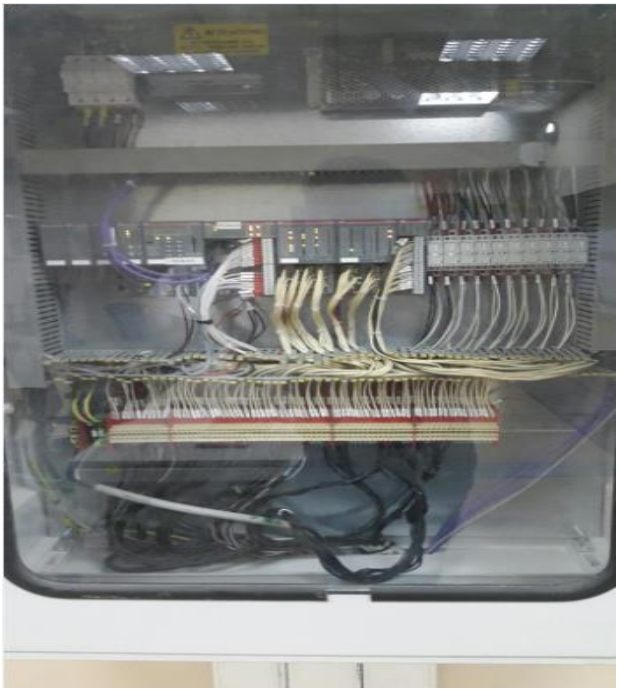


Figure.20 (Main PLC Board)

Peshraw tunnel PLC system:

-Digital input/out ≈2000 point (25% spare)

- Analog input ≈ 180 point (25% spare)

- Programming languages (CodSys Software) to integrated programming system based on IEC-61131-3, off line and on line debugging, process parameters monitoring.

- PLC has its emergency programs that can operate the system in case of SCADA communication failure (degraded mode), any data to be store.

2. Electrical Power System:

There is substation near each portal, each substation supplies power to half tunnel equipment, each one has CCR (control center room) these CCRs act as hot standby redundancy with:

Main CCR: Sulaimanyah side

Slave CCR: Sitak side

2.1 – MV Switchgear (11 KV) and Voltage Transformer (11/0.4 Kv):

The MV switchgear has been installed in both substations (Sulaimanyah and Sitak side) to supply LV boards (Tunnel is dividing to two side and each substation will supply power to a half tunnel equipments).

Figure.21 (MV Switchgear)

METAL CLAD 11KV Switchgear specifications:

- Rated voltage 17.5 KV, Service voltage 11 Kv 3 phase 50 Hz, Rated current on Bus bar 1250 A.

- Vacuum circuit breaker (ABB) wound up by an electric motor with closing and tripping coils.

- IP 42, Closing spring charger and signaling circuit is 110 Vdc.

- Schneider Brand standard IEC 62271 – 200

- Each MV has 2 incomer with one out going feeder.

- Remote control of MV circuit breakers from the operator's work

Station (display alarms and switching)

- Close permission 11 Kv transformer incoming and outgoing CB.

- Each MV has a SEPAM controller that can be adjust and change the parameters.

- Each bus section connected, throw a circuit breaker' to an

Incoming power supply feeder.

Transformer is ONAN Type 11/0.4 Kv 1600KVA capacity.

Figure.22 (Transformer)

2.2 – Diesel emergency FG WILSON P730E and ATS:

Peshraw Tunnel has two number of 600 Kva generator, it can supply half equipments inside and outside tunnel, also automatic transfer switch (ATS) between normal line and generator line to switch between them in case of line off.

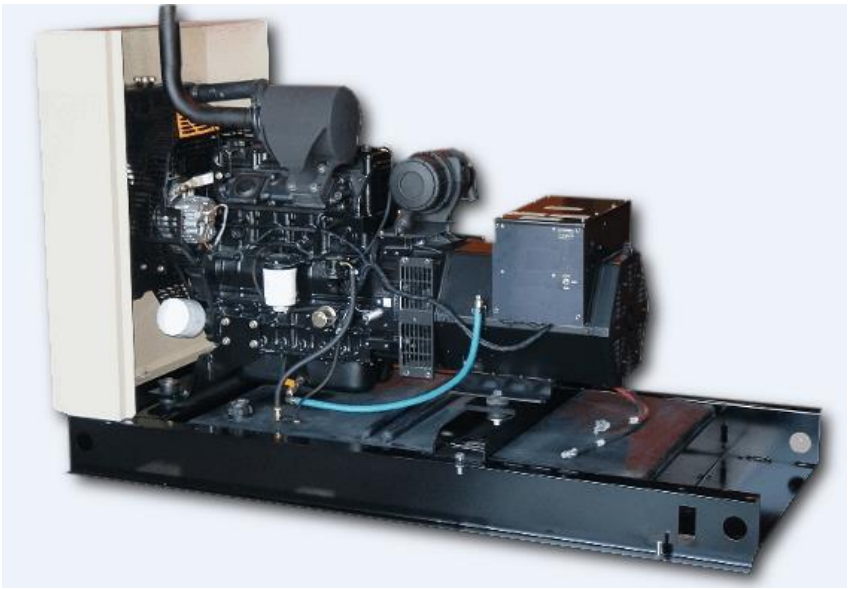


Figure.23 (Generator)

2.3– Low Voltage (LV) Boards:

As explained the tunnel is dividing into two section (Sulaimanyah side and Sitak side), and from each side have a substation that LV boards inside there to supply powers a half tunnel equipments.

LV boards separated as follow:

A- NMDP (Normal Main Distribution Panel).

Supply power to whole electrical equipments inside and outside tunnel

Figure.24 (NMDP Board)

B- EMDP (Emergency Main Distribution Panel)

Supply power to half equipments of tunnel (21 jet fans and lighting system in case of normal line off).

Figure.25 (EMDP Board)

C- UMDP (UPS Main Distribution Panel) and UPS:

Three phase 400vac/50HZ, rated for continuous duty, and capable of

Supplying the continuous load for:

- Four hours for tunnel control and monitoring systems

- 30 minute emergency lighting operation about (40kw)

- Static 'no break' bypasses automatic switching, and manual bypass switch, the time transfer is less than 40msec.

- NI-CD free maintenance batteries with boosting and floating charging

- Lead/lag operation that can switch luminaries at 1300m distance

- High efficiency with harmonics making as in G5/3 (UK).

- Supply 100% of their rated load at the output terminals, and capable of supplying 125% of its

- Capable of accepting current surges when lighting is switched on without going into the by-pass mode.

- Interfaced with SCADA (MODBUS)

The UPS rating is about 80KVA as typical.

Figure.26 (UMDP Board)

D- Tunnel Lighting Board (OLDB):

About 698 luminaries (Thorn, type 7824B) are distributed in tunnel, their operation adaptation of human in dark eye transition. And tunnel control system to have luminance meter at each portal and accordingly will control the luminaries operation in tunnel

There are twelve switching contactor in each sub station

- Four of them UPS supplied

- Eight of them diesel emergency supplied

E- Capacitor Bank:

Power correction board technical characters:

TECHNICAL CHARACTERISTICS	
Supply Voltage	115-230-400 Vac on request ±10% 50/60Hz
Maximum Power Consumption	4 VA
Input Voltage	3 inputs 400 V ±10% phase to phase, 50/60Hz
Input Impedance	>1 Mohm
Input Current	3 inputs from external CT /5A
Over Current	20% continuously
Current Circuit Consumption	<0,25 VA
Voltage Measurement Accuracy	±1% full-scale
Current Measurement Accuracy	±1% full-scale
Current Resolution	10 mA x CT/5
Current THDI Accuracy	±1% f.s. Irms>10%f.s.; ±5% f.s. Irms<10% f.s.
Frequency accuracy	0,2% f.s.
Temperature Measurement Accuracy	± 1°C
Time Accuracy	± 1 second
Relay Contacts of Cooling Device	5A 250V RC NO
Alarm Relay Contacts	5A 250V NC
RS232 Communications	Requires specific external adapter
Working Temperature	from 0°C to +55°C
Humidity	95% uncondensed
Storage Temperature	-20°C +70°C
Wirings	Removable terminals
Dimensions	96 x 96 x 60 mm DIN 43700
Weight	450 gr.

F- 110V Voltage DC:

Rated power	6 KVA, 110 VDC, 50 ADC
Input voltage window	1X230 NOM, +/- 10 %
Battery voltage	110 VDC 54 EL PB HERMETIC
Recharge time	5 HOURS TO 90 %- RIPPLE FREE- IU DIN 41773
Led and measurement information local status indication	Vdc, Adc, VBATT, LED ALARM STATUS ALARM
Dimension	800X800X1800
Weight only ups	500 KG
parallelability	YES
Remote alarm	I/O V FREE CONTACT
standard	EN6204 on
Input frequency	45-65 HZ
Battery cabinet dimension	tbd
Battery cabinet Weight	tbd
Battery capacity	130 Ah

SCADA system input/output for electric power supplies (substations) NMDP, EMDP, UMDP, OLDB, SP, MV, and Generator:

A- Status monitoring of circuit breakers such as:

- Local/remote

- Open/close

- Breaker position (operating, test)

- D.C voltage presence/AC power presence

- Trip

- Emergency stops

B- Commands control such as:

- Open/close

- Forward/reverse for jet fan VFD

- Diesel and ATI, 1250A, load transfer panel with motorized switch FG WILSON.

C- Monitor the measurement and status for IED devices

- Voltages, currents, frequency, power factor

- Kw, kvar and energy kw-hour consumption

- Power factor correction on stages

D- Alarms data for protection relays

All breakers in LV Boards are motorized.

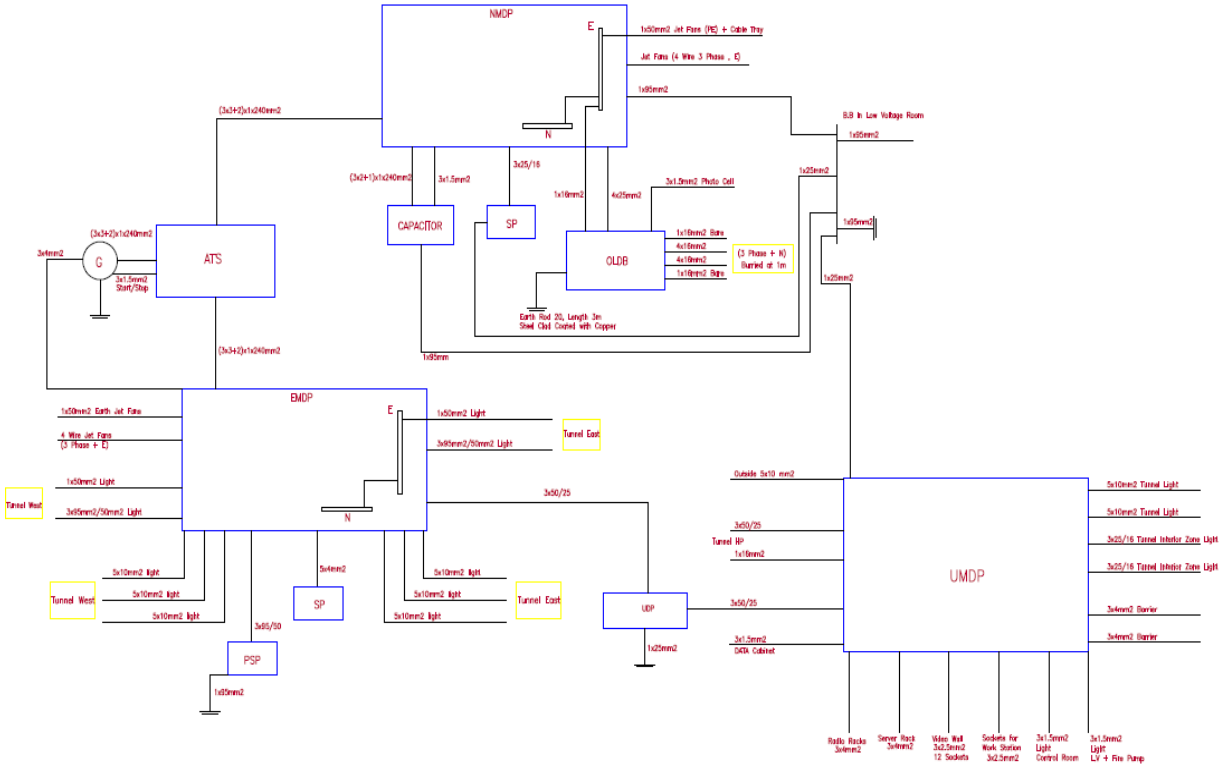


Figure.27 (LV Block Diagram and Cable Distribution)