

DOCUMENT TITLE: Technical Description Class 1 - 4 Electrical Actuation System
PROJECT TITLE: ISO 1 to 4-Mech.Interfaces
PROJECT: 600144
PACKAGE DESCRIPTION:
DOCUMENT NUMBER: 600144-TD-0001
REV: 01
NUMBER OF PAGES: 15

DATE:
CLIENT: Talisman Energy
CLIENT PO:
CLIENT DOC NO.:
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OBJECTIVE

The objective of this document is to present a comprehensive technical description of the Blue Logic Electrical powered ISO Class 1 to 4 Electrical Torque Tool and subsea actuation system. Relevant technical aspects for information and familiarization are covered as well as outlined technical data.

ABSTRACT

The Blue Logic ISO Class 1 to 4 Electrical Torque Tool and Actuation System (ELTT) is designed to be operable by most relevant ROV Systems available. The system is powered by a permanent magnet Servo Motor system with excellent power-to-weight and size- ratio and the best accuracy available on the market for such applications. This gives a submerged weight of the ELTT of only 22kg. It offers an accuracy and controllability which is superior to any hydraulic tool and actuation systems available. The system offers FULL control over torque, speed and position in all operation modes since torque-control is fully integrated in the tool's control system and can be controlled from zero to full speed with full accuracy from the Topside Control system (MMI).

The Blue Logic ELTT is designed and built in accordance with all relevant industry standards. The system is designed and optimized for control of torque, turn speed and turn count and has the ability to diagnose valves or other equipment that is being operated with automatic generated reports.

The custom made gearbox used in the Class 1 – 4 tool system has a unique built in feature where the Tool System rotating output pipe can be re-connected to either the 3rd or 2nd stage in order to operate all torque classes with optimized speed and accuracy. Therefore the practical achievable output torque and speed range exceeds other known systems available on the market.

The ELTT's position is measured continuously and displayed electronically in the top-side control system. In addition, the tool output shaft position is measured directly by the built in position display in rear end of the Tool. This indicator is "all mechanical" and is connected directly to the output pipe through a hollow shaft in the center of the tool.

The ELTT system has an Electrical Power Can (EPC) which is normally installed on the ROV prior to connecting the Electrical Torque Tool. The EPC includes the required power control system needed for operation and control of the Torque Tool. The Electrical Power Can is configurable to allow for different ROV systems and their available power/voltage. By this configuration, with a separate Power Can on the ROV, the Torque Tool Size and weight is kept to an absolute minimum. This EPC can also be used with other types of electrical ROV tools.

If the Blue Logic Inductive Subsea Connector System (Subsea USB) is implemented, the tool system can easily be connected and disconnected subsea when required thus offering full flexibility.



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As an additional feature, the tool system can be delivered with built in battery/capacitor/UPS power for increased peak effect or operation using alternative subsea tool platforms.

Industry history has shown that for many commonly used torque tool systems, accurate torque control has been difficult to achieve and document. Typical hydraulic powered Torque Tool Systems are very sensitive for temperature and speed wrt Torque Control. Difference between static and dynamic torque is known to be a notorious problem. The Blue Logic Electrical Tool System represents a "step change" with regards to these issues. A Torque Test Jig capable of measuring both static and dynamic torque has therefore been developed and is available also in a Subsea Version. On the other hand, it can be discussed whether this is needed as the tool is calibrated and will not be affected by type of ROV, temperature of hydraulic oil etc.

The Tool system has been based on pre-qualified control system also qualified for marine applications according to Kongsberg Maritime requirements. Currently 400 actuation systems are in use 24/7 for accurate and continuous regulation and control of Diesel fuel pumps on marine diesel engines. A significant number of accumulated operational hours with MTBF statistics are therefore available.

For subsea Tool Change, the Torque Tool and Actuation system can be delivered with the Blue Logic inductive subsea connector (Subsea USB) allowing for a power takeout up to 2kW.

The Torque Tool and Actuation system is available configured for temporary intervention use or as permanent installed Actuator Systems.

REVISION CHANGE/RECORD

REV	REASON FOR REVISION/ DESCRIPTION OF CHANGES
01	Prepared for information. Document replaces 500118-TD-0001



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1. INTRODUCTION

The Blue Logic Electrical Torque Tool and Actuation System (ELTT) consist of the following components and subsystems:

- A) Torque Tool/ Actuator
- B) Electric Power Can (EPC)
- C) Umbilical between Tool and EPC
- D) Topside Control system (User Interface)
- E) Replaceable output pipes (To cover Class 1-4)
- F) Static Torque Calibration Unit (hydraulic load cell)
- G) Combined Static and Dynamic Torque Calibration Unit
- H) Inductive Connector system for subsea tool changeout

For intervention purposes, typically Aluminum and 316/S165 materials are selected. When delivered for permanent or semi-permanent applications, corrosion free materials as Super Duplex, titanium and 6MO are typically used. Configuration and material usage can be adjusted to meet most Client and project specific needs as required.

The rotating Tool system is equipped with a special developed Magnet Encoder Card (MENC) for position measurement and control.

1.1. DOCUMENT USE

This document shall be used as a general information. For detailed dimensional information, please see detailed Blue Logic drawings. For details wrt operation, please see dedicated User Manua

I.

1.2. REFERENCES

Latest version of the following documents

Id.	Doc. No	Originator	Document Title
/01/	500118-TD-0009	Blue Logic	User Manual for Class 1-4 Electrical Torque Tool System
/02/	600128-TD-0006_	Blue Loigic	Subsea USB Product_0,5 - 2,0 KW Technical Description_Rev-01

1.3. ABBREVIATIONS

- ROV: Remotely Operated Vehicle
- HPU: Hydraulic Power Unit
- FAT: Factory Acceptance Test

2. TECHNICAL DESCRIPTION

2.1. GENERAL SYSTEM OVERVIEW

The Blue Logic Class 1-4 Electrical Torque Tool and Actuation System is a module based design. It is a compact, flexible, and robust precision tool for operation in all Subsea and ROV applications. The selection of a state of the art electrical servo motor and gear system in combination with a field proven control system gives unique precision and operability. The Tool can operate with full and accurate torque even in static conditions. It has a unique control of the applied torque and seating forces on valves and clamps.

The control system with the Graphical User Interface can be installed on any PC/ Laptop's. All relevant parameters for operating the tool can be set, controlled and run from this control platform. The control system has a built in report system generating operation reports with output torque VS operation angle curves. The tool also facilitates import of preapproved operational criteria in order to minimize risk of damage.

The Blue Logic Torque Tool and Actuation System combines all known advantages with a hydraulic torque tool system with the technology and advantages available from a modern Servo Based Electrical Controlled Drive system.

The ELTT is designed for operation on ROV's with minimum 5A 110 VAC of power available.

For ROV tool operation, typical configuration will be adjusted for 1 phase 110VAC @ Max 40A. Communication through Ethernet /RS232/RS485.

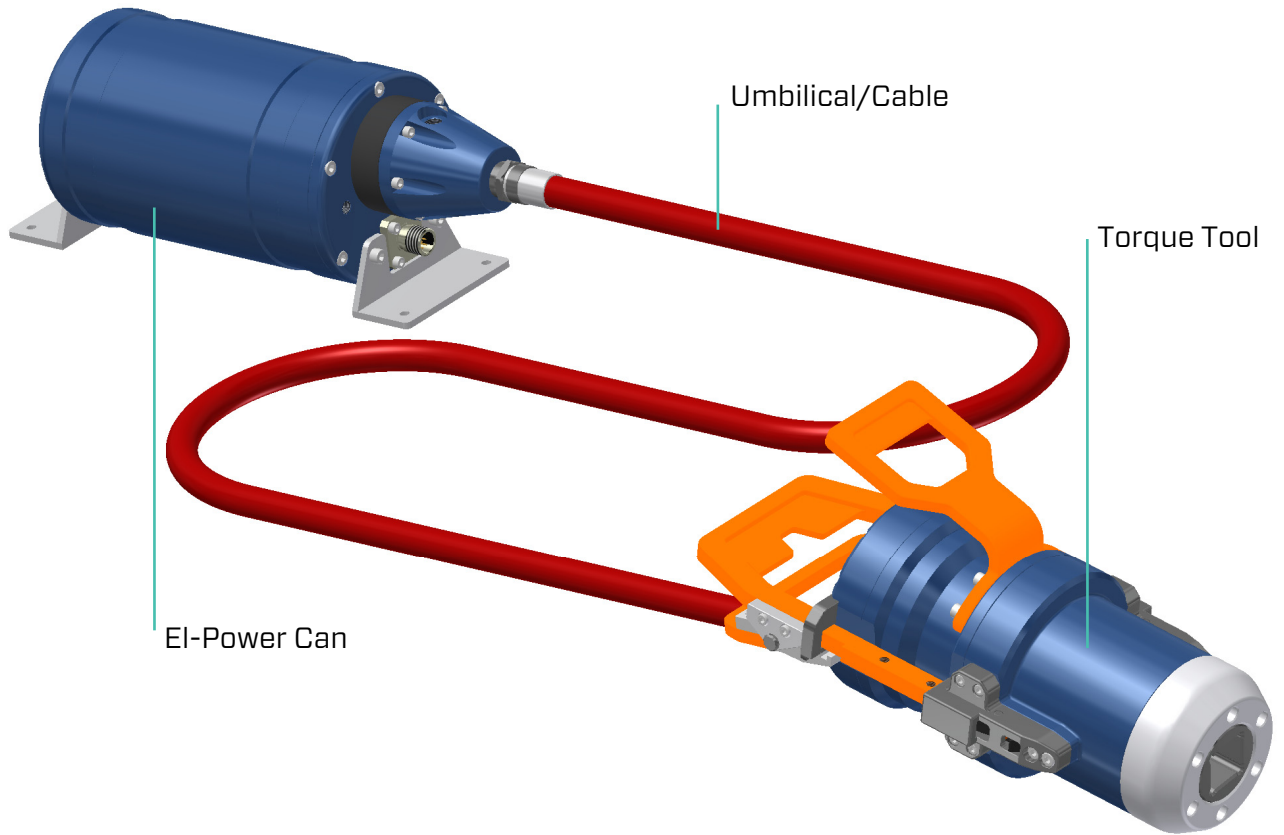


Figure 1 Torque Tool, Umbilical and EI Power Can

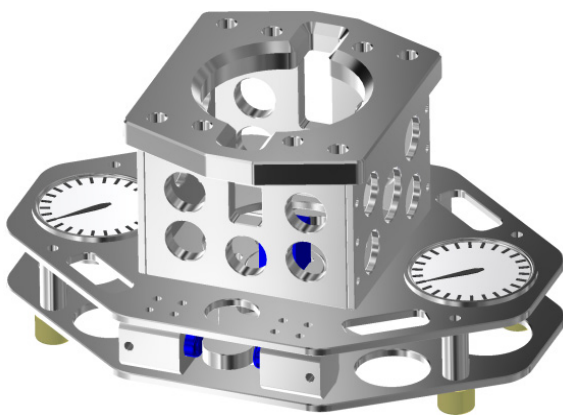


Figure 2 Torque Verification Unit (static)



Figure 3 Inductive Connector System

2.2. TORQUE TOOL / ACTUATOR

2.2.1. General

2.2.2. Drive System

The Electrical Torque Tool is powered by a permanent magnet servo motor. The motor system is qualified for use in harsh maritime environment and has a long track record in actuators placed directly onto marine diesel engines typically running in continuous regulation mode 24/7. The motor transfers the torque into a very compact specially designed 3-stage planetary gear system. A unique function with two different output axles from both the two last gear stages gives the possibility to connect output ISO Square key to either the third or the second gear stage. This results in a Torque Tool with unique precision and accuracy in all modes as well as the capability of very high output speed when torque is low if required.

The ELTT Gear System has been specially designed for this subsea application. Tool Weight, size and compactness have been in focus when designing the Gearbox which is fully integrated in the mechanical design of the Tool.

2.2.3. Outer Housing

The Tool has an outer protective aluminum 6082T6 housing with integrated mechanical interface toward the ISO Torque buckets. The internal parts in the Torque Tool are fully submerged in oil the housing internal oil system is pressure compensated by use of the flexible umbilical between the Tool and Electrical Control Can.

2.2.4. Output Interface

All standard ISO output key interfaces type 1 to 4 can be inserted in the ELTT. The Output key is easily changed topside, and the ELTT will then automatically switch between High and Low torque mode. This unique feature is achieved by a center pin in the key which is reporting absolute output position to the control system. Accurate High and Low torque modes are therefore achieved without the need for changing the motor as is often required on hydraulic tool systems.

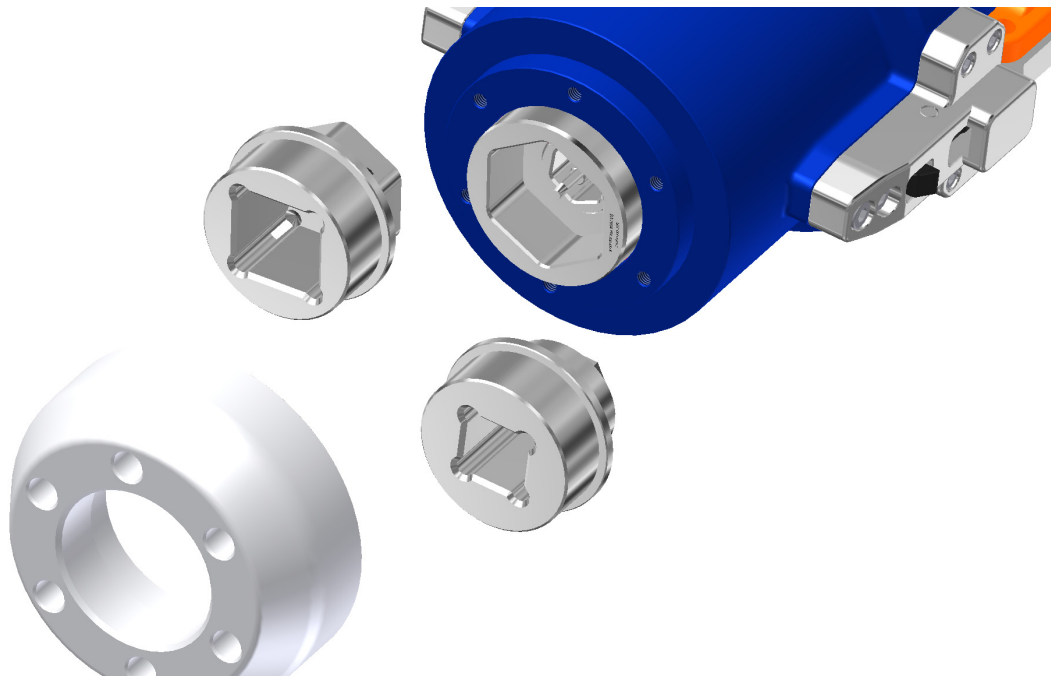


Figure 4: ISO Class 2 and 4 output keys are easily changed out topside

The ELTT delivers output torque according to ISO/API requirements as follows:

1)ISO Class 1	67 Nm
2)ISO Class 2	271Nm
3)ISO Class 3	1355 Nm
4) ISO Class 4	2711 Nm

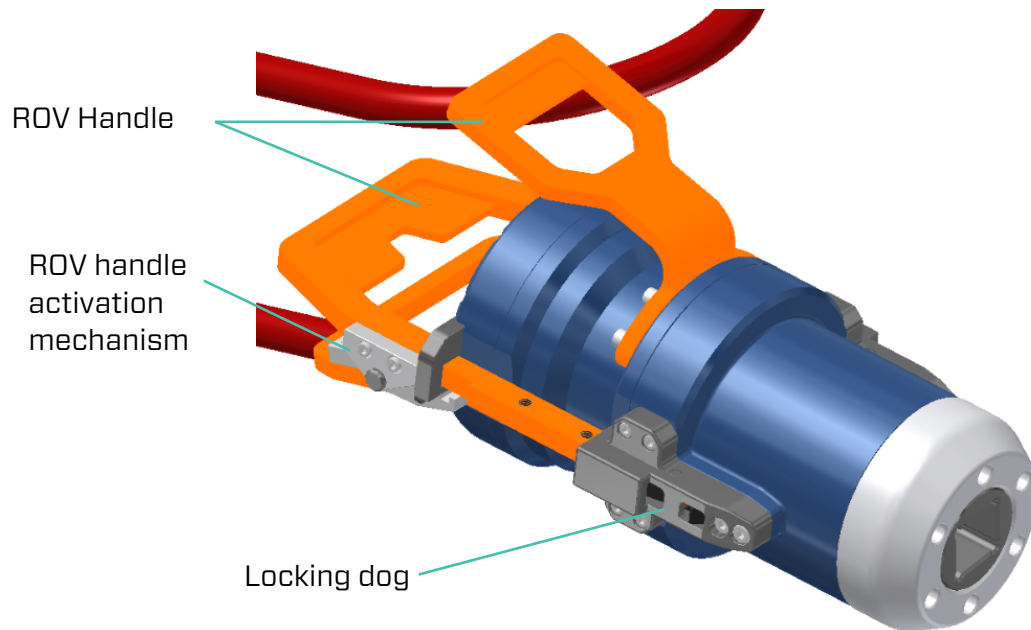
2.2.5. ROV Handle

The Torque Tool is typically equipped with two different ROV handles; one stationary handle connected directly to the outer Torque Tool housing and one multifunctional handle which also operates and controls the Tool Locking dogs which is used to lock the tool into the ISO/ Api interface.

2.2.5.1. Locking System

The Tool is equipped with a special designed ROV handle which is operated by use of a standard 7-function ROV manipulator. The handle can be mechanically set in 3 different positions:

- Open:** Latches are de-activated and the tool is free to be inserted/removed from the Interface Bucket
- Install:** Tool can be pushed directly into the Interface, but when fully inserted, the latching dogs will be spring activated and will prevent the Tool from being pulled out undersireable.
- Locked:** The locking dogs are locked in "Locking position"



2.2.6. Position measurement

The Standard configured Tool is equipped with three independent position sensors:

1. Mechanical absolute position indicator in the rear end of the Tool
2. Electronic position measurement system on the output shaft (MENC)
3. Electronic motor position measurement (MENC)

2.2.6.1. Mechanical position indicator

The mechanical position indicator is connected directly to the Tool output shaft and is an all mechanical continuously rotating indicator.

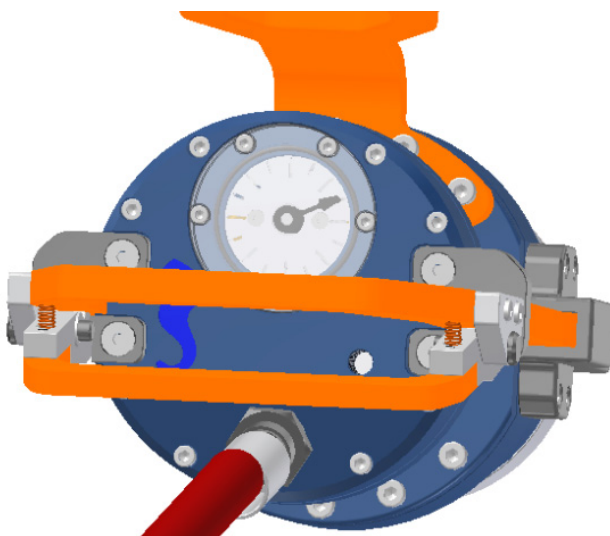


Figure 5 Tool Rear end shown with mechanical position indicator



2.2.6.2. Magnet Encoder Card System (MENC)

The Magnet Encoder Cards is a very compact, reliable, intelligent and accurate position indicator. It is used high speed motor position indication and for accurate electronic measurement of output shaft position.

2.2.7. Umbilical

The electrical umbilical transfers both power and communication to the tool. It consists of electrical wires protected by an outer robust fibre reinforced hydraulic rubber hose. This offers excellent protection and built in pressure compensation of the actuation system. Also, this configuration facilitates easy repair.

2.3. EL POWER CAN

The EI-Tooling Power Can (EPC) is a separate installed electrical power and control Unit which converts the ROV supplied 110 or 220 VAC to DC power suitable for the Tool. The EPC will normally be installed onto the ROV frame at a suitable place and is equipped with connectors for input power/ signal and Tool Output power and signal. The EPC is an atmospheric can designed for a maximum depth of 3000m.

To minimize the Torque Tool Size, the EPC, includes the required driver and power electronic to operate the Torque Tool. The system is designed for operation on ROV's with minimum 5A 110VAC of power available.

Power and Communication:

- 1) 1 phase 110VAC @ Max 40A.
- 2) Ethernet /RS232/RS485

2.4. CONTROL SYSTEM

In general, the Torque Tool Control System consists of the following main components:

- 2 off MENC position cards installed in Torque Tool Housing
- Servo Controller
- Power Stage
- AC/DC Power Board
- AC/DC Control Power Board
- Topside Computer with Control Software and Graphical User Interface

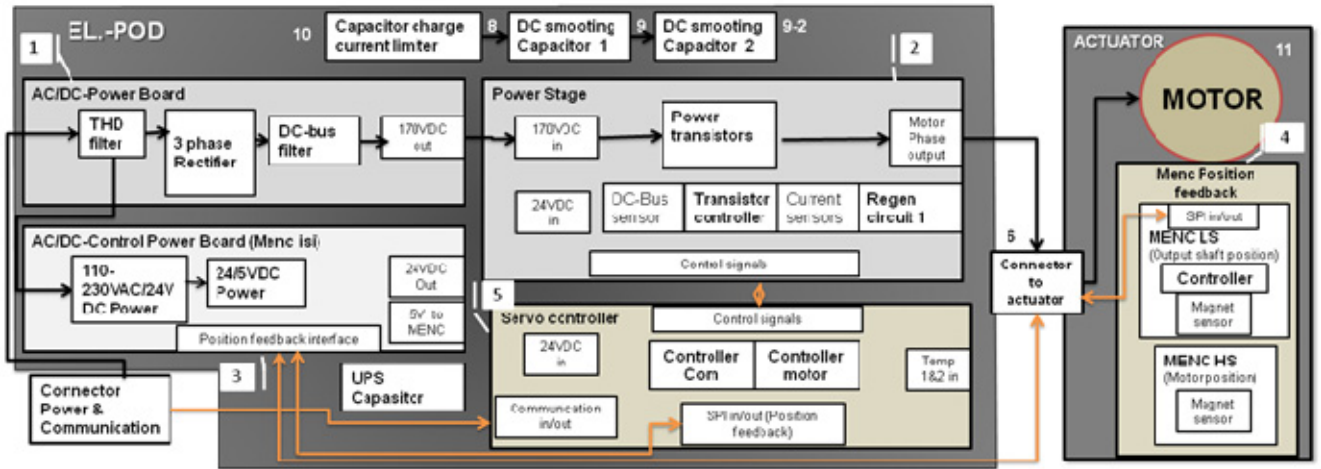


Figure 6 Control System general layout

All control system components are based on field proven components initially designed for permanent subsea actuator use and qualified for use in marine applications.

2.4.1. Diagnostic

The following diagnostic are logged:

- El-Pod temperature
- Transistor cooling block temperature
- Actuator temperature
- Main Supply voltage
- Motor current
- Performed Torque
- Motor position
- Actuator output shaft position

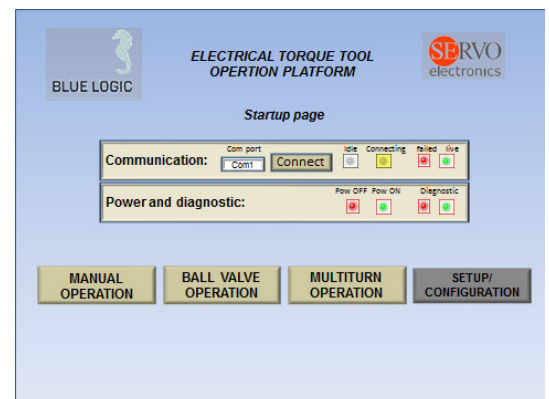
Warnings according to above list will change the “Health” lamp. The operator will be able to shut down the warning window temporarily or permanent.

A detected critical error will change the “Health window” to red and the operation will be shut down. A popup window specifying details will occur. If overload or over temperature is detected reset will not be possible until reasonable temperatures are present and stabilized.

2.5. TOPSIDE CONTROL SYSTEM

The EPC communicates with the Topside Control system by RS232 protocol. The Top Side Control System consists of PC based software installable on any dedicated Portable PC or on an existing computer in the ROV Control Room.

The Topside Control system has a Graphical User Interface to control Torque output in Nm, Turn Speed in rpm, and Turn Count. Position accuracy in the





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Topside Graphical User Interface (GUI) allows for position measurements down to 0.1 degree. The position feedback signal is measured directly on the output pipe, thus giving a 100% reliable and correct signal as well as to fully verify actual rotation of the output pipe. This is in contrast to most conventional Torque Tool Systems available, which normally only records the motor movement and then calculates output position.

All relevant parameters for Subsea operation of the Torque Tool System will be operable from the control system and there are built in safe operation features in order to prevent over torque during operation. All the parameters are continuously logged in the Top-Side Control system and can be exported to a file/operation report in order to be documented, i.e. torque vs operation angle curves.

The Graphical User Interface for ELLT can be tailor made and configured to meet client requirements, project specific operations or dedicated special subsea operations/ tools.

The Graphical User Interface will include dedicated pages for most critical subsea operations such as:

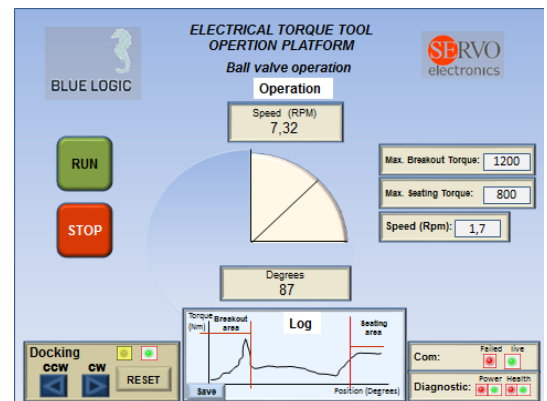
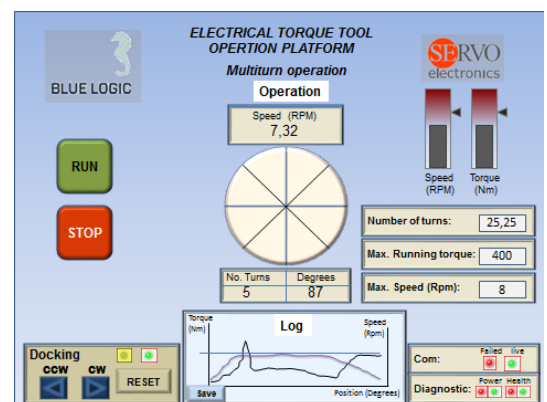
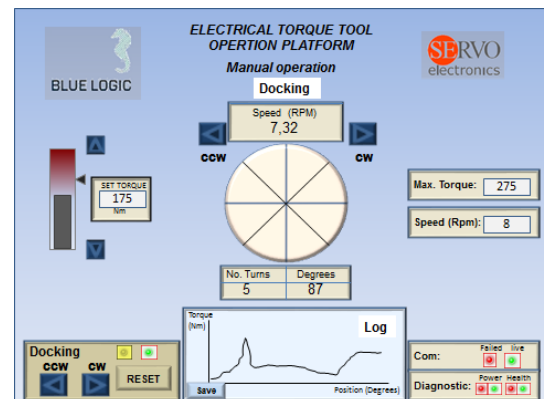
1. General Multipurpose Torque Tool operation
2. Ball Valve Operation
3. Multi turn Valve operation (Choke)
4. Clamp operation

A safe docking mode is also available to ease docking and engagement of subsea interfaces without undesired operation of interface.

2.6. TORQUE CALIBRATION UNIT

The Blue Logic Subsea Torque Verification Jig is a fully hydraulic Torque Test jig that displays applied torque directly on a mechanical Subsea manometer. The system can be used both Subsea and on deck. Due to an extremely compact design, the Torque Verification Jig only weights 25 kg in air and 20 kg submerged.

If required, a dynamic torque test unit can be delivered upon request.



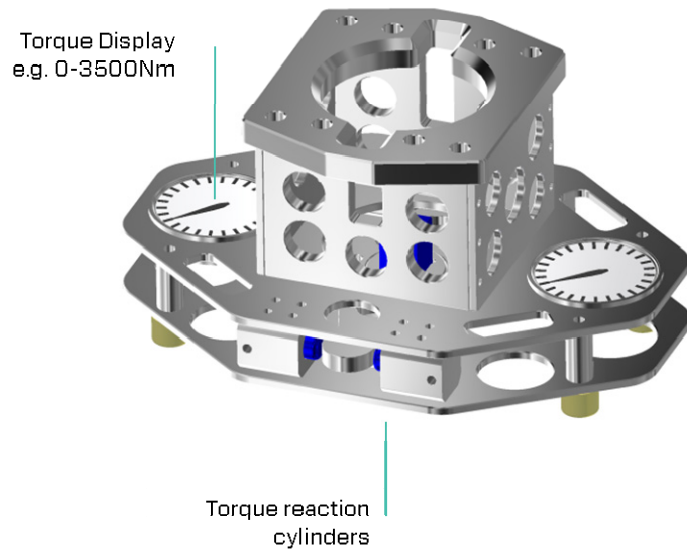


Figure 7 Torque Calibration Unit

2.7. INDUCTIVE SUBSEA CONNECTOR (SUBSEA USB)

Blue Logic has developed an inductive Subsea Connector System named "Subsea USB" due to the ability to transfer both power and communication. It operates on inductive principles and hence they are fully sealed with no electrical pins or wires exposed to seawater (Galvanic sealed). Voltage is transferred directly in the connector interface between the male and female connector thus allowing for optimal performance of the Tool regardless of power supply/voltage and quality available from the ROV system.

Typically the male connector will be installed on the ROV and the female connector will be connected to the ROV. By use of a Blue Logic Subsea USB system, the EI Power Can can be omitted.

There are several advantages of using an USB connection:

- 1) It is very tolerant for debris
- 2) Earth fault will not take down ROV
- 3) Increased current capacity and thus higher speed potential
- 4) Subsea change of tools



3. TECHNICAL DATA

Torque Tool Weight in Air:	28	Kg
Submerged Weight Torque	22	Kg
Design water depth	3000	m
Max Output torque High Torque Mode:	3000	Nm
Max Output speed High Torque Mode :	5,9	Rpm
Max Output speed Low Torque Mode:	32	Rpm
Supply Voltage (using AC)	110-230	VAC
Supply Voltage (using DC)	160-320	VDC
Serial communication:	RS422/RS485/ 37800kBaud	

Note 1; Max output speed depending on supply voltage