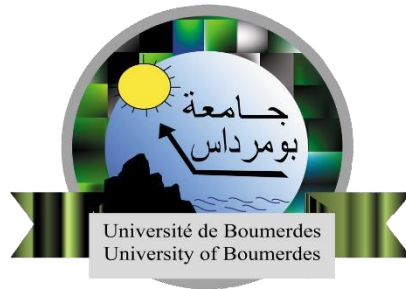


People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
University M'Hamed BOUGARA – Boumerdes



Institute of Electrical and Electronic Engineering
Department of Power and Control.

Final Year Project Report Presented in Partial Fulfilment of
the Requirements for the Degree of

MASTER

In Control

Option: Control

Title:

Automation and Supervision
Of a Top drive Varco TDS 11/SA
At ENTP (TP-232).

Presented by:

Tifrani Mohammed.

Tiabine Mohammed.

Supervisor:

Dr. Abderahmane OUADI

2023/2022

Abstract

Oil and gas are regarded as key sources of energy in this century, and they are utilized in numerous nations worldwide. Our reliance on fossil fuels is so profound that oil companies around the world have decided to do their utmost to extract oil through a variety of drilling techniques to meet market demand. Companies have come up with a new drilling technology that involves introducing advanced equipment to accelerate the drilling process; this equipment is called the Top Drive. At ENTP, they use a legacy Control system based on old technology (Electro-hydraulic). It has a multitude of issues, notably when it comes to downtime because of the frequent, intensive maintenance needed; Therefore, in our study, we aim to renovate the control system of the Varco Top drive by introducing the torque and speed function, alarm function, brake function using a Programmable logical Controller with the human-machine interface which displays the speed, torque and set the torque limit with alarm, brake, and pipe handler screen to improve the control system and ease the supervision. The results of the experimental implementation demonstrate that a high level of automation can greatly improve equipment reliability and productivity.

Résumé

Le pétrole et le gaz sont considérés comme des sources d'énergie clés au cours de ce siècle, et ils sont utilisés dans de nombreux pays du monde entier. Notre dépendance à l'égard des combustibles fossiles est telle que les sociétés pétrolières du monde entier ont décidé de faire tout leur possible pour extraire du pétrole au moyen de diverses techniques de forage pour répondre à la demande du marché. Les entreprises ont mis au point une nouvelle technologie de forage qui comprend l'introduction d'équipement de pointe pour accélérer le processus de forage ; cet équipement s'appelle le Top Drive. Chez ENTP, ils utilisent un ancien système de contrôle basé sur une technologie ancienne (électrohydraulique). Il a une multitude de problèmes, notamment en ce qui concerne les temps d'arrêt en raison de la maintenance fréquente et intensive nécessaire; Par conséquent, dans notre étude, nous visons à rénover le système de commande de la Varco Top drive en introduisant la fonction de couple et de vitesse, fonction d'alarme, fonction de freinage à l'aide d'un contrôleur logique programmable avec l'interface homme-machine qui affiche la vitesse, le couple et la limite de couple avec alarme, frein et écran de pipe Handler pour améliorer le système de contrôle et faciliter la supervision. Les résultats de la mise en œuvre expérimentale montrent qu'un niveau élevé d'automatisation peut grandement améliorer la fiabilité et la productivité des équipements

ملخص

يعتبر النفط والغاز مصدرين رئيسيين للطاقة في هذا القرن، ويتم استخدامهما في العديد من الدول في جميع أنحاء العالم. إن اعتمادنا على الوقود الأحفوري عميق للغاية لدرجة أن شركات النفط في جميع أنحاء العالم قررت بذل قصارى جهدها لاستخراج النفط من خلال مجموعة متنوعة من تقنيات الحفر لتلبية طلب السوق. توصلت الشركات إلى تقنية حفر جديدة تتضمن إدخال معدات متقدمة لتسريع عملية الحفر ؛ تسمى بـ top drive. ولديها العديد من القضايا، لا (Electro-hydraulic) ، يستخدمون نظام التحكم القديم القائم على التكنولوجيا القديمة ENTP في سيما عندما يتعلق الأمر بوقت التوقف بسبب الصيانة المتكررة والمكلفة اللازمة ؛ لذلك، في دراستنا، نهدف إلى تجديد نظام من خلال إدخال وظيفة عزم الدوران والسرعة، ووظيفة الإنذار، ووظيفة الفرامل باستخدام وحدة Varco Top التحكم في محرك تحكم منطقية قابلة للبرمجة مع واجهة الإنسان والآلة التي تعرض السرعة، عزم الدوران وضبط حد عزم الدوران مع شاشة معالج الإنذار والفرامل والأنابيب لتحسين نظام التحكم وتسهيل الإشراف. تظهر نتائج التنفيذ التجريبي أن المستوى العالي من التشغيل الآلي يمكن أن يحسن بشكل كبير موثوقية المعدات وإنتاجيتها.

Dedications

First of ALL, MY success is in Allah's hands

After five years of hard work, I want to thank my family my mother father, and all my brothers and sister for supporting my dreams and me. for my mother the moon of my night and the candle of my heart, for my father who always encourages me to do what I like, for all my friends who were there with me in all the ups and downs.

To my aunt and his husband for standing by my side through all the tough time

*To everyone who supported me: **thank you***

Tifrani Mohammed

Dedications

*It is with great emotions that I dedicate this modest
graduation work:*

To my father and mother

To my dear brother and my dear sisters

To all my family

To all my friends

and all my loved ones.

Tiabine Mohammed

Acknowledgement

I am grateful to Allah for guiding me on the path to completion of this project. I wish also to express my sincerest thanks:

*I would like to express my sincere gratitude to **Dr. OUADI Abderahmane**,
Who has supported and helped us in finishing this thesis with his advice
given during hard moments of work;*

*I would also like to thank
Mr. Ilyes for allowing me to proudly use his precious time to discuss and work on
this thesis.*

*I am grateful to the members of the jury for their careful consideration and
willingness to judge this work.*

*I would like to thank **Mr. Nadjib Haroun** and **Mr. Yacer Bey**, in particular, for all
the assistance they provided throughout my internship at **ENTP Tp-232**.*

List of figures:

Figure 1 : Organizational structure [1]	4
Figure 2: TP-232.....	8
Figure. 3: Station Ground Plan TP232 [2].....	8
Figure 4:Schematic layout of petroleum drilling rig [19].....	10
Figure 5: Rotating equipment of the drilling rig. [4]	11
Figure 6: Circulation system of the drilling rig [4].....	12
Figure 7: Tubular handling Schematics [16]	13
Figure 8: Schematic of Hoisting System [17].....	14
Figure 9: Drawwork real image.	15
Figure 10: Power Disruption Diagram [18].....	15
Figure 11: BOP schematic [15]	16
Figure 12:CanRig	19
Figure 13:BENTEC	19
Figure 14:TESCO	19
Figure 15: Real Image of varco TDS 11SA.....	20
Figure 16: Varco Version Development.....	21
Figure 17: Torque Speed curve.....	23
Figure 18: TDS 11SA main component	23
Figure 19: TDS power train cutaway.....	24
Figure 10: Hydraulic brake system [10]	25
Figure 11: Cooling system [10]	26
Figure 22: Drill stem Assembly.....	27
Figure 123: carriage assembly	27
Figure 24: Pipehandler with torque backup clamp [10]	28
Figure 25: Biderctionnel link Tilt	29
Figure 26: Load Collar	29
Figure 27: Stand jump option [10].....	31
Figure 28: AC Motor [10].....	32
Figure 29: Varco console.....	33
Figure 30: Physical Console [10]	34
Figure 31 : Hardware Configuration in TIA portal.....	42
Figure 32: the PLC S7-1200 configuration	43
Figure 33: TIA Portal Preliminary Interface.....	43
Figure 34: Main OB1	45
Figure 35: TDS AC Select function.....	46
Figure 36: TDS flow chart.....	47
Figure 37: Blower function.....	49
Figure 38: flowchart blower	49
Figure 39: Oil System Function.....	50
Figure 40: Oil pump flowchart.	50
Figure 41: IBOP Control function	51
Figure 42: IBOP flowchart.	51
Figure 43: Torque Wrench function	52
Figure 44: Torque wrench flowchart	53
Figure 45: Link Tilt Function	54
Figure 46: Linkt tilt Flowchart	55
Figure 47: Brake dsc Function.....	56
Figure 48: brake flowchart.....	57
Figure 49: Torque and speed Command.....	61
Figure 50: Comparator flowchart	62
Figure 51: Spin mode torque command.....	63
Figure 52: Top ramp torque command.	64
Figure 53: torque information function	65
Figure 54: RPM indicator.	65
Figure 55: Linear scaling flowchart.....	66

Figure 56: Alarm Function.....	69
Figure 57: Horsepower limitation.....	70
Figure 58: Horsepower limitation flow chart.....	71
Figure 59: Main Graph Screen.....	72
Figure 60: Graph Screen.....	73
Figure 61: Alarm Screen.....	73
Figure 62: BRK&PH screen.....	74
Figure 63: Make-up recipes.....	74
Figure 64: VFD schematics diagram [20].....	75
Figure 65: V/F relation in VFD.....	75
Figure 66: SINAMICS CU240E-2 PN VFD.....	76
Figure 67: 1212 dc/dc/rly.....	78
Figure 68: Test bench lab image.....	79
Figure 69: Motor coupled generator test bench.....	79
Figure A.1: IBOP.....	84
Figure A.2: TDS 11/SA.....	84
Figure A.3: brake disc.....	84
Figure A.4: Current graph from HMI.....	85
Figure A.5: Torque/Speed Graphs.....	85
Figure A.6: Shot pin of Link Adapter.....	85

List of Tables:

Table 1: Activity statistic.....	5
Table 2: Number of active work hours.....	5
Table 3: The technical specification of TDS 11SA.....	22
Table 4: Verco Drilling console table.....	35
Table 5: Torque values for load carrying components.....	40
Table 6: Telegram used in the project.....	77
Table 7: the commissioning VFD parameters.....	78
Table 8: System tags.....	91
Table 9: HMI tags.....	92
Table 10: Receive vfd DB.....	93
Table 11: DB 16.....	94

Acronyms

- **TDS** Top drive system.
- **P** Pressure.
- **VFD** variable frequency Drive.
- **PLC** programmable logic controller.
- **HMI** Human machine interface.
- **HP** horsepower.
- **DB** Database.
- **T** Time.
- **V** Voltage.
- **I** Current.
- **Lbs-ft** pounds-feet.
- **RPM** Rotations Per Minute.
- **BHP** Bottom-Hole Pressure.
- **BHA** Bottom-Hole Assembly.
- **ROP** Rate Of Penetration.
- **WOB** Weight-On-Bit.
- **CBHP** Constant Bottom-Hole Pressure.
- **CFM** cubic feet meter.

Contents

Abstract	I
Dedication.....	II
Acknowledgement.....	IV
List of figures:	VI
List of Tables:	VII
Acronyms	VIII
Contents.....	IX
General Introduction	1
Chapter I: Drilling rig (Tp-232).....	2
Introduction	3
1. Presentation of the host company	3
1.1 Introduction:	3
1.2. History of the company:	3
1.3. Organizational structure:	4
1.4. ENTP activities:.....	5
1.5. Site Plan TP-232:.....	7
1.6. Tp-232 Rig Specifications:.....	9
2. Drilling Rig:	10
2.2 Rotating Component:.....	11
2.3 Mud circulation component:.....	12
2.4 Tubular handling Component:.....	13
2.5 Hoisting System:	14
2.6 Power generation:	15
2.7 BOP (Blow Out Preventive):.....	16
Conclusion:	17
Chapter II: Top DriveVarco TDS 11/SA	18
Introduction	19
1. Top drive:	19
2. VARCO TDS 11/SA Top drive:	20
3. Varco TDS 11SA features:.....	20
4. History of Varco TDS 11/SA:.....	21
4.1 Varco timeline development:	21
5. General Information:	22
Torque/Speed Curves:	22
6. TDS-11SA Major components:.....	23
6.1 Motor housing and swivel assembly:	23
6.2 Motor cooling system:	25
6.3 Carriage and guide beam:	26

6.4 PH-50 pipehandler:.....	27
6.5 Hydraulic control system:.....	30
6.6 Counterbalance system:.....	30
6.7 AC drilling motors and control system:	31
6.8 driller’s console:	33
7. Varco Console Control System:.....	34
8. Operating procedures:	38
8.1 Start-up procedure:	38
8.2 Rotating link adapter:	39
8.3 IBOP safety valves:	39
8.4 Torque backup clamp:	39
8.5 Link tilt:	39
8.6 Tool joint locks:.....	39
8.7 Torque values for load-carrying components:.....	39
Conclusion:	40
Chapter III: Programming and Supervision.	41
Introduction:	42
1. Hardware configuration:	42
2. Software configuration:.....	43
2.1 TIA PORTAL:.....	43
2.2 Program blocks:.....	44
2.3 Organization Blocks:	44
2.4 Function:.....	44
2.5 Function Block:	44
3. Programming:.....	44
3.1 Main [OB1]:	44
3.2 TDS AC Select:	45
3.3 Blowers Function:	47
3.4 Oil System Function:	49
3.5 IBOP Control:.....	50
3.6 Torque Wrench:.....	51
3.7 Link Tilt Control:	53
3.8 Brakes:.....	55
3.9 Torque and speed Command:.....	57
3.10 Torque Information :	64
3.12 RPM Indicator:	65
3.13 Alarm function :	65
3.14 Horsepower limitation function:.....	70
4. HMI DESIGN:	71
Main Screen:.....	72
4.1 The Graph screen:.....	73
4.2 The Alarm Screen:.....	73
4.3 BRK&PH:.....	74

4.4 Makeup Torque Recipes:.....	74
5. Variable Frequency Drive (VFD):	75
5.1 VFD Control Methods:.....	75
5.1.1 Scalar control methods:	75
5.1.2 Vector Control Method:	76
5.2 Siemens G120 variable frequency drive:	76
6. Industrial Communication protocol:	77
6.1 Profinet:	77
6.2 Telegram:.....	77
7. Experimental Implementation:	78
7.1 The G120VFD:	78
7.2 Schneider HMI:	78
7.3 The Siemens 1212 PLC:	78
7.4 The motor-coupled generator:	79
Conclusion:	80
General Conclusion	81
References:	82
Appendix A:	83
Documents and some pictures inside the Drilling rig.	83
Appendix B:	90
Tables of Tags and Variables (PLC, VFD).	90

General Introduction

In the Oil&gas industrial world, where competition is an essential factor in a company's survival, automation has become standard practice. Electronic components and their falling costs have led to new technologies that reduce the need for human labour and increase the accuracy of measurement and control systems.

This project seeks to design a program to automate the Varco Top Drive TDS 11SA within ENTP. Firstly, a study of the oil rig's drilling process and the TDS 11/SA functions is presented, next, a program that can manage top drive operations both manually and automatically is created. Then a developed Human Machine Interface (HMI) for an operator to control the Top Drive, which will be used for monitoring and supervising.

The work is divided into three chapters:

- ✓ The first chapter contains a representation of the host company ENTP, its Services, and activities then we give a general overview of the oil rig's main Component. The first chapter contains a representation of the host company ENTP, its Services, and activities then we give a general overview of the oil rig's main Component s, such as the deck and Drilling Units. We then describe the process of a typical drilling operation, including how the rig components work together for this purpose.
- ✓ In the second chapter, a comprehensive overview of the Top drive TDS 11/SA system is provided, including its components, features, and capabilities . In addition, the chapter describes how a Top drive TDS 11/SA system works and how it is used in various applications. Finally, an overview of the different models of TDS 11/SA systems that are available is provided; Also, comparison of the rotary table and the top drive system as well as, the different operation modes explained
- ✓ Finally, in the last chapter, the PLC code is shown, which is the automation of the TDS 11/SA, describing the specifications, going from the hardware configuration to programming with STEP 7 TIA Portal and the supervision with HMI. An experimental implementation is accomplished using the laboratory-provided material to validate the program functionality.

Chapter I: Drilling rig (Tp-232)

Drilling rig (Tp-232)

Introduction

In this chapter, firstly, we will present the host company ENTP, the main activities of ENTP, The history of ENTP and its shareholders, Secondly, the presentation of the drilling rig station and its main component for a general overview with technical specifications of TP-232.

1. Presentation of the host company

1.1 Introduction:

The National Well Works Company or as it is stated in French “L’Entreprise Nationale des Travaux aux Puits” by the abbreviation “ENTP” was created by decree no. 81/171 on 01/08/1981.

- The ENTP is defined as a joint-stock company held by two shareholders:
- Sonatrach Holding Petroleum Services: 51%.
- TRAVEN Investment Management Company: 49%.

ENTP works in the field of drilling and work-over. Its activity also extends to related services: oil maintenance, transport, and general well services. As the leading drilling contractor in Algeria, ENTP holds more than 50% of the market.

To ensure its development, the ENTP draws up an annual plan and a medium-term plan accompanied by a financial projection highlighting the financial needs compared to the available funds and/or the bank assistance to be requested.

Given the real possibilities offered by the Algerian capital market, ENTP intends to use the financial market and use existing instruments to finance part of its investment program.

As such, the ENTP has decided to raise funds by issuing a dinar bond, which is the subject of this information notice [1].

1.2. History of the company:

From 1968, Algerian drilling became an activity of SONATRACH, “Keskassa 1” was the first well drilled; the operational structure was called the “Petroleum Services Branch” (PSB) and had a fleet of four rigs.

- In July 1972: PSB takes the name of “Direction des Travaux Pétroliers” (DTP).
- 1 August 1981: Since the restructuring of SONATRACH in the early 1980s, ENTP emerged as the successor of the DTP for drilling and work-over activities. Created by decree No. 81-171, ENTP became operational on January 1, 1983.
- June 1989: Transformation of the legal status of ENTP into a joint-stock company, held by the «Holding Public Realization and Grand Travaux».
- March 1998: ENTP is part of the Sonatrach Hydrocarbon Services Group (GSH).

The shareholders are :

- Sonatrach : Holding SPP 51%.
- Energy Works Participation Management Company TRAVEN 49 [1].

1.3. Organizational structure:

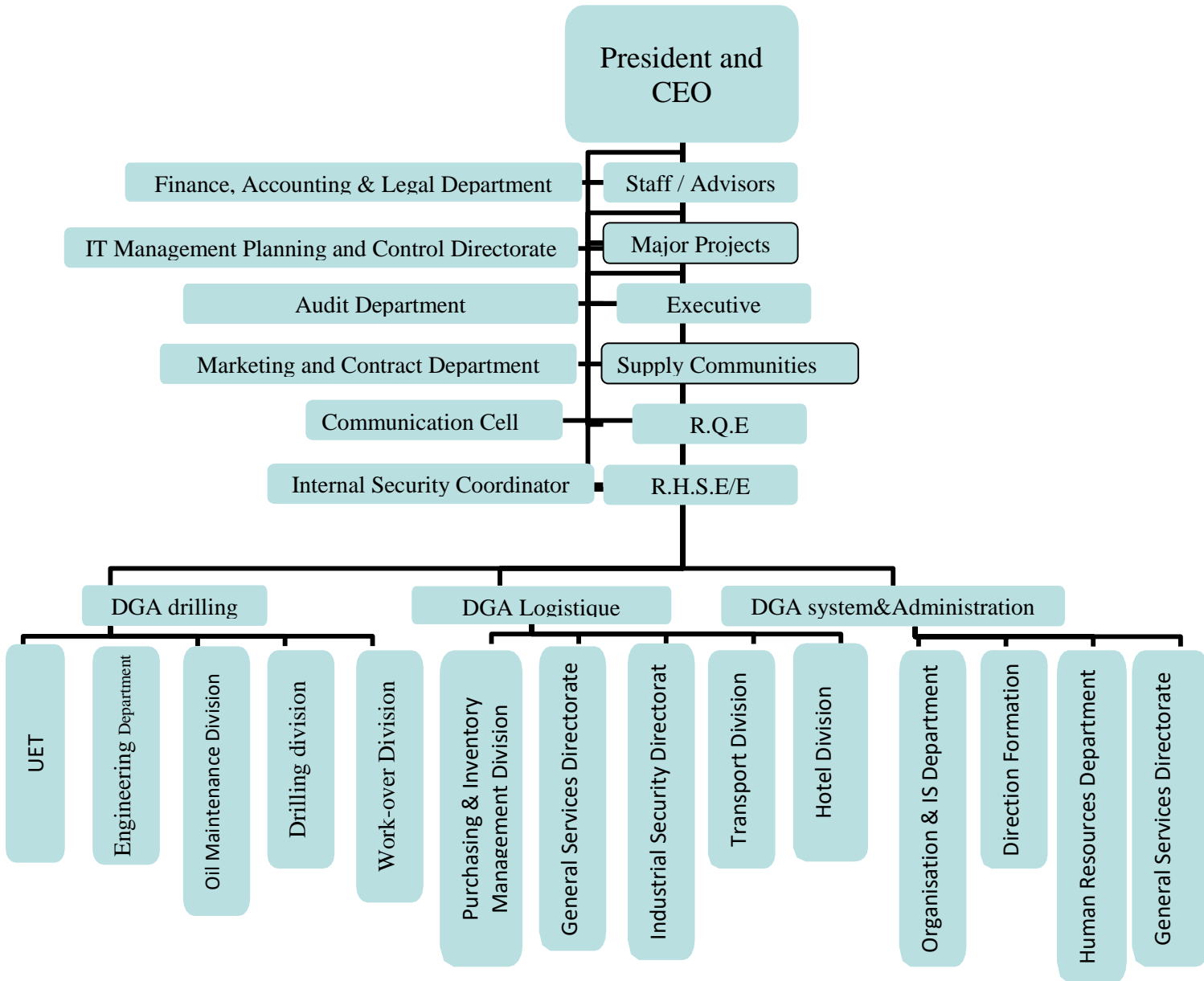


Figure 1 : Organizational structure [1]

1.4. ENTP activities:

A- Drilling and Work-Over:

Drilling and work-over activities (maintenance of oil, gas and water wells) generate more than 90% of the company's revenues. The Drilling and Work-Over divisions have as missions:

- Drilling of oil and gas wells, deep and medium depth, recovery and maintenance of wells, both exploration and development.
- Drilling deep water wells.

ENTP manages 38 devices with modern equipment such as:

- Silicon Controlled Rectifier (SCR).
- Top Driver.
- Wireless Network Communication [1].

Table 1: Activity statistic [1]

	Drilling	Work-Over	Hydraulic	Total
2001	49	135	-	184
2002	52	148	1	201
2003	67	137	-	204
2004	72	125	1	198

B- Oil maintenance activity:

This activity is carried out by the oil maintenance division, which is responsible for:

- Equipment and camp upgrades.
- Renovation of electrical and household appliances.
- Manufacturing and reconditioning spare parts, interventions on:
 - Well, prevention and safety.
 - Measurement and regulation.
 - Welding work on high-pressure pipes, mud or water circuits, and sections of the drill rig mast.

The Division has 14 workshops with modern equipment, located in Hassi-Messaoud, occupying a covered area of 9,750 m² and an uncovered area of 49,800 m², as well as four installation areas of the renovated drilling rigs [1].

The evolution of operating parameters in terms of the number of hours worked with labor and the number of machine hours in the years 2003 and 2004 is given in the table below:

Table 2: Number of active work hours [1]

	2003		2004	
	Labor hours Work	Machine hours	Labor hours Work	Machine hours
Maintenance of Drilling Equipment	38 109	8 448	33 895	5 260
Maintenance of Industrial Motors and Electricity	45 524	474	36 925	425
Maintenance of Special Equipment	40 979	4 353	39 708	5 020
Manufacture and boiler-making Welding	135 469	16 805	113 406	53 169
Renovation and maintenance of drilling camps	106 249	6 514	104 213	9 041
Total	366 330	36 594	328 147	72 915

C- The transport activity:

The transport division is assigned:

- The relocation of rigs and drilling camps.
- Delivery of equipment and consumables to drilling rigs.
- Maintenance of company vehicles and equipment.

The downtime of the transport fleet for 2004 increased by 16%, from 14,785 days in 2003 to 17,090 days. The immobilization rate increased from 28% in 2003 to 31% due to preventive maintenance. The transport fleet operated for 29,018 days in 2004, an increase of 15% compared to 2003. The utilization rate has increased from 48% of available time in 2003 to 52% in 2004. In terms of the number of DTM operations, the transport activity achieved a physical production of 206 DTM (74 DTM for drilling and 132 for Work-Over). Compared to the year 2003, the number of DTM decreased by 10 units [1].

D- Hotel activity and catering:

The hotel business provides accommodation and catering services:

- To drilling rig personnel.
- To personnel operating on fixed bases.
- Oil company personnel.

The average activity is 1,500,000 rations per year.

The Hotel Division has three living bases and about thirty drilling camps with a capacity of 4,140 beds. These storage capacities are 860 m³ in refrigeration and 590 m³ in dry, as well as capacity with a fleet of 32 refrigerated transport vehicles with a capacity of 1043 m³ [1].

E- Other activities:

ENTP also carries out other activities through its Engineering Department and its Tubular Equipment Unit (UET).

The Engineering department's mission is to:

- Revamping of drilling rigs (form improvement, remodeling).
- The technical assistance of the operating divisions in:
 - Technical specifications of drilling equipment.
 - Revamping procedures.
 - Technical studies for the acquisition of drilling rigs and equipment.
 - Provision of technical documentation and standards for design projects.

In terms of revamping, since the company was founded, the ENTP has refurbished and renovated 24 drilling rigs for 185,549,151 USD.

The tubular equipment unit (UET) has been ISO 9001/94 certified since June 2001 and ISO 9001/2000 certified.

Its services are as follows:

- Inspection of ENTP tubular equipment.
- Repair of drill lining components.
- Reloading the stabilizers.
- Non-destructive testing of joint-operation equipment with TUBOSCOPE-VECT for Sonatrach associates.

The UET is equipped with a fixed electromagnetic inspection unit (scanner) and two (02) mobile units acquired in 2003.

The UET has specialized workshops for:

- Manufacture of short products such as Short Drill Collars, Drill Stem Subs, Basket Subs, and Lift Subs based on API standard specifications.
- The soldering of the blades of tungsten carbide stabilizers.

UET is repairing a range of products: Drill Pipe, Drill Collar, Kelly Heavy Weight, Drill Stem Sub, Basket Sub, Stabilizer, Casing, and Tubing. The UET has a storage capacity of 40,000 m² [1].

F- Opportunities and Market Place:

Due to the large services provided by the company and the company is growing rapidly. ENTP is constantly looking for new ways to improve their services and offer more value to their customers; Thus, ENTP has many clients:

- 1- SONATRACH.
- 2- The partners of SONATRACH:
 - REPSOL YPF
 - BHP PETROLEUM
 - GULF OIL GULF KEYSTONE
 - CEPSA
 - ARCO
 - WESTERN OXY
 - Eni Group AGIP
 - HALIBURTON
 - SPERRY-SUN Drilling Services.
- 3- South Wilayas for hydraulic drilling.

The majority of ENTP's business comes from SONATRACH, which also holds the top spot among drilling contractors in Algeria with more than 50% of the market. The majority of its rivals in the market include ENAFOR (28 rigs), a different SONATRACH affiliate, as well as other businesses including NABORS (five rigs), SEDCO (three rigs), SAIPEM (two rigs), and PRIDE (two rigs) [1].

1.5. Site Plan TP-232:

The situation plan is not fixed; it can be changed with each new platform recognition.

- No. /DHSE/QHSE/2023.
- Rig Name: TP-232 (Figure 1.2).
- Client: SONATRACH.
- Oil Reservoir: HASSI MESSAOUD.
- Starting Date: 02/01/2023.
- Distance from HASSI MESSAOUD: 80 KM.



Figure 2: TP-232.

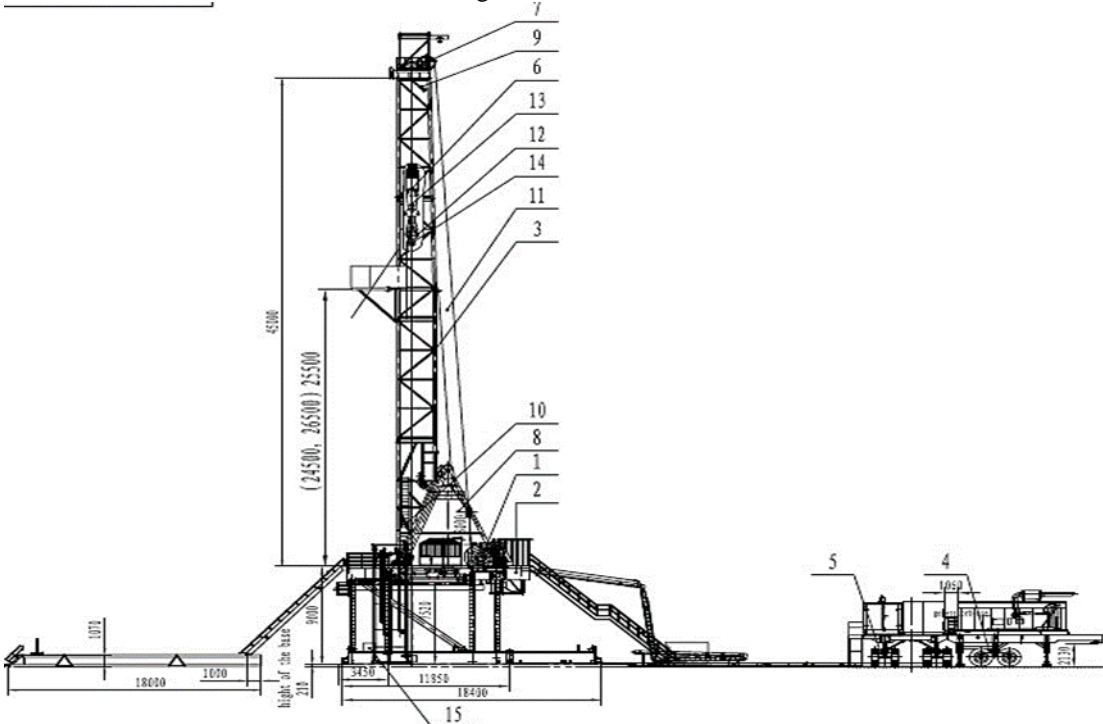


Figure. 3: Station Ground Plan TP232 [2].

1.6. Tp-232 Rig Specifications:

TP232 Station Equipment Specifications [3]:

MANUFACTURER: BOMCO
DATE OF CONSTRUCTION 2009

MAST:

Type: BOMCO JJ315/45-K13
Clear Height X Base Width (m-ft):
45 (148) X 9 (29.5)
Static Hook Load with 12lines (Lbs.-Short ton)
787,000 - 393

SUBSTRUCTURE:

Type Swing Lift: DZ315/9-S14
Height (m-ft.): 9 - 29.53
Rotary Load capacity (Lbs-short ton):
787,000 - 393
Rated setback capacity (Lbs-short ton):
500,000 - 250

DEAD LINE ANCHOR:

Make / Type: BOMCO / JZ400B.1.5 (1-3/8")
Rated load capacity (Lbs-short ton):
76,000 - 38

DRAWWORKS:

Make & Type: BOMCO JC50D
Horsepower Capacity (HP): 1500
Max line pull (KN-Lb.):340 - 76,435
Drilling line diameter (inch): 1-3/8"
Auxiliary brake TYPE DWS50D Eddy current
brake

CROWN & TRAVELING BLOCKS:

Make / Type: TC315-11 / YC 315
Crown Block load Capacity (Lbs.-Short ton):
787,000 - 393

MUD SYSTEM

PUMP Make & type: BOMCO, F-160
Horsepower Capacity (HP): F-1600L
Quantity: three

MUD TANKS:

Shaker tank Qty/ (bbl- m3): 440-70
Active Tanks Qty/ (bbl- m3): 352-56
Pill Tanks Qty/ (bbl- m3): 90-14.3
Reserve tanks Qty/ (bbl- m3): five / (452- 72)
Trip tank Qty/ (bbl- m3): 69-11
Trip tank linear capacity (l/cm): 30
Total Capacity (bbl- m3):3145-500.

SOLIDS CONTROL EQUIPMENT:

Shale Shaker

Make & Type: MI SWACO- Mongoose
Quantity & Capacity (m3/h-gpm)
3 / (136 - 600)

Desander

Make & Type DERRICK
Quantity & Capacity (m3/h-gpm)
ThreeX10" - (340-1500)
Mud Cleaner / Desilter
Make & Type DERRICK

Sheaves Quantity: 6+1
Travelling Block load Capacity:
(Lbs.-Short ton) 700,000 - 350
Hook load Capacity (Lbs-short ton):
700,000 - 350

ROTARY TABLE:

Make & Type BOMCO ZP-37
Maximum opening (inch) 37-1/2"
Maximum Static load (kN-Lbf):5850 - 1,315,000
Max table speed (RPM):300

TOP DRIVE SYSTEM:

Make & Type TDS NOV-11SA
API load Capacity (short ton - Lbs)
400 - 800,000
Power &Pressure Rating (HP-Psi) 700 / 7,500
Drilling Torque (N.m - Lbf. ft) 44,000 - 32,500

ROTARY SWIVEL

Make & Type NOV - P400
Rated capacity (short ton - Lbs) 400 - 800,000
Rated working Pressure (Psi) 5000

RIG POWER

SCR system makes BOMCO
Engine quantity, make & type
Four (04), CATERPILLAR-3512A
The generator Sets quantity & model
Four (04), CAT-6P6-1500
Total Continuous Power (HP) 5 736
The horsepower rating for each set (HP) 1 321
Generator frequency & voltage: 60HZ - 600 V

Quantity & Capacity (m3/h-gpm)
20X4" - (227-1000)

BOP EQUIPMENT

Make: Annular: NOV / Ram: W.O.M
ANNULAR :(20 3/4 - 3000 Psi) &
(13 5/8 - 5000 Psi)
DOUBLE RAM: 13 5/8 - 10,000 Psi
SINGLE RAM 13 5/8 - 10,000 P

2. Drilling Rig:

Workforce and hardware systems are the two main components needed for oil and natural gas drilling. A rotating drilling platform's purpose is to reduce the overall cost of drilling and finishing a usable hole. Figure 4 shows a schematic of a typical rig and its parts. The two types of rotary drilling rigs are onshore (land) and offshore (marine). Modern land rigs are built-in units or skid mounted so they can be transferred from one drilling site to another. Their primary design advantages are mobility, flexibility, and maximum depth of operation. Derrick or mast, power and prime movers, hoisting equipment, rotating components, circulation system, tubular and tubular handling equipment, and bit make up the majority of rotary drilling rig components.

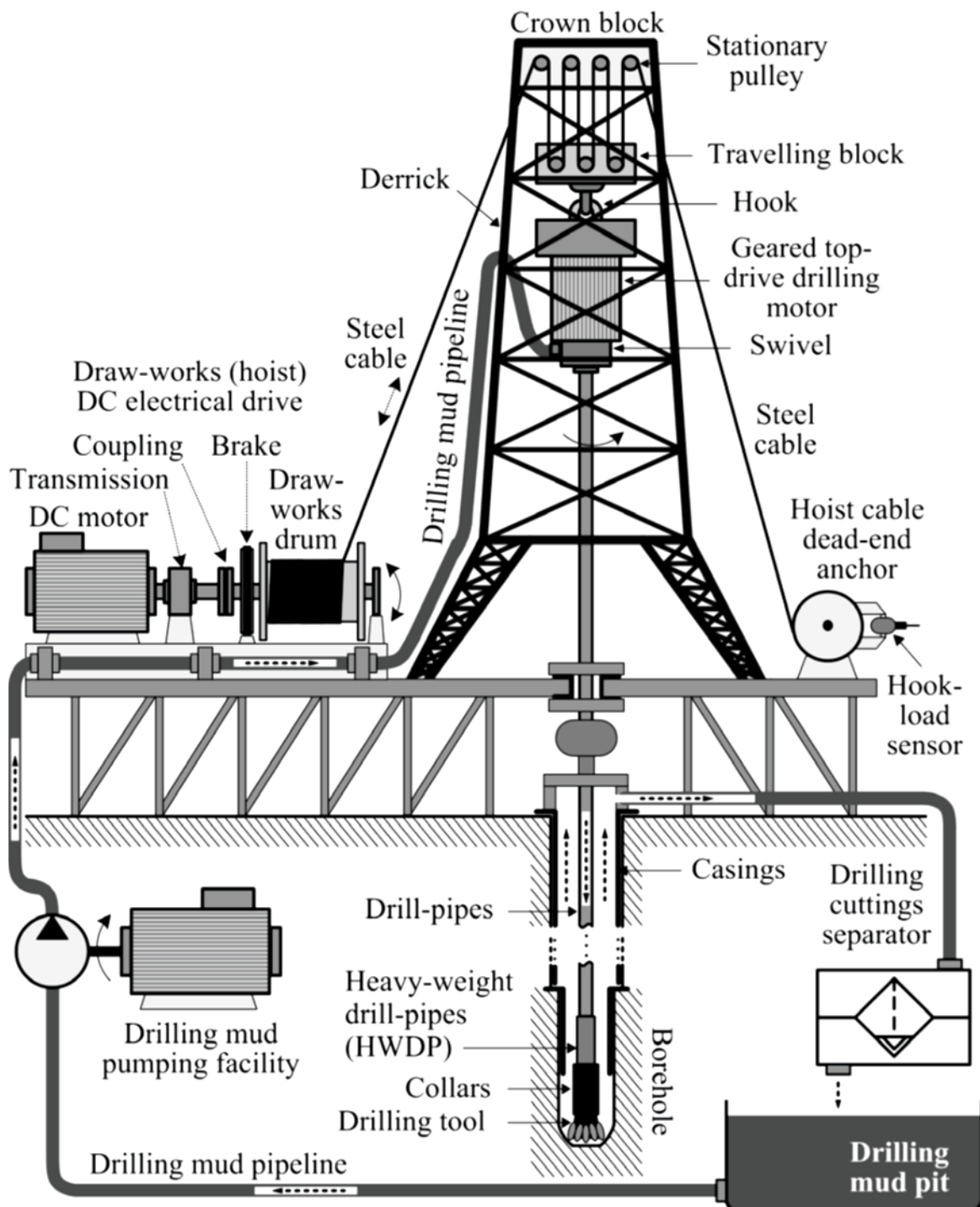


Figure 4: Schematic layout of petroleum drilling rig [19]

2.2 Rotating Component:

Is the piece of equipment that rotates the drill string. Swivel, Kelly spinner, Kelly or top drive, Kelly bushing, master bushing, and rotary table make up the rotating component (Figure 1-3).

2.2.1 Swivel:

Is a mechanical device that supports the weight of the drill string and allows it to freely revolve. It is suspended on the travelling block's hook. It offers a connector for the rotary hose and a channel for drilling fluid to flow into the drill stem.

2.2.2 Kelly spinner:

Is a tool that spins the Kelly to create tool joints when creating connections. It is placed below the swivel and is pneumatically operated.

2.2.3 Kelly:

Is the substantial steel square or hexagonal element linked to the top joint of the drill pipe and suspended from the swivel through the rotary table to spin the drill stem as the rotary table rotates. It features a hole in the centre that allows fluid to flow up the annulus and into the drill stem or the other way around. The rotary table drives the Kelly bushing through which the Kelly travels.

2.2.4 Top drive:

Is a AC-powered electrical motor that is mounted at the swivel position on the drilling rig. It facilitates digging a borehole by allowing the drill stem to rotate. The Tp-232 top drive is a power swivel that spins the drill string directly without the use of a rotary table or Kelly.

2.2.5 Kelly bushing:

Is a piece of equipment that inserts into the master bushing of a rotary table to transmit torque to the Kelly while simultaneously allowing vertical movement of the Kelly to drill a hole. The Kelly bushing is square or hexagonal, having slightly larger internal dimensions than outside dimensions, allowing the Kelly to move freely up and down within.

2.2.6 Master bushing:

Is a piece of equipment that mounts within a drilling rig's rotary table to accept the slips. In addition, drive the Kelly bushing, which drives the rotary table's circular motion onto the Kelly bushing.

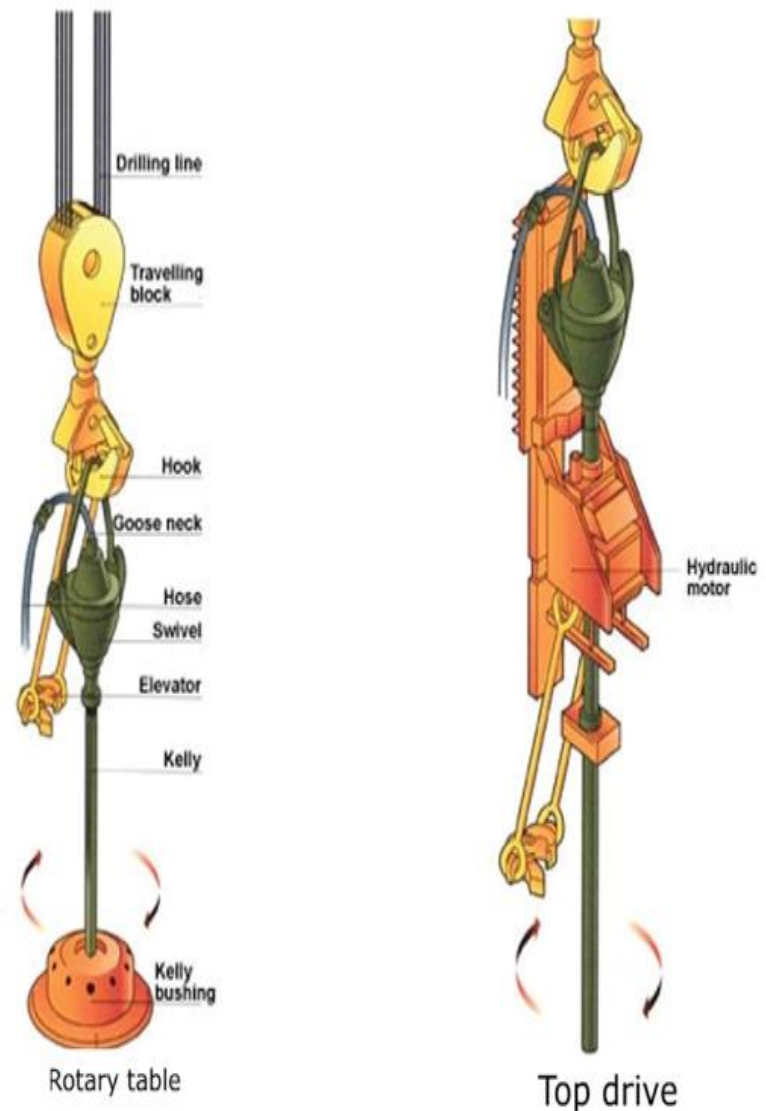


Figure 5: Rotating equipment of the drilling rig. [4]

2.2.7 Rotary table:

Is the section of the drill floor used to turn the drill stem. It has a bevelled gear arrangement to create the rotational motion and opening into which bushings are fitted to drive and support the drilling assembly. Tp-232 consists of a rotary table but it's used as a standby system in case of top driller failure.

2.3 Mud circulation component:

Drilling fluid flows from the centre of the drill bit and is driven up the exterior of the drill pipe between the drill string and the well walls (annular) onto the ground's surface, where it is cleaned and cycled back to the well. The cleaning procedure begins with the shale shaker, which is essentially a vibrating screen. The bigger particles will be removed because of this. Other solids removal equipment, such as desander and desilter, can be used to remove the finer particles. If the mud contains formation gas, it will be run through a degasser, which will remove the gas from the liquid mud.

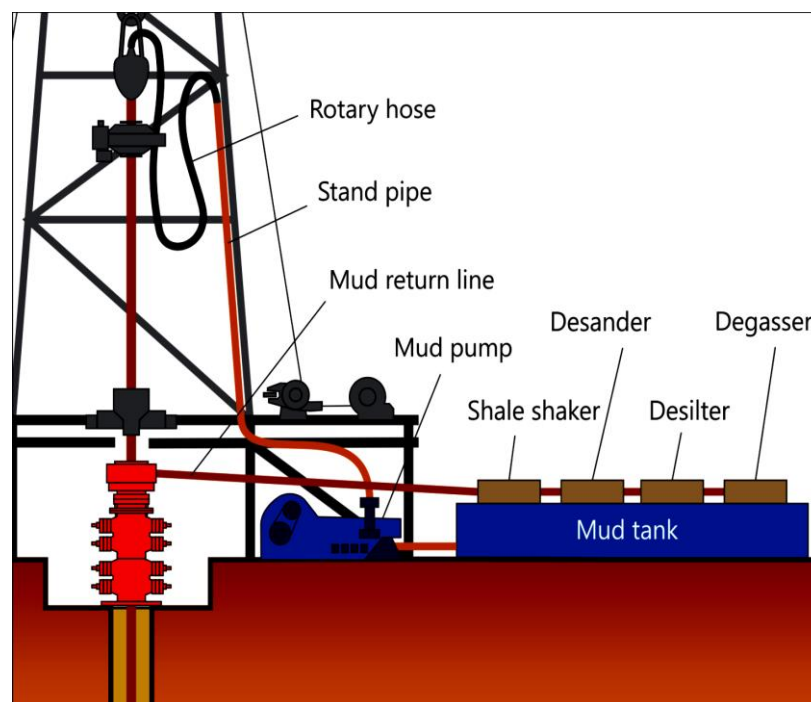


Figure 6: Circulation system of the drilling rig [4].

2.3.1 Mud pump:

On an oilrig BHA, a huge, high-pressure, high-volume pump is used to circulate drilling fluid down the drill pipe and out of the annulus. It could be a double-acting duplex (2-cylinder) pump with four pumping actions per pump cycle, or a single-acting triplex (3-cylinder) pump with three pumping actions per pump cycle, both of which have pistons or plungers that travel in replaceable liners and are driven by a crankshaft actuated by an engine or motor.

2.3.2 Mud tank:

Is an open-top steel container in which the consistency of drilling fluid and its level in the tanks is observed. It serves as a reservoir for drilling fluid.

2.3.3 Pump manifold:

Is a system of pipelines and valves that collects drilling fluid from mud pumps and transports it to the next circulation component. It is intended to manage, distribute, and monitor the flow of drilling fluid.

2.3.7 Shale shaker:

Is the principal solids-removing device that uses one or more vibrating screens to separate cuttings from the circulating fluid for reuse. While the mud pours on top of the screens, the cutting is removed.

2.3.4 Degasser:

Air, methane, hydrogen sulfide (H₂S), carbon dioxide (CO₂), and other gases are removed from drilling fluids and reused continually. It aids in lowering the risk of explosions and other hazards during the drilling procedure.

2.3.5 Desander:

Is a centrifugal device that removes sand-size particles from drilling fluid to prevent pump wear.

2.3.6 Desilter:

Is also a centrifugal device used to remove free silt particles from drilling fluid. When compared to a desander, its design combines a higher number of smaller cones, allowing it to remove particles with smaller diameters than a desander.

2.3.8 Mud return line:

Is the huge diameter metal or the drilling fluid tunnel when it exits the well.

2.4 Tubular handling

Component:

2.4.1 Drill pipe:

Is the longest section of the drill string and is heavy hot-rolled, pierced, and seamlessly tubed. It connects the surface equipment with the bottom hole assembly and the bit is used to rotate the bit and for drilling fluid circulation.

2.4.2 Drill collar:

Is a thick-walled, heavy, and large-diameter steel tube placed between the drill pipe and the bit in the drill stem to provide weight on a Bit WOB. It can be a cylindrical or spiral shape and is threaded at both ends (male and female) to allow multiple drill collars to be joined above the bit assembly.

2.4.3 Drill bits:

Are cutting tools used to create cylindrical holes. Bits are located at the bottom of the drill string and are suited for particular conditions, such as formation, which is to be drilled. The Three types of bit are:

- Roller cone bits.
- Fixed cutter bits.
- Hybrid bits.

2.4.4 stabilizer:

A drill string's bottom whole assembly (BHA) uses a drilling stabilizer as a piece of downhole machinery.

To prevent inadvertent sidetracking, and vibrations, and to guarantee the quality of the hole being drilled, it mechanically stabilizes the BHA in the borehole.

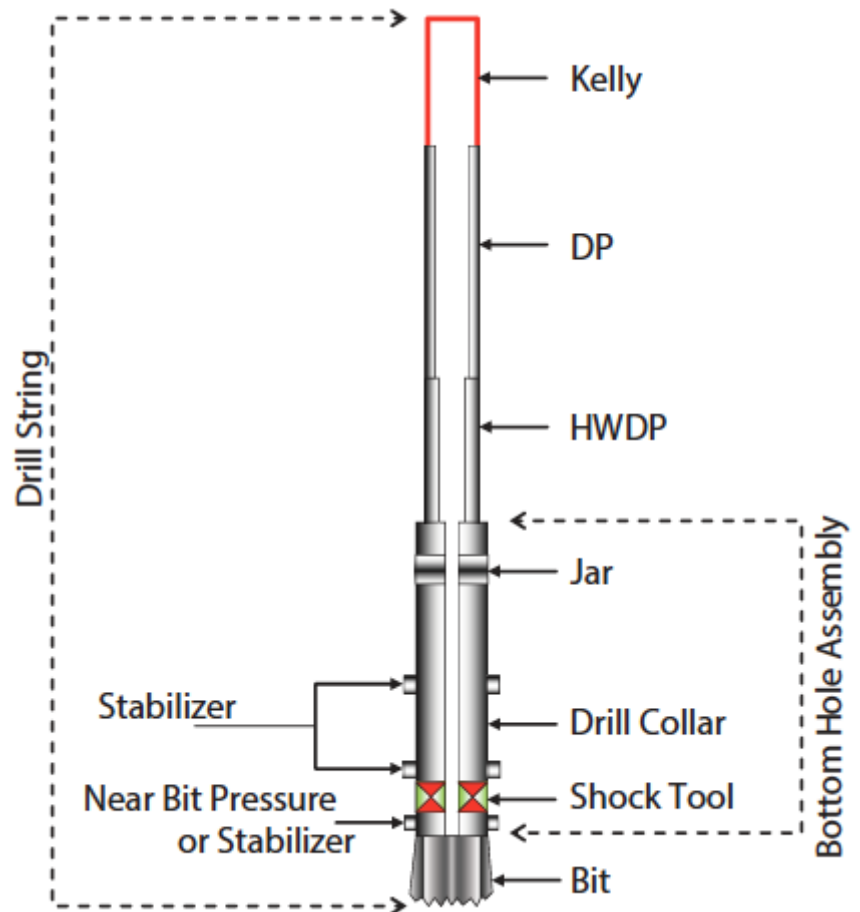


Figure 7: Tubular handling Schematics [16]

2.4.5 Jar:

A drilling jar is a piece of equipment that operates in the bottom-hole assembly to unstick a drill string that becomes stuck while drilling. It works like a hammer to deliver an impact to the stuck place by releasing strain energy from the drill string.

2.5 Hoisting System:

Which is used to perform all lifting activities on the rig and helps in lowering or raising equipment into or out of the well. It consists of:

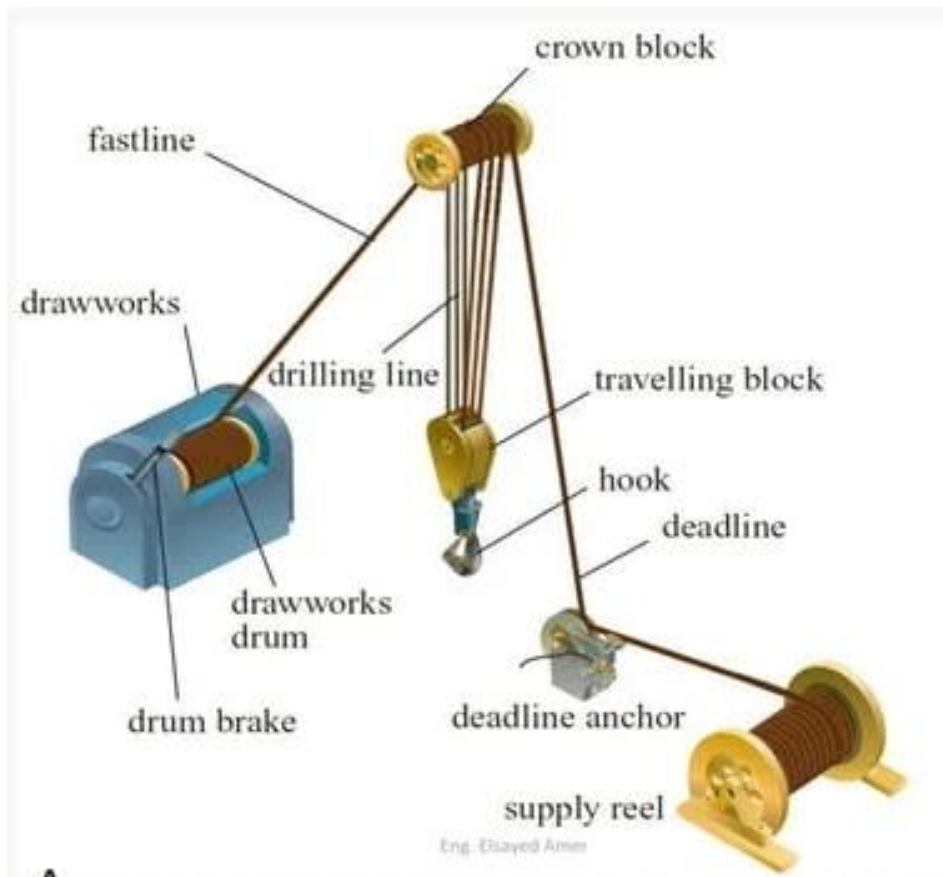


Figure 8: Schematic of Hoisting System [17]

2.5.1 Crown block:

Is a permanent assembly of sheaves (single or double) with a wire rope drilling line flowing between them, positioned at the top of the mast, through which the drilling line is threaded. It is used to reverse the pull directly from the drawworks to the moving block.

2.5.2 Traveling block and hook:

The combination is used in the well to safely and effectively hoist and lower tools and equipment. It is the set of sheaves or pulleys that threads or reeves the drill line (wire rope), is located opposite the crown block, and allows large loads to be lifted out of or lowered into the wellbore. The swivel and Kelly are picked up and secured using the hook, which is placed beneath the travelling block.

2.5.3 Supply reel:

Is a spool that stores the unused portion of the drill line

2.5.4 Deadline anchor:

It is frequently bolted to the substructure and is the device that holds down the wire rope's deadline. It offers weight measures as well as set deadlines [4].

2.5.5 Drill line:

Is the wire rope that holds the drilling instruments in place. It is threaded or reeved through the travelling block and crown block to allow the drill string to be lowered and lifted into and out of the borehole. The deadline anchor then secured the drill line to the rig floor.

2.5.5 Drawworks:

Is the main operating component of the hoisting system and is used to transmit power from prime movers to the hoisting drum that lifts drill string, casing, or tubing string out of and lowers it back into the borehole. They consist of a large-diameter steel spool, brakes, a power source, and assorted auxiliary devices. The primary function of Drawworks is to reel out and reel in the drill line, a large diameter wire rope, in a controlled manner. The speeds for hoisting the drill string could be changed by the driller via an integrated gear system.



Figure 9: Drawwork real image.

2.6 Power generation:

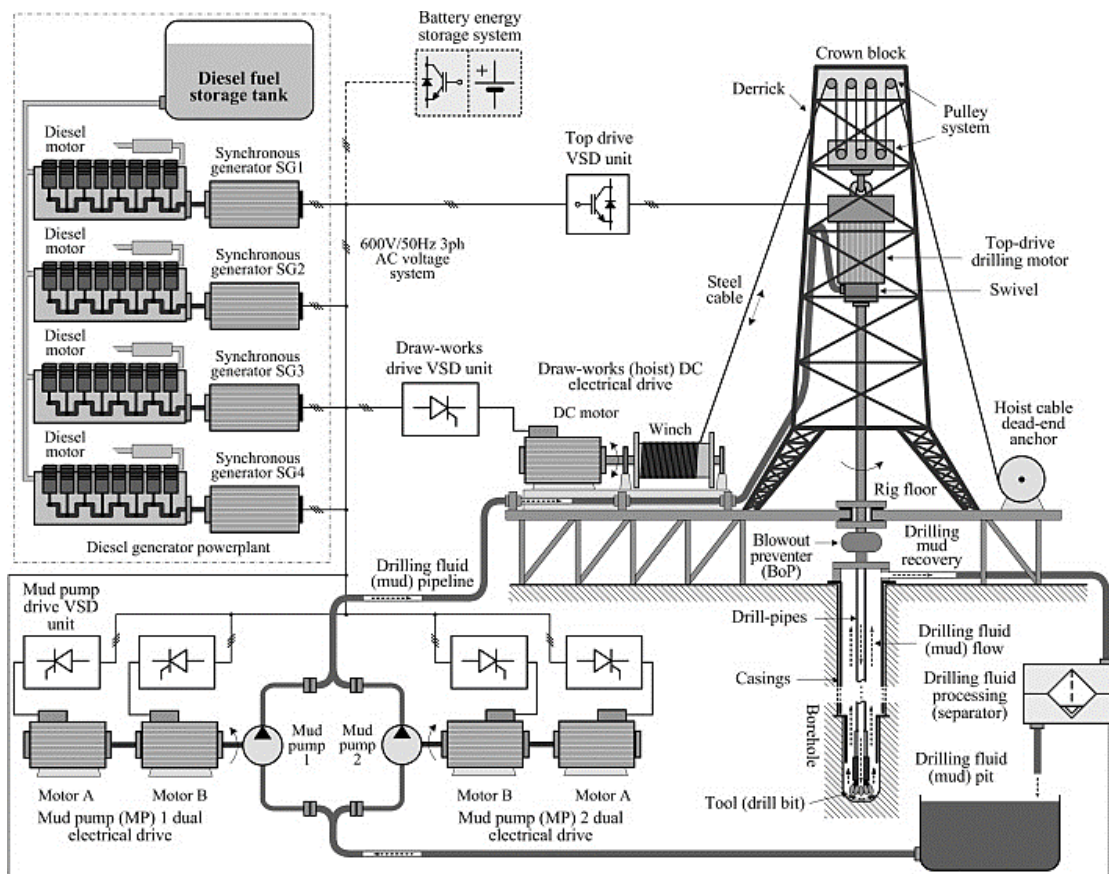


Figure 10: Power Disruption Diagram [18]

The particular land-based oil-drilling rig, depicted by the schematic representation in Fig. 10, is powered by a diesel engine-based synchronous generator power plant comprising four generator units. Individual generators intended for supplying the local 600V/60 Hz three-phase AC electrical microgrid are rated with apparent power $S_N = 875$ kVA and power factor $\cos\phi = 0.8$ (700 kW/525 kVAr nominal active and reactive power), and 1000 rpm rated speed. Numerous high-power loads, such as electrical drives powering dual drilling fluid (drilling mud) pumps, drilling hoist (draw-works) electrical drive, top-drive speed-controlled drilling motor, and drilling mud processing plant, characterize the drilling rig microgrid [5].

2.7 BOP (Blow Out Preventive):

As deep and ultra-deep oil wells account for the majority of oil wells discovered in our nation, their well pressure during the extraction of oil and natural gas is significantly higher than that of typical deep oil wells. Higher standards for well control technology and equipment are therefore proposed. The main well control mechanism is the BOP. The well may be immediately sealed off during drilling operations in the event of an emergency such as an overflow, kick, or blowout. Failure of the BOP will result in blowouts and other harmful incidents.

The BOP may be separated into a ram preventer, ring preventer, and rotary preventer according to the capping element's concept. At high load circumstances, the ram preventer offers strong well sealing and corrosion resistance, but it stops too many leaks and fails to close the well when a blowout has occurred. The annular preventer can seal the annular space between a string and the wellhead when there is a string in the well, but it is not long-lasting enough to be used in long-term shut-in situations. The annular preventer is designed to completely seal the well if the well is empty. Underbalanced drilling typically employs rotary BOP to deliver torque while capping the well.

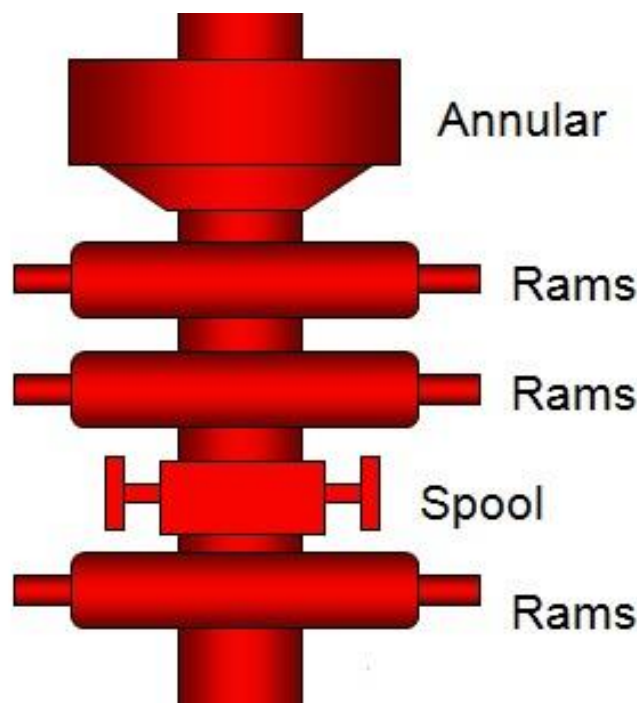


Figure 11: BOP schematic [15]

Conclusion:

In conclusion, this chapter has provided an overview of rig components and the role of ENTP as a leading provider of oilfield drilling and services. We have discussed the various types of rigs and their components, including the drill bit, drill string, and the various types of drilling systems like hoisting, Mud circulation that are used in the drilling process.

Therefore, by the end of this chapter, we are capable of digging deeper into our target topic, which is the top drive that will be presented in the next chapter in more detail to perform proper Automation and supervision for the Varco TDS.

Chapter II: Top Drive Varco TDS 11/SA

Top Drive Varco TDS 11/SA

Introduction

Currently, the oil and gas industry is receiving billions of dollars in investment, and many countries are devoting their intellectual resources to advancing technology. This presents a challenge of increasing the efficiency of capital investments. One way to address this challenge and improve the quality and profitability of oil and gas companies is to use drilling rigs equipped with a top drive system (TDS).

The TDS developed by Varco is suitable for use in wells with significant vertical deviation at the bottom, as well as those with deviation in the direction of drilling. These systems satisfy the market's requirements for reliability and power when dealing with high torque loads, reduce repair costs, and ensure a high level of safety. Additionally, they come with accessible and high-quality servicing.

1. Top drive:

As mentioned previously in the first chapter, a top drive is a big motor system, which is hoisted in a derrick or mast of a drilling rig. A top drive is a modern rotating system, which has been popular with many drilling contractors and oil operators. Top drives can be used on all types of rigs, from truck-mounted rigs to offshore rigs. The lifting device is integrated into the structure of the mast via a guide rail system and can be moved up and down by an electric motor of Drawwork. This is done using a control console, which controls all factors like Torque and speed. The Top Drive combines the functions of several other pieces of rig equipment in one tool, allowing the operator to perform a variety of tasks with fewer workers than would otherwise be necessary. The main functions of a Top Drive are rotating the drill string; allowing mud circulation through the pipe and different drilling operations. There are many types of Top drives like BENTEC, VARCO, TESCO, and CANRIG [6].



Figure 12:CanRig



Figure 13:BENTEC



Figure 14:TESCO

2. VARCO TDS 11/SA Top drive:

Varco Drilling Systems acknowledges the accelerating demand for increased productivity in land drilling operations and has responded to this growing market with the development of the innovative TDS-11SA Top Drive Drilling System.

Varco Engineering has made use of the recent advancements in AC technology by designing the TDS-11SA is to be powered by two AC drilling motors (either 400 or 350 hp each, depending on the configuration). These 800-hp and 700-hp systems produce 32,500 and 37,500 ft. lb. of drilling torque respectively. They can provide 47,000 and 55,000 ft. lb. of make-up/break-out torque respectively [7].

The TDS-11SA is compact enough to operate safely in a standard 142' mast while providing 500 tons of hoisting capacity. Its highly portable design allows for rig-up and rig-down in just a few hours. It easily integrates into existing rigs at minimal installation cost and minimal rig modification.

3. Varco TDS 11SA features:

The following TDS-11SA features describe how this drilling system will help you increase productivity and reduce the cost per well:

- AC motors have no brushes, brush gear, or commutator—reducing maintenance costs; Additionally, AC motors have no arcing devices.
- The TDS-11SA has an onboard hydraulics system that eliminates the need for a stand-alone.
- Hydraulic power unit and fluid service loop—further reducing accessory costs.
- The two AC motors, the Varco integrated swivel, and the new rig-up and rig-down.
- Techniques reduce downtime while providing the most compact and portable drilling.
- Package available on the market today.
- The two motors and the drive train provide a redundant power path, increasing the life expectancy of these components. This also reduces downtime and maintenance costs.
- The TDS-11SA features a hydraulic link tilt that can tilt the elevator to either side of the well centre.
- The TDS-11SA is specifically built for quick portability.
- The TDS-11SA uses helical gearing to reduce noise.
- A higher speed (2400 rpm max.) TDS-11SA is available [8].



Figure 15: Real Image of varco TDS 11SA

4. History of Varco TDS 11/SA:

Since the advent of rotary drilling in the early 1900s, drilling technology has made steady and, in some cases, spectacular progress. In a little over 100 years, well depths have gone from the 70-foot depth of Drake's well to over 40,000 feet at the rig on the Kola Peninsula east of Finland.

To accomplish this, advances were necessary for rig design, equipment, bits, materials, and drilling techniques.

In 1982, they introduced the industry's first top-drive drilling system. By replacing the traditional rotary drive and Kelly with an advanced system that rotates the drill string and handles entire 93-ft. stands of pipe, Varco was able to reduce drilling time by up to 25% while increasing the overall capability and efficiency of the drilling operation.

As a result, Varco Top Drive Drilling Systems have now become the new performance standard for the drilling industry [8].

4.1 Varco timeline development:

For years, the backbone of oil industry power has been the 1000 hp DC traction motor adapted from locomotives they are used extensively to power a variety of drilling operations.

DC traction motors are rugged, dependable, readily available sources of high-torque electric power. These characteristics made them the ideal choice for the conversion of drilling equipment from direct-drive diesel to electric power. In developing its TDS, Varco first turned to these DC motors to power its new technology. In addition, while they were appropriate for some applications, it became evident that smaller, more compact motors were needed for today's performance requirements. There was a need for an efficient, high-performance alternative to traditional DC systems. As part of Varco's ongoing development effort, various AC motors and drives were reviewed to satisfy the specific requirements of drilling applications. [10]

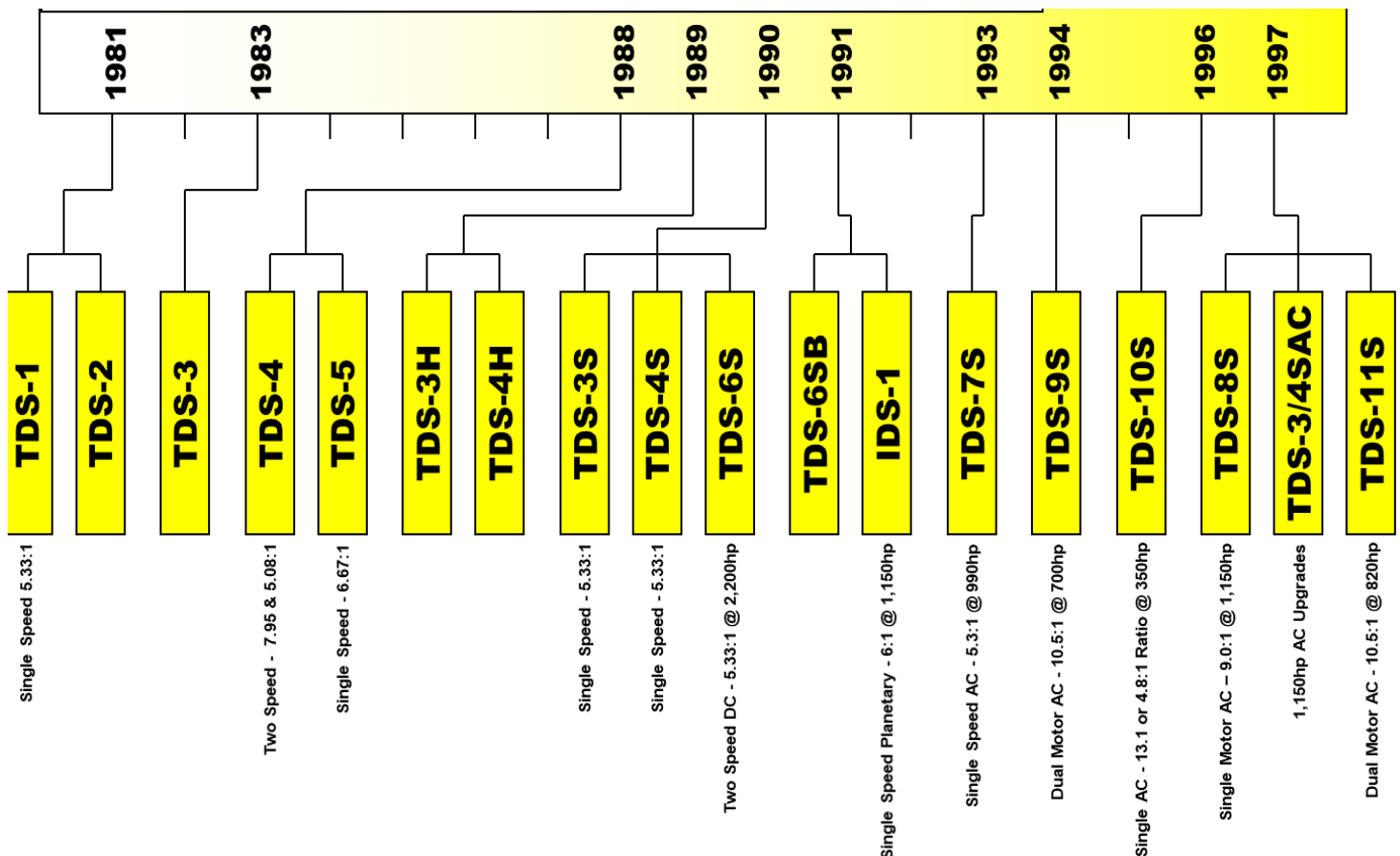


Figure 16: Varco Version Development

5. General Information:

The following table shows the technical specification of TDS 11SA [9].

Table 3: The technical specification of TDS 11SA

Drilling Motor Type	Baldor Reliance AC Induction Motors
Horsepower Rating	2 x 400 HP
TDS Working Height	19 ft (5,791 mm)
Weight	28,000 lb (12,700 kg)
Transmission	
Gear Ratio	10.5 :1
Lube	Force-fed, filtered, air-cooled
Drilling Parameters	
Maximum Speed	228 RPM
Maximum Continuous Torque	37,100 ft-lb (50,301 N-m)
The speed at Maximum Breakout Torque	110 RPM
Maximum Breakout Torque	65,000 ft-lb (88,128 N-m)
Maximum Makeup Torque	55,000 ft-lb (74,570 N-m)
Static Lock Brake	39,000 ft-lb (52,877 N-m)
Rating Capacities	
Hoisting and Rotating	500 tons (453,592 kg)
Water Course	3 in (76.2 mm)
Washpipe Packing	7,500 psi (517 bar)
Pipe Handler	PH-75
Torque Capacity	75,000 ft-lb (101,686 N-m)
Connection OD	4 in – 8½ in (101.6 mm – 215.9 mm)
IBOP Pressure Rating	15,000 psi (1,034 bar)
Upper IBOP	6½ in API Reg. RH Box (remotely operated)
Lower IBOP	6½ in API Reg. RH Pin/Box (manual)
Rotation/Orientation	360°/Unlimited
Other	
Cooling System	Local Blower
Hydraulic Power	Onboard
Temperature Range	-40°C to +55°C (-40°F to +131°F)*
Casing Running Tool Ready	Optional
Elevator Links	250, 350 and 500 ton API
Footprint	65.2 in x 56.1 in (1,656 mm x 1,425 mm)

Torque/Speed Curves:

One of the best curves that give a clear insight into the performance of the TDS is the Torque/Speed Curves which may be used as a good comparison means between the TDS systems to know the appropriate one fitted the task. As shown in the graph, the torque and speed relationship is inversely proportional since the rated output power of a motor is a fixed value.

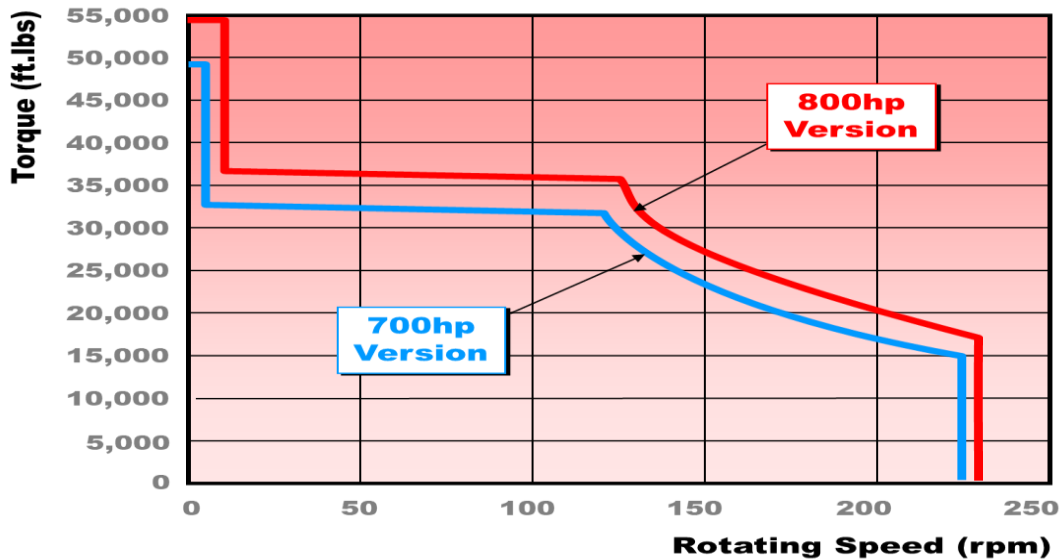


Figure 17: Torque Speed curve

6. TDS-11SA Major components:

The TDS-11SA drilling system includes the following main assemblies and subassemblies:

- Motor housing and swivel assembly. [10]
- Motor cooling system.
- Carriage and guide beam.
- PH-50 pipehandler.
- Hydraulic control system.
- Counterbalance system.
- AC drilling motors and control system.

6.1 Motor housing and swivel assembly:

The power generated by AC drilling motors is transferred to the drill string via the transmission/motor housing and swivel assembly. A single-speed double-reduction spur gear arrangement offers a 10.5:1 ratio from the motors to the main shaft within the transmission/motor housing main body.

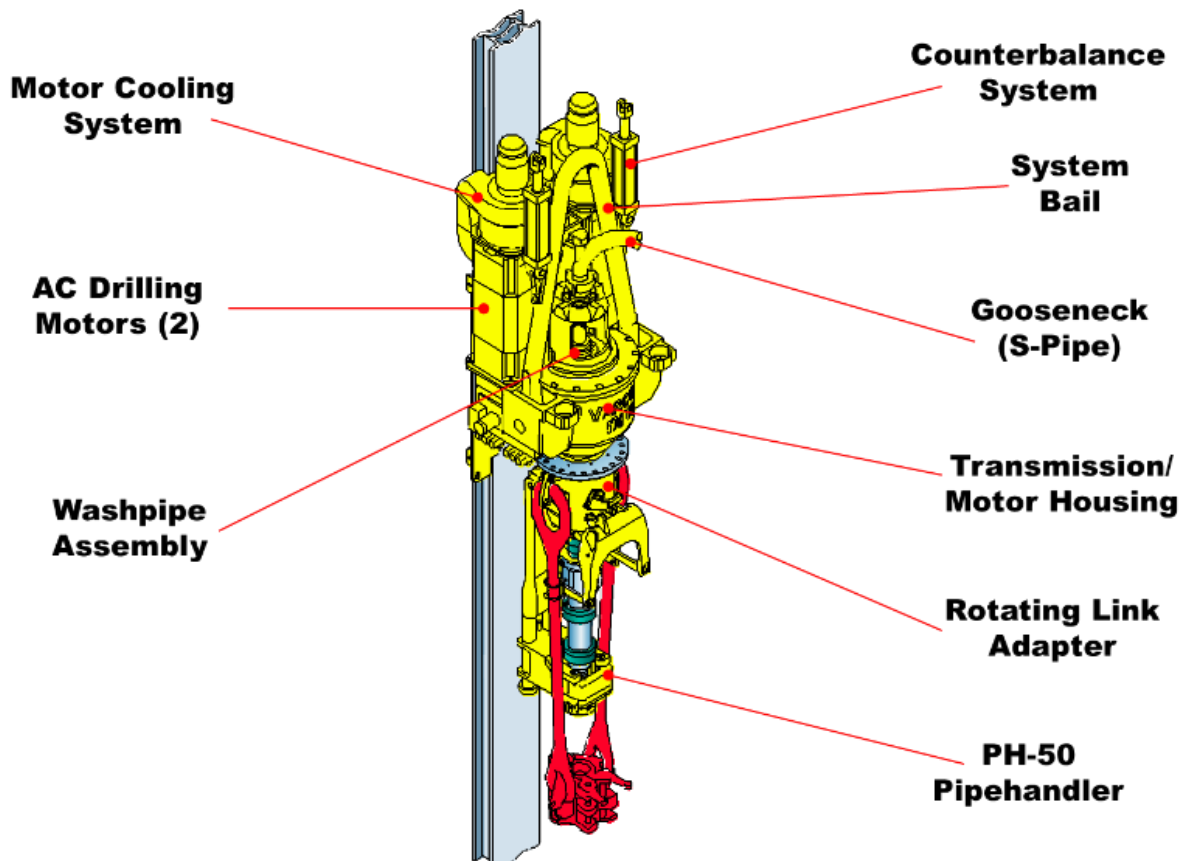


Figure 18: TDS 11SA main component

The primary thrust bearing, which is positioned inside the motor housing, supports drilling loads, while the loaded stem, which bypasses the thrust bearing and supports the spinning link adapter and pipe handler, supports tripping loads. The motor housing's main body serves as a sealed oil lubrication reservoir for the transmission gears and bearings. An oil pump built into the main body forces oil into the bearings and gears. A low-speed hydraulic motor powers the oil pump. The filtered lubricating oil runs continuously through the main thrust bearing, take-up bearing, lower radial and compound gear bearings, and gear meshes. Between the main shaft/swivel stem and the S-pipe, weldment is an industry-standard wash pipe packing box assembly. The bonnet provides support for the S-pipe weldment. To attach to typical rotary drilling hooks, the forged alloy steel bail swings forward. The bail is equipped with grease-lubricated bronze bushings. This assembly is comprised of the following subassemblies [10]:

6.1.1 Transmission and swivel housing:

The assembly consists of the following components:

- Bonnet.
- Main body and transmission housing.
- 2 Motor pinions–34T.
- 2 Compound gears–63T/18T.
- Bull gear–102T

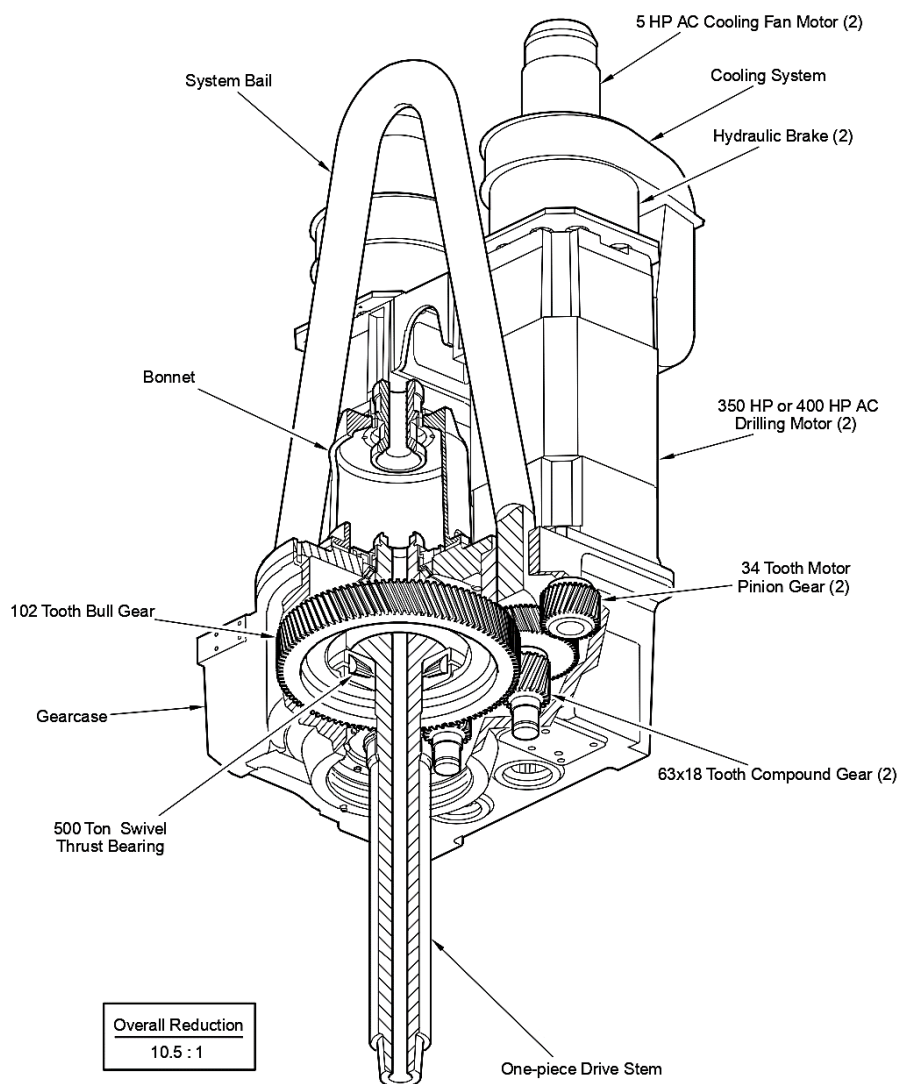


Figure 19: TDS power train cutaway.

- Main shaft
- Integrated swivel assembly
- Lubrication system

The single-speed helical gear gearbox with double reduction provides the 10.5:1 ratio from the motors to the main shaft. The transmission, main thrust, and radial bearings are housed in the main body and gearcase cover. The gearcase cover protects the upper take-up bearing and holds the AC motors and bonnet in place. The bull gear is attached to the main shaft's load shoulder. The gears and bearings are all lubricated by a pressurized system built into the main body and cover.

6.1.2 Integrated swivel assembly:

The transmission housing and main body serve as a sealed oil lubrication reservoir for the gears and bearings. An oil pump built into the housing and operated by a hydraulic motor feeds the bearings and gears. The filtered lubricating fluid runs continuously through the main thrust bearing, upper taper bearing, lower radial and compound gear bearings, and gear meshes.

The drill string may be rotated thanks to an industry-standard washpipe packing assembly situated between the main shaft and gooseneck. The assembly is supported by the bonnet, which is attached to the gearcase and provides lateral support.

Bail pins secure a forged alloy steel swivel bail to the main body. To attach to normal drilling hooks, it swings forward. The bail is held in place by grease-lubricated bronze bushings. For wireline packing assemblies, an extra length is supplied to allow for operator clearance between the gooseneck and hook.

6.1.3 Drilling motors and brakes:

Two 400-hp or two 350-hp AC drilling motors power the TDS-11SA. To eliminate shimming or particular alignment during motor installation, the motors are mounted vertically side by side on top of the transmission gearcase cover with a modified face.

Each motor features a double-ended shaft with a drive pinion on the bottom and a disc brake rotor on the top. Two hydraulic calliper disc brakes are mounted on the top end of each motor and may be readily inspected and maintained through the access covers around the brake covers. When undertaking directed operations, the calliper disc brakes also aid in drill string alignment. They are controlled remotely from the driller's panel.

6.2 Motor cooling system:

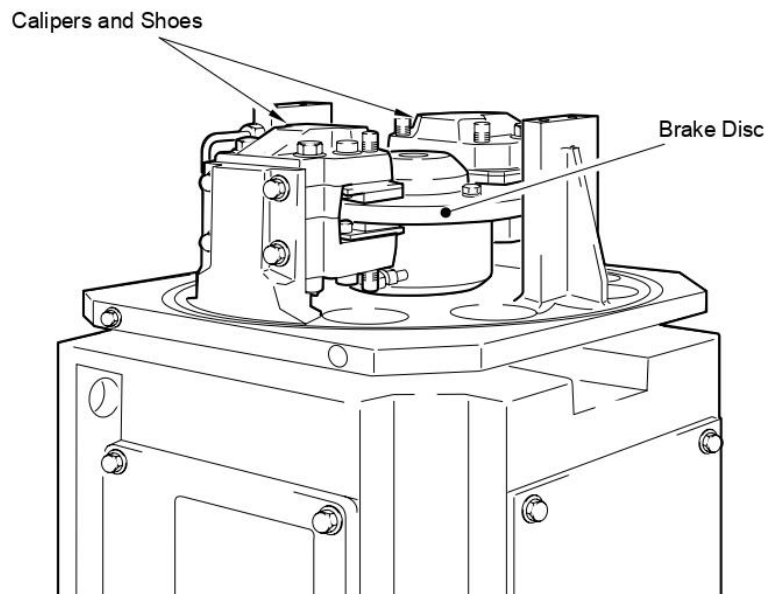


Figure 10: Hydraulic brake system [10]

The TDS-11SA's motor cooling system is a local intake centrifugal blower with two 5 hp AC motors installed on top of each AC drilling motor. The mechanism takes air over the brake and distributes it to an aperture at the top of each motor through stiff ducting. The cooling air then enters the open-frame type AC drilling motors and leaves via the louvred hole towards the bottom of the motors. This tough, uncomplicated design offers dependable service with good airflow [10].

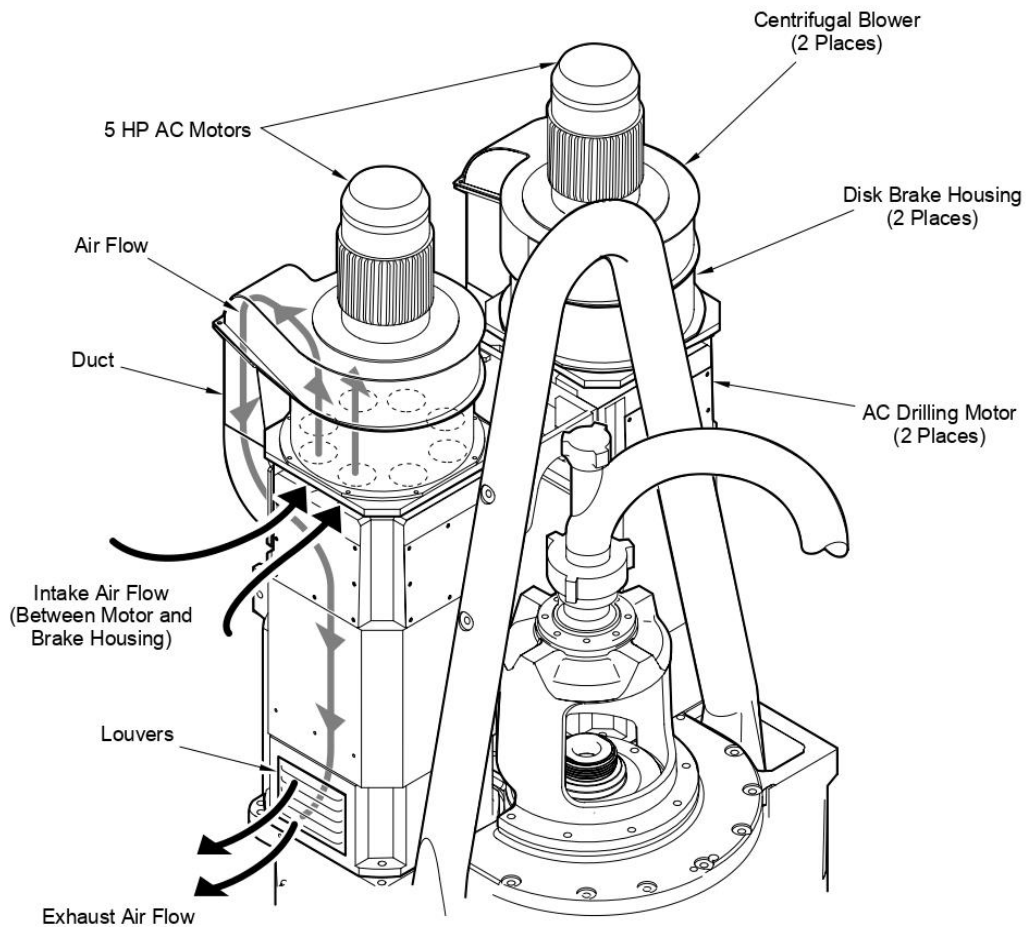


Figure 11: Cooling system [10]

6.3 Carriage and guide beam:

The TDS-11SA drilling equipment moves on a hanging guide beam through a carriage linked to the gearcase. The guide beam hangs from the crown and reaches within seven feet of the drill floor. There, it connects to a torque response beam installed across the bottom portion of the mast or derrick. The drilling torque is responded through the carriage and into the guide beam. The guide beam is available in 18' pieces (132 lb/ft) and hangs from a pad eye at the summit. To aid installation, the guide beam parts are fastened together such that they hinge. You may assemble them one component at a time on the drill floor while lifting the guide beam to the crown attachment [10].

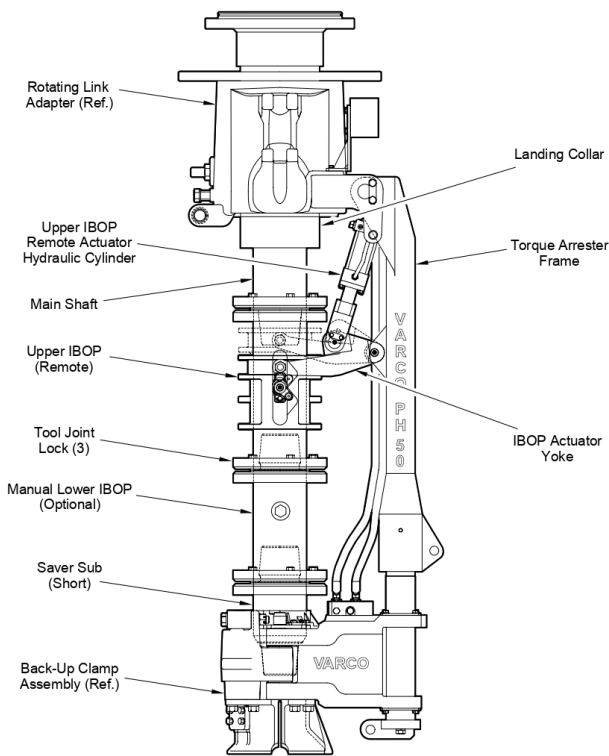


Figure 22: Drill stem Assembly

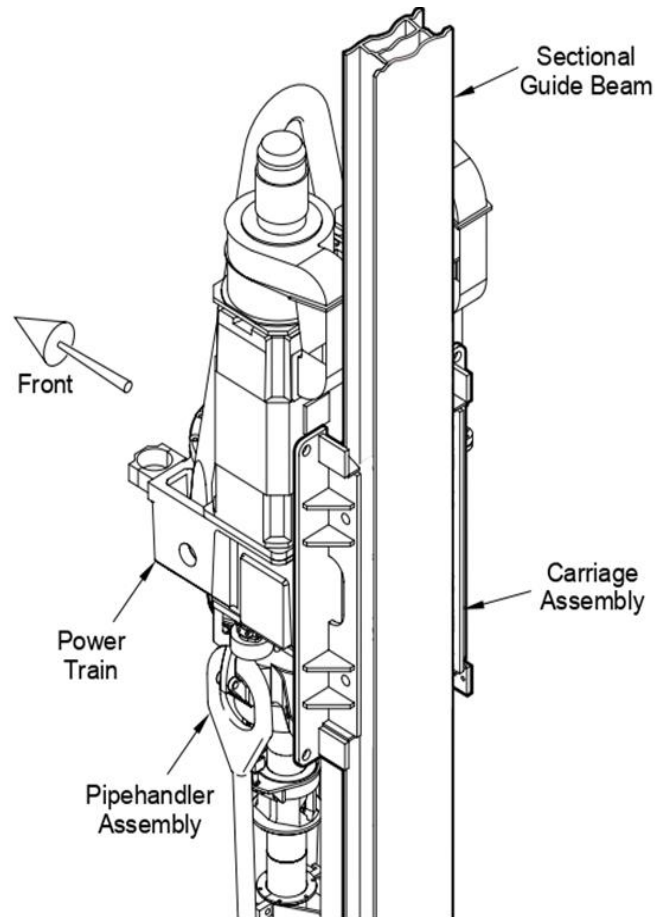


Figure 123: carriage assembly

6.4 PH-50 pipehandler:

The PH-50 pipehandler consists of the following major components [10]:

6.4.1 Powered rotating head/link adapter:

The powered rotating head/rotating link adapter keeps the hydraulic lines connected as the pipehandler spins with the drill stem components while tripping out or adjusting the link tilt.

The motorized rotating head/link adapter is rotated in either direction by a hydraulic drive motor.

An electronic solenoid valve linked to a switch on the driller's console controls the hydraulic motor. A pinion gear on the hydraulic drive motor rotates the positioning gear attached to the top of the rotating link adapter. By choosing, the pipehandler clamp mode and activating a hydraulically driven shot pin during make or brake operations, the spinning link adapter may be secured into any of 24 index locations. When the hydraulic drive motor is turned off.

The torque arrestor frame and the link tilt cylinders are suspended from the spinning link adapter.

The stem support is connected to the link adapter. Internal hydraulic fluid passageways in the stem are connected to the rotating link adapter's fluid passages. The top-end radial channels feed fluid from the main manifold into the stem. This fluid is directed from the stem through its grooves to the link adapter and then to all of the pipe handler's actuators.

Fluid flows between the two components when spinning or in any fixed state.

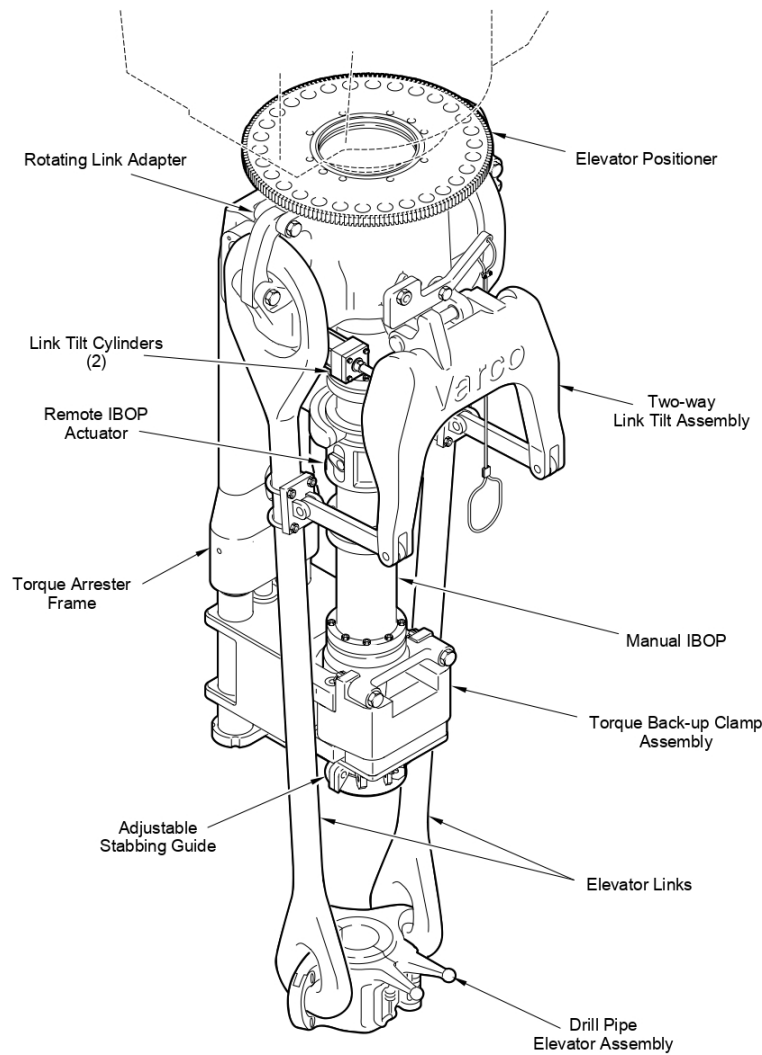


Figure 24: Pipehandler with torque backup clamp [10]

6.4.2 Bidirectional link tilt:

Two hydraulic cylinders and clamp assemblies make up the link tilt assembly. The link tilt assembly is clamped to 350-ton elevator links that are 108 inches long. The cylinder assembly's clasp restricts the elevator's movement to the adjustable derrick man position. Pulling a cable to release the clasp allows the elevator to go to the mousehole or overdrill position.

The link tilt is controlled by a three-position switch on the driller's console. The TILT setting directs the linkages to the mousehole or derrickman. The DRILL setting tilts the link back to clear the drill pipe and raises the elevator to allow drilling to the floor. The link is held in any intermediate position by the spring-centred position. A separate float switch is employed to allow the links to dangle freely. The linkages can be halted at any point in between. When the FLOAT position button on the driller's console is pressed, the links float back to the well centre.

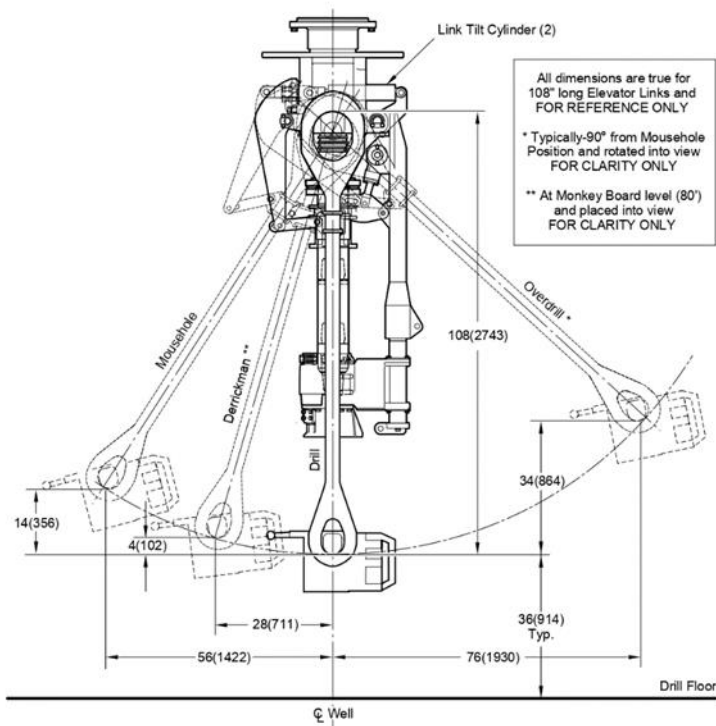


Figure 25: Bidirectional link Tilt

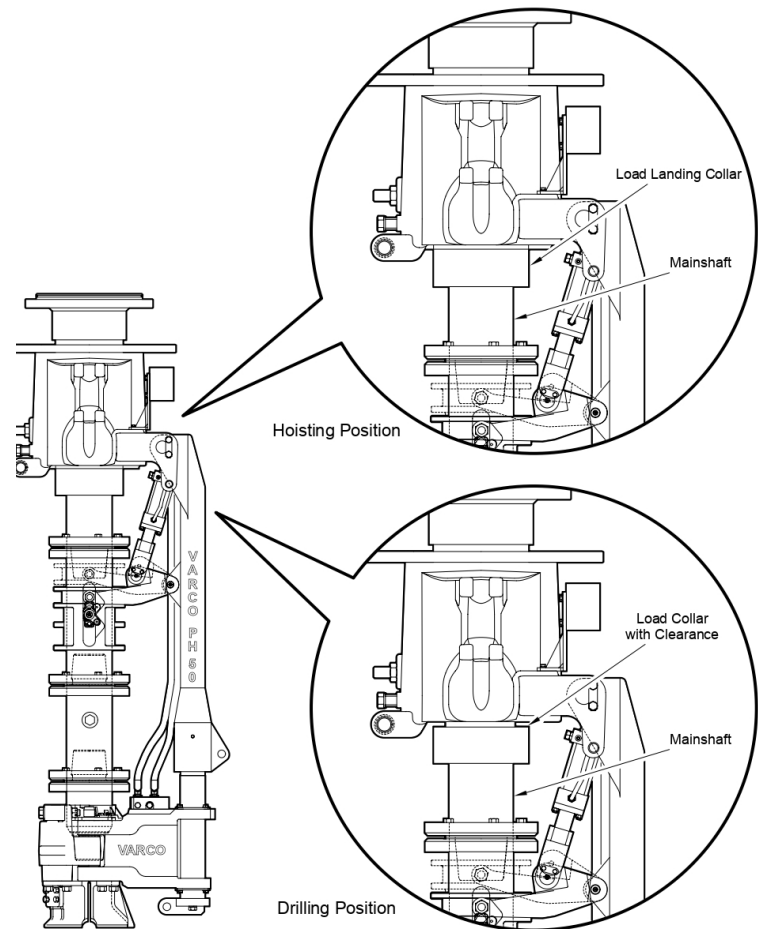


Figure 26: Load Collar

6.4.3 Loading collar:

Elevator hoisting loads are transferred from the elevator links through the elevator into the load Collar, mounted on the main shaft (figure 26)

6.4.4 Remote upper IBOP actuator:

The two ball-type IBOP valves are internal opening safety valves that are full-size. The well control system is comprised of the remotely operated upper valve and the manually operated bottom valve. Both valves feature 6-5/8" normal R. H. connections and pressure ratings of 15,000 psi.

The top IBOP valve is OPEN and a two-position switch on the driller's console controls CLOSE functions. When the switch is pressed, a hydraulic cylinder connected to the torque arrestor slides an actuator shell up and down through a non-rotating lever arrangement. This lever system operates the top IBOP valve by driving a tiny crank arm on each side of the valve.

6.4.5 Torque backup clamp:

The backup clamp assembly is placed beneath the saver sub's lower shoulder. When linked to the saver sub, it has two grasping jaws with die inserts and a clamping cylinder for grabbing the box end of the drill string. A torque arrestor frame suspended from the spinning link adapter supports the torque backup clamp cylinder. It is attached to the torque arrestor frame and may float up and down to allow for thread engagement/disengagement and reactive backup torque when forming and breaking connections.

6.5 Hydraulic control system:

The hydraulic control system is completely self-contained (onboard) and supplies all hydraulic power. It eliminates the need for an additional service loop. The system consists of reliable, industry-standard components that operate the following assemblies [10]:

- Counterbalance system.
- AC motor brakes.
- Lubrication system.
- Powered rotating head.
- Remotely actuated IBOP.
- Torque backup clamp.
- Link tilt.

A 10 hp, 1800-rpm AC motor direct linked to two hydraulic pumps powers the hydraulic control system. A fixed displacement pump powers the lubricating oil system, whereas all other functions are powered by a variable displacement pump.

All solenoid, pressure, and flow control valves are housed in an integrated hydraulic manifold that is mounted to the main body.

The hydraulic oil is supplied by a "sealed" stainless steel reservoir. This avoids the requirement for rig movements to be drained and refilled. Strainers and oil level sight gauges are installed in the reservoir, which is positioned between the two AC drilling motors.

Hydro-pneumatic accumulators control all the IBOP, pressure control valves, and balancing systems.

6.6 Counterbalance system:

The balancing mechanism protects tool joint threads while connecting or disconnecting the TDS-11SA. It takes the place of the hook compensator spring.

Two hydraulic cylinders with connection hardware, a hydraulic accumulator, and a hydraulic manifold comprise the system. The hydraulic cylinders are situated between the hook's ears and the incorporated swivel bail. They are linked to a hydraulic accumulator. The counterbalance circuit in the main hydraulic control system manifold charges the accumulator with hydraulic fluid and maintains it at a predefined pressure level. To help in rig-up and rig-down operations, a remote valve on the driller's console allows the counterbalance cylinders to extend and retract [10].

6.6.1 Stand jump Option:

STAND JUMP is a new function created by Varco for the TDS-11SA. It comprises a switch on the driller's console that allows you to change the mode of operation of the counterbalance cylinders from DRILL to STAND JUMP, which is a normal counterbalance condition. The STAND JUMP function enables the cylinders to raise the top drive's weight off the drill string while breaking off a connection. This reduces tension on the threads and prevents damage. The cylinders push the swivel bail away from its resting place on the hook.

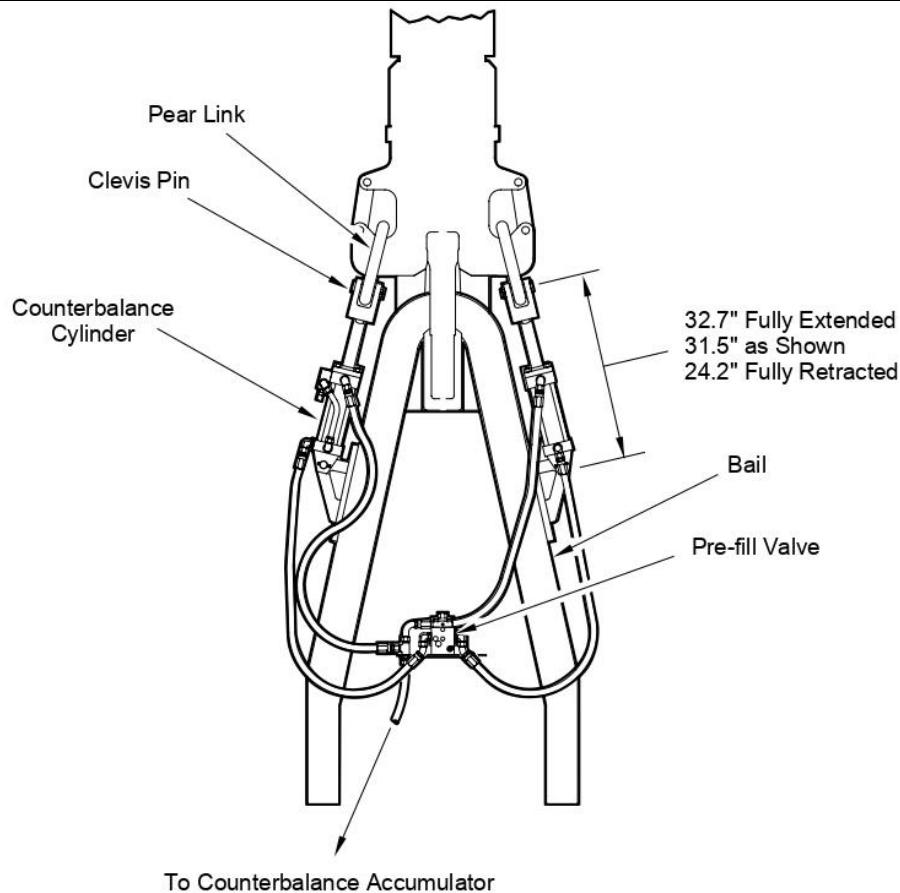


Figure 27: Stand jump option [10]

6.7 AC drilling motors and control system:

Two 400-hp or 350-hp AC motors power the TDS-11SA. They are mounted on top of the gearcase, reducing the distance between the well centerline and the back of the guiding beam.

Varco chose AC drilling motors for the TDS-11SA because they offer the following advantages [10]:

- Reliability.
- Low maintenance.
- Nonpolluting.
- Wide operational range.
- May be stalled indefinitely at full torque.
- 150% overload capability for up to one minute.
- Non-sparking.

The TDS-11SA is powered by 600 VAC, 3-phase AC motors. The input frequency ranges from 0 to 80 Hz. 1100 CFM of cooling air is required for each motor.

Each motor is rated at 400 hp or 350 hp and has a maximum continuous output torque of 1,800 ft-lb or 1,550 ft-lb. From 0 to 1200 motor rpm, the maximum continuous torque is available, with continuous 400 hp or 350 hp available from 1200 motor rpm up to the maximum rated motor speed of 2400 rpm.

The combination of two 400 hp AC motors (800 hp total) and the 10.5:1 gear ratio produces 37,500 ft-lb of torque at drill speeds ranging from 0 to 114 rpm.

At a maximum drill speed of 228 rpm, the 800 output horsepower delivers 18,250 ft-lb of torque.

The combination of two 350 hp AC motors (700 hp total) and the 10.5:1 gear ratio produces 32,500 ft-lb of torque at drill speeds ranging from 0 to 114 rpm.

At a maximum drill speed of 228 rpm, the 700 output horsepower generates 15,100 ft-lb of torque.

The open-frame design of the AC drilling motors allows the cooling air to pass through the inside of the motors, which provides a more efficient transfer of rotor and winding heat to the cooling air. The motors are manufactured specifically for top drive applications. They include:

- Internal temperature sensors.
- Double varnish-impregnated windings.
- Upgraded bearing/shaft seals.
- High-capacity bearings.
- Tapered output shafts.

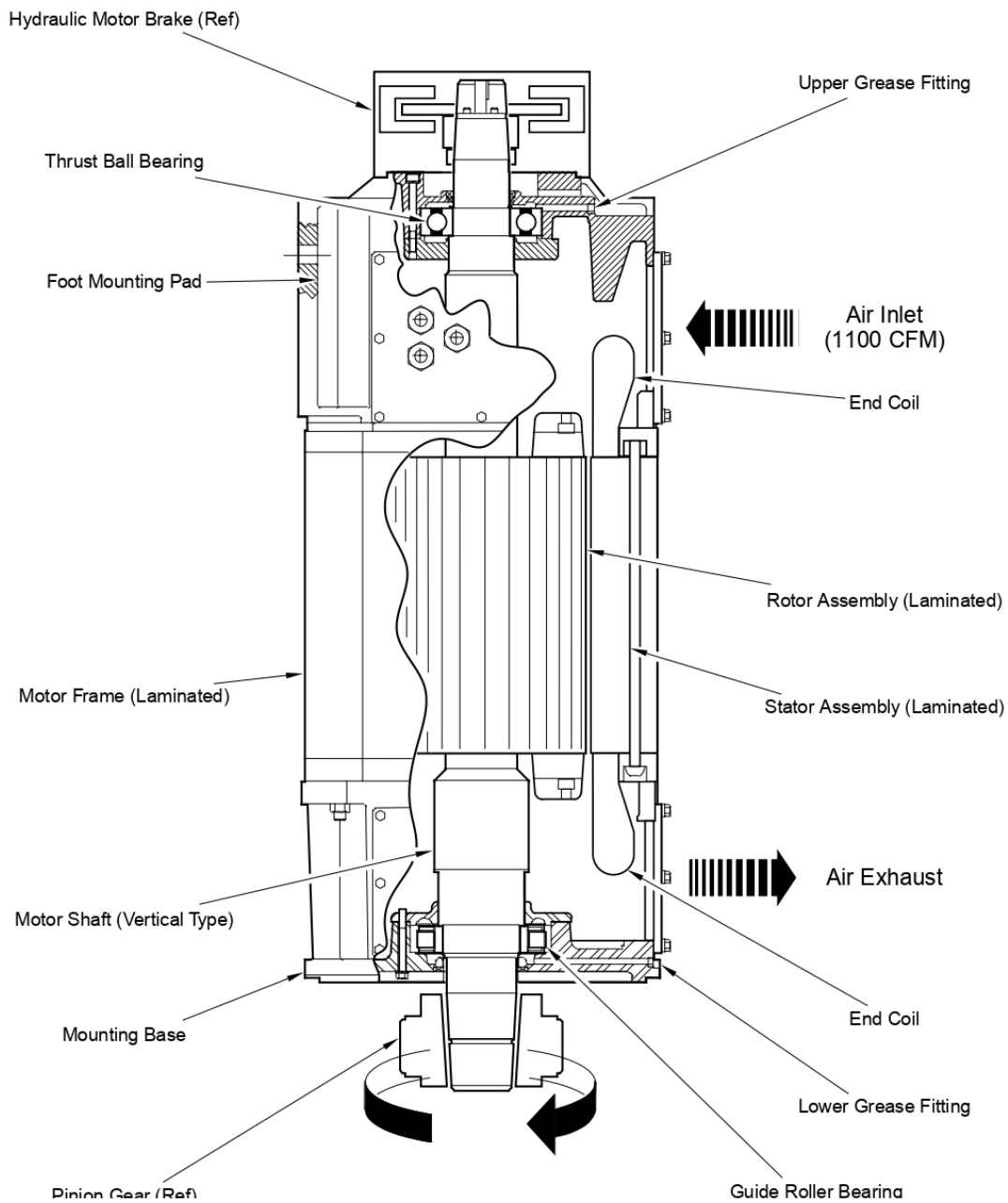


Figure 28: AC Motor [10]

Indicators:

Various indicators report status/faults to the driller:

- Oil pressure loss.
- Drill motor over temperature.
- Blower loss.
- IBOP closed.
- Brake.
- Drive fault.

7. Varco Console Control System:

The stainless steel Varco driller’s console (VDC) is waterproof and purgeable. The console’s front panel drops down to allow access to components.

Table 3-1 identifies and describes VDC components.

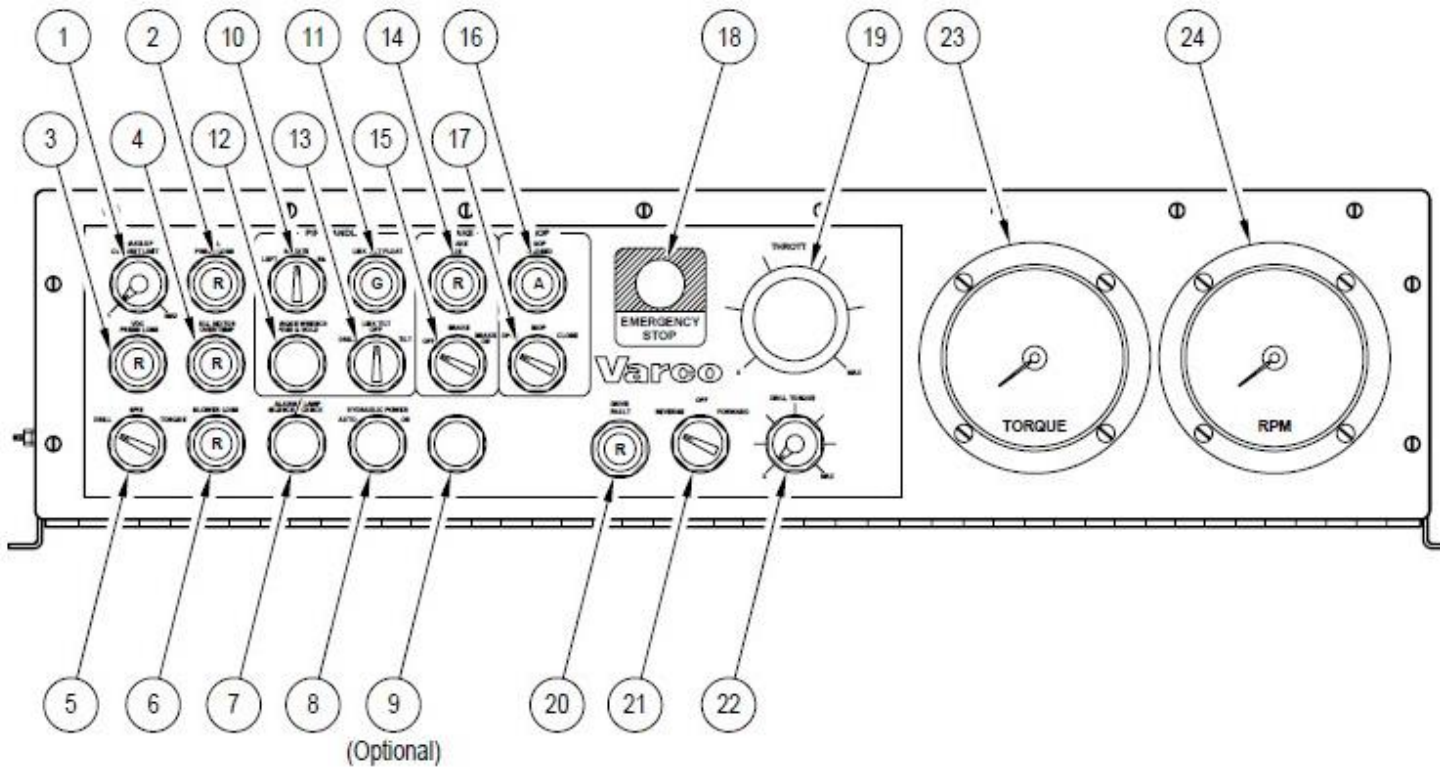


Figure 30: Physical Console [10]

Table 4: Varco Drilling console table

Ref.	Name	Type	Function
1	MAKE-UP CURRENT LIMIT:	Potentiometer Sets current limit in VFD during makeup	Operations. This sets the maximum allowable makeup connection torque. The torque is adjusted by setting the brake and adjusting the MAKE-UP CURRENT LIMIT potentiometer to increase or decrease the torque as indicated on the TORQUE meter
2	OIL PRESS LOSS	Red indicator	Flashes and horn sounds when an oil pressure loss is detected in the gearcase lubrication system. Pressing the ALARM SILENCE push button turns off the alarm whereas the indicator remains on until the fault is cleared
3	VDC PRESS LOSS	Red indicator	Indicator flashes and horn sounds when a loss of purge pressure in the VDC is detected. Pressing the ALARM SILENCE push button turns off the alarm whereas the indicator remains on until the fault is cleared
4	DRILL MOTOR OVERTEMP	Red indicator Indicator flashes and horn sounds when	An overtemperature condition is detected in a drilling motor. Pressing the ALARM SILENCE push button turns off the alarm whereas the indicator remains on until the fault is cleared.
5	DRILL/SPIN/ TORQUE	Position selector switch	DRILL position selects the normal drilling mode with the rotational speed controlled by the THROTTLE and the maximum torque controlled by the DRILL TORQUE potentiometer. SPIN mode is a fixed-speed mode. TORQUE mode is the makeup mode. In the torque mode, torque increases gradually up to the limit set by the MAKE-UP CURRENT LIMIT potentiometer.

6	BLOWER LOSS	Red Indicator	Indicator flashes and horn sounds when a blower fault is detected. Pressing the ALARM SILENCE push button turns off the alarm whereas the indicator remains on until the fault is cleared.
7	ALARM SILENCE/ LAMP CHECK	Pushbutton switch	When pressed while the alarm horn is sounding, silences the horn. However, the fault indicator that caused the alarm to sound remains lit until the fault is cleared or reset. If the fault is not cleared within 5 minutes, the alarm horn sounds again. When this switch is pressed and held for 2 seconds, it lights all of the indicators on the VDC for a lamp check.
8	HYDRAULIC POWER AUTO/ON	Position switch	When set to AUTO, turns on the hydraulic pump commanded by the PLC. When set to ON, turns on the hydraulic pump regardless of the operating mode
9	COUNTERBALANCE DRILL/STAND JUMP(This is an optional switch. When the switch is not included, counter- balance actuators function as they would in the DRILL position.)	Position switch	In the DRILL position, counterbalance actuators receive enough pressure to counterbalance the weight of the TDS. In the STAND JUMP position, counterbalance actuators receive enough pressure to lift the TDS to separate drill pipe connection as it unscrews
10	(PIPEHANDLER) ROTATE LEFT/RIGHT	Position momentary switch with centre off	When held in the LEFT position, rotates the head to the left. When held in the RIGHT position, rotates the head to the right. The switch automatically returns to the centre (off) position when released.
11	(PIPEHANDLER) LINK TILT FLOAT	Greenlighted pushbutton	The links “float” to the centre (neutral) position when the push button is pressed
12	IPEHANDLER) TORQUE WRENCH PUSH & HOLD	Pushbutton switch	When pressed and held, engages the pipe clamp and shot pin lock

13	(PIPEHANDLER) LINK TILT DRILL/OFF/TILT	Position maintained switch	When set to DRILL, link tilt cylinders are retracted to place the head in the normal drilling position. When set to TILT, link tilt cylinders are extended to tilt the head for makeup operations. When set to OFF, the head remains in its present position.
14	BRAKE ON	Red indicator	Indicator lights to indicate the brake is on when the brake solenoid is energized
15	BRAKE OFF/AUTO/ON	Position switch	When set to ON, the brake solenoid is energized to set the brakes and light the BRAKE ON indicator. When set to AUTO, the brake is released when THROTTLE is advanced and is set when THROTTLE is turned off. When set to OFF, the brake is released.
16	IBOP CLOSED	Amber indicator	Lights when hydraulic pressure is applied to the cylinder that closes the IBOP valve.
17	IBOP OPEN/CLOSE	Position switch	OPEN position extends the actuator cylinder to open the IBOP valve. CLOSE position retracts the actuator cylinder to close IBOP the valve
18	EMERGENCY STOP	Mushroom pushbutton	When pressed, shuts down all operations. The switch is hardwired to the VFD and when pressed, deselects the VFD regardless of the throttle position. However, the auxiliary cooling motors remain on
19	THROTTLE: 0 ⇒ MAX	Potentiometer	Controls speed of drilling motors. The resulting drill pipe speed is displayed on the RPM meter
20	DRIVE FAULT	Red indicator	Indicator flashes and horn sounds when a VDC fault is detected. Pressing the ALARM SILENCE push button turns off the alarm whereas the indicator remains on until the fault is cleared

21	REVERSE/OFF/ FORWARD	Position switch	Controls the direction of rotation of the drilling motors in both drilling and makeup modes of operation
22	DRILL TORQUE: 0 ⇒ MAX	Potentiometer	Sets current limit in VFD during drilling operations. This sets the maximum allowable drill pipe torque. The torque is adjusted by setting the brake and adjusting the DRILL TORQUE potentiometer to increase or decrease the torque as indicated on the TORQUE meter
23	TORQUE: 0 → 50,000 ft/lb	Meter (0 - 10 VDC)	Displays drill pipe torque in ft-lb. In drilling mode, torque is set by the DRILL TORQUE potentiometer, and in makeup mode, by the MAKE-UP CURRENT LIMIT potentiometer
24	RPM: 0 → 250 rpm	Meter (0 - 10 VDC)	Displays drill pipe rotational speed in rpm. The rotational speed is controlled by the THROTTLE control.

8. Operating procedures:

8.1 Start-up procedure:

Use the following procedures to start up the TDS-11SA:

1. Check the lubrication level on the sight gauge in the main body.
2. Check the hydraulic fluid level on the sight gauge in the reservoir.
3. Check the hydraulic filter indicator located on the filter mounted on the left AC drilling motor.
4. The indicator may be out because the fluid is cold. Reset the indicator and check its status after the hydraulic system is warmed up.
5. Check the lube filter indicator.
6. With the top drive near the drill floor, exercise each control on the VDC.
7. Rotate the drive shaft [10].

8.2 Rotating link adapter:

The weight of the drill string is supported by the spinning link adapter via a series of links that dangle from the adapter. The positioning gear is a required component of the rotating link adapter. The pipehandler is rotated by the positioning gear, which is linked to a hydraulic motor-driven pinion gear. The rotating link adapter also serves as a hydraulic slip ring, supplying all of the hydraulic channels required between the fixed load stem and the rotating link adapter.

8.3 IBOP safety valves:

Turning the VDC's IBOP switch to the CLOSE position retracts the hydraulic actuator cylinder rod, causing the yoke and actuator shell body to rise (Figure 26). This upward movement causes the crank assembly to revolve 90 degrees, shutting the IBOP ball valve.

When the switch is turned to the OPEN position, the cylinder rod expands, forcing the IBOP actuator shell downward and opening the IBOP. After applying full hydraulic pressure to completely open the valve, a hydraulic timing circuit decreases the pressure while preserving the shell position.

8.4 Torque backup clamp:

When the shot pin is fully engaged in the rotating link adapter positioning gear, the pipehandler clamp cylinder has two jaw assemblies that clamp on the box portion of a tool joint. When you press the torque wrench clamp switch, the link adapter gently turns until the shot pin engages. The torque backup clamp jaws clamp onto the tool joint when the shot pin is fully engaged. The AC drilling motors make or break connections while the tool joint is kept in position by the clamp cylinder.

8.5 Link tilt:

The link tilt is made up of two double-rod assemblies, with the top rod attached to the spinning link adapter and the bottom end of the cylinder attached to the elevator links (Figure 25). The drill pipe elevator is extended to the derrickman position by turning the link tilt switch on the VDC to the right. The cylinder assembly's clasp restricts the elevator to travel to the derrickman position.

When the latch cable on each cylinder is pulled, the latch is released, allowing the elevator to proceed to the mousehole position.

The drill pipe elevator is retracted to the drill-down position by turning the link tilt switch to the left. The elevator may be returned to the well centre by pressing the link tilt float button.

Elevator travel may be tailored to the derrickman and mousehole.

To adjust the derrickman position, adjust the shims and/or flip stop as required at the end of the cylinders (Figure 25). The initial mousehole setting should be 45 in. from the bottom of the link clamps to the bottom of the link eyes. If it is necessary to adjust the mousehole position, relocate the clamps on the links as required.

8.6 Tool joint locks:

Three tool joint locks are installed over the joints to prevent inadvertent breaks out between the main shaft, upper IBOP, lower IBOP, and saver sub. Each of these locking assemblies consists of an inner double-tapered split sleeve and two external rings. Tightening the bolts draws the two external rings together over the split internal sleeve providing the locking force (Figure 23.).

Factory tests demonstrate that a tool joint lock properly installed can resist a torque of up to 30,000 ft-lb. A 6 5/8 in. API connection made up to 46,000 ft-lb can resist a net torque of 76,000 ft-lb.

8.7 Torque values for load-carrying components:

Proper makeup torque is critical to the function of drill stem components. Table 4 only includes components within the TDS-11SA.

Table 5: Torque values for load carrying components [10]

Components	ID	Connection	OD Min. *	torque Max.	torque
Upper safety valve to main stem/main shaft	3 in	6 5/8 in. API Reg	7 3/8 in	46,000 ft-lb	63,000 ft-lb
Lower safety valve to upper safety valve	3 in	6 5/8 in. API Reg	7 3/8 in	46,000 ft-lb	63,000 ft-lb
Saver sub to lower safety valve	3 in	6 5/8 in. API Reg	7 3/8 in	46,000 ft-lb	63,000 ft-lb
Crossover sub to lower safety valve	3 in	6 5/8 in. API Reg	7 3/8 in	46,000 ft-lb	63,000 ft-lb

Conclusion:

Based on the analysis of the Top Drive TDS SA/11, it can be concluded that this technology has revolutionized the drilling industry. The TDS SA/11 has proven to be a reliable and efficient system that enhances drilling operations by providing better control, safety, and increased drilling speed. Moreover, the TDS SA/11 reduces downtime and maintenance costs, resulting in improved profitability for drilling companies. However, despite its many advantages, proper maintenance and operation procedures are necessary to ensure the longevity and optimal performance of the system. Therefore, it is recommended that drilling companies provide comprehensive training to their operators and maintenance staff to ensure that the TDS SA/11 continues to provide its maximum benefits. Overall, the TDS SA/11 is a game-changing technology that has transformed the drilling industry and will continue to do so for years to come.

Chapter III: Programming and Supervision.

Programming and Supervision

Introduction:

As we presented in the previous chapter, all the components and their functions. This chapter is about the program that we develop that controls the components to perform their function and supervising.

This program will control and supervise the machine. We will elaborate on the details in this chapter by presenting all the blocks, functions, tags, and HMI screens that were used. This program will be implemented on S7-1200 PLCs using the software TIA PORTAL V17 from Siemens.

1. Hardware configuration:

What we need to configure in this machine are:

- the INPUT/OUTPUT addresses of each module.
- the communications protocol between the PLC and the other module.
- HMI panel.

In this hardware configuration, we have SIEMENS S7-1200 PLC (CPU 1217C-3 PN-2)

With [11]:

- Integrated digital inputs: Of which 10 are 24 V DC inputs and 4 are 1.5 V DC differential inputs.
- Integrated analog inputs: With a range of 0 to 10 V.
- Integrated analog outputs: With a range of 0 to 20 mA.
- Pulse outputs (PTO): With a frequency of up to 1 MHz.
- Pulse-width modulated outputs (PWM): With a frequency of up to 100 kHz.
- Integrated Ethernet interfaces: For communication with other devices and systems.
- Fast counters: With a maximum frequency of 1 MHz.
- Expansion by additional communication interfaces: E.g. RS485, RS232, and PROFIBUS.

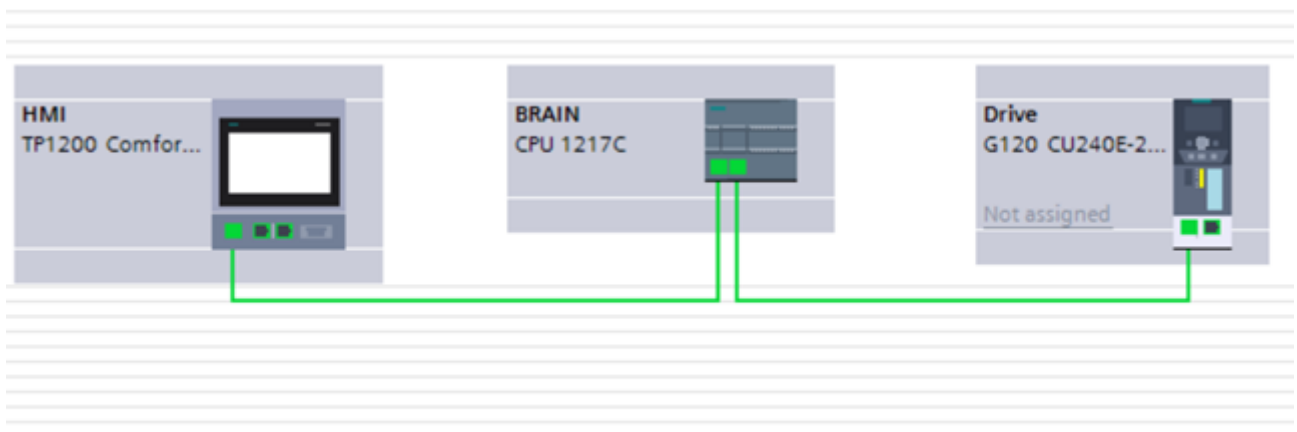


Figure 31 : Hardware Configuration in TIA portal



Figure 32: the PLC S7-1200 configuration

2. Software configuration:

2.1 TIA PORTAL:

Siemens TIA Portal (Totally Integrated Automation Portal) is a software platform for programming and configuring automation systems. It offers a unified programming and configuration environment for PLCs, HMIs, drives, and other automation components. Engineers can easily build complicated automation systems using a variety of tools and capabilities available on the TIA Portal. It also has a user-friendly interface, which makes navigation easy, so it is usable for both users who are beginners as well as professionals. Engineers can use TIA Portal to manage their automation projects and boost productivity while lowering costs and decreasing mistakes. Overall, TIA Portal is a robust and adaptable automation platform that has won the hearts of many automation professionals worldwide [12].

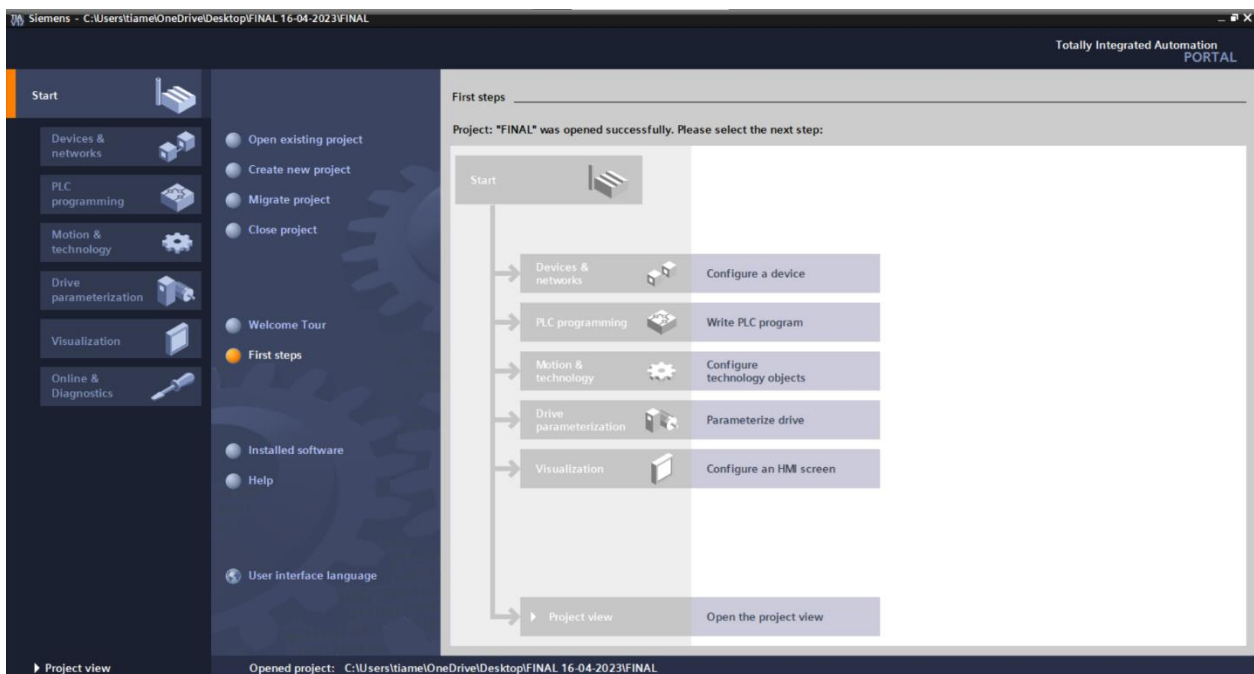


Figure 33: TIA Portal Preliminary Interface

2.2 Program blocks:

In Siemens TIA Portal, program blocks refer to the basic building blocks of a PLC (Programmable Logic Controller) application. These instructions inform the PLC what to do, such as reading input signals, conducting logic operations, and regulating output signals. As needed, program blocks can be created, modified, and reused, enabling efficient and flexible programming. They are often structured in a hierarchical framework, with higher-level blocks requesting certain duties from lower-level blocks. There are four types of these blocks

2.2.1 Organization Blocks:

Organization Blocks (OBs) are the primary building blocks of a PLC program that control its execution. They are triggered by certain events or conditions. OBs give PLC programming a systematic and methodical approach, enabling the creation of code that is effective and easy to maintain. There are numerous sorts of OBs, each with a distinct function.

- OB1 (cycle interrupt OB): Executed once per scan cycle and controls the overall execution of the program.
- OB35 (time-of-day OB): Executed at a specific time of day and is used for time-based control functions.
- OB100 (hardware interrupt OB): Triggered when a hardware error occurs and is responsible for handling the error and stopping the program if necessary.

2.2.2 Function:

A function (FC) in TIA Portal is a memoryless code block. It includes a program that is executed when the function is called by another code block or another function, which makes it perfect for recursive and complicated structures. It has no instance data block where block parameter values can be kept. As a result, when an FC is called, all formal parameters (such as those described under in, out, and in Out) must be assigned actual values rather than being left blank.

2.2.3 Function Block:

Function blocks (FB) are code blocks that permanently store their input, output, and in-out parameters in instance data blocks, allowing them to be accessed even after the block has been run. Therefore, they are also known as "memory blocks". Like an FC, it contains a program that is always performed when another code block calls it. And it can also be called several times throughout a program. When an FB is called, the formal parameters can be left blank. When a function block call is made, we refer to it as an instance. Each instance of a function block requires an instance data block, which stores instance-specific values for the formal parameters stated in the function block.

2.2.4 Data-base:

A data block (DB) in Siemens TIA Portal is a memory area that can be used to store data. DBs are used to store all sorts of data, such as variables, arrays, structures, and constants. They can be used to organize data, make it easier to access, and to share data between different parts of a program.

3. Programming:

The TIA Portal programming language is a combination of two prominent PLC programming languages: Ladder Diagram (LD) and Function Block Diagram (FBD). LD is a graphical programming language that employs ladder-like symbols to express logical functions, whereas (FBD) is a modular language that uses interconnected function blocks to generate complicated logic. The hybrid language used in TIA Portal combines the best of both worlds, delivering an easy-to-understand and simple graphical interface while still allowing for flexibility and versatility.

3.1 Main [OB1]:

In Siemens PLCs, OB1 is a necessary block that is run once when the PLC is started or restarted. It is used to set up connection parameters and other system settings, as well as to initialize variables and data structures. OB1 also acts as a watchdog, monitoring the state of the PLC and ensuring that it remains operational. We also used Structured Text (ST) to call other functions, which is a high-level language that is based on Pascal, and it is designed to be easy to read and write while also providing powerful functionality like loops, conditional statements, and function calls, allowing

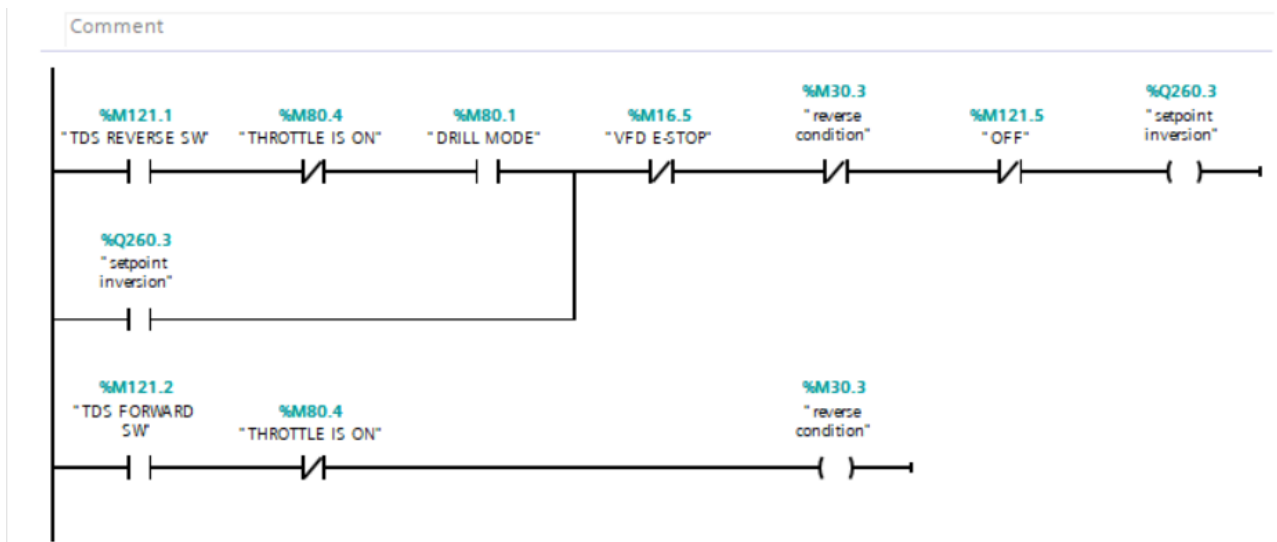
programmers to create complex and modular programs.

▼ Block title: "Main Program Sweep (Cycle)"		
Comment		
▼ Network 1:		
Comment		
1	CALL "ANALOG IN"	%FC20
2	CALL "RPM INDICATOR"	%FC21
3	CALL "TORQUE INFORMATION"	%FC22
4	CALL "SIEMENS COMM PP04"	%FC26
5	CALL "TDS AC SELECT"	%FC30
6	CALL "VFD SPEED SET POINT"	%FC36
7	CALL "TORQUE COMMAND"	%FC37
8	CALL "BLOWER ON"	%FC54
9	CALL "OIL SYSTEM ON"	%FC55
10	CALL "BRAKE CONTROL"	%FC61
11	CALL "TW-PH75"	%FC64
12	CALL "IBOP CONTROL"	%FC65
13	CALL "LINK TILT CONTROL"	%FC68
14	CALL "ALARMS"	%FC81
15		

Figure 34: Main OB1

3.2 TDS AC Select:

The TOP DRIVE is selected when assigned to forward or reverse, the throttle is in the OFF position, and the drill mode is selected. Once TDS is selected, it will be latched. The drive should be on when the throttle is on, spin mode, or torque mode. To change the direction, we have to go into



drill mode. In case of an emergency and the E-STOP button is pushed down, we have to go to drill mode and pull the E-STOP button out to reset (TDS select).

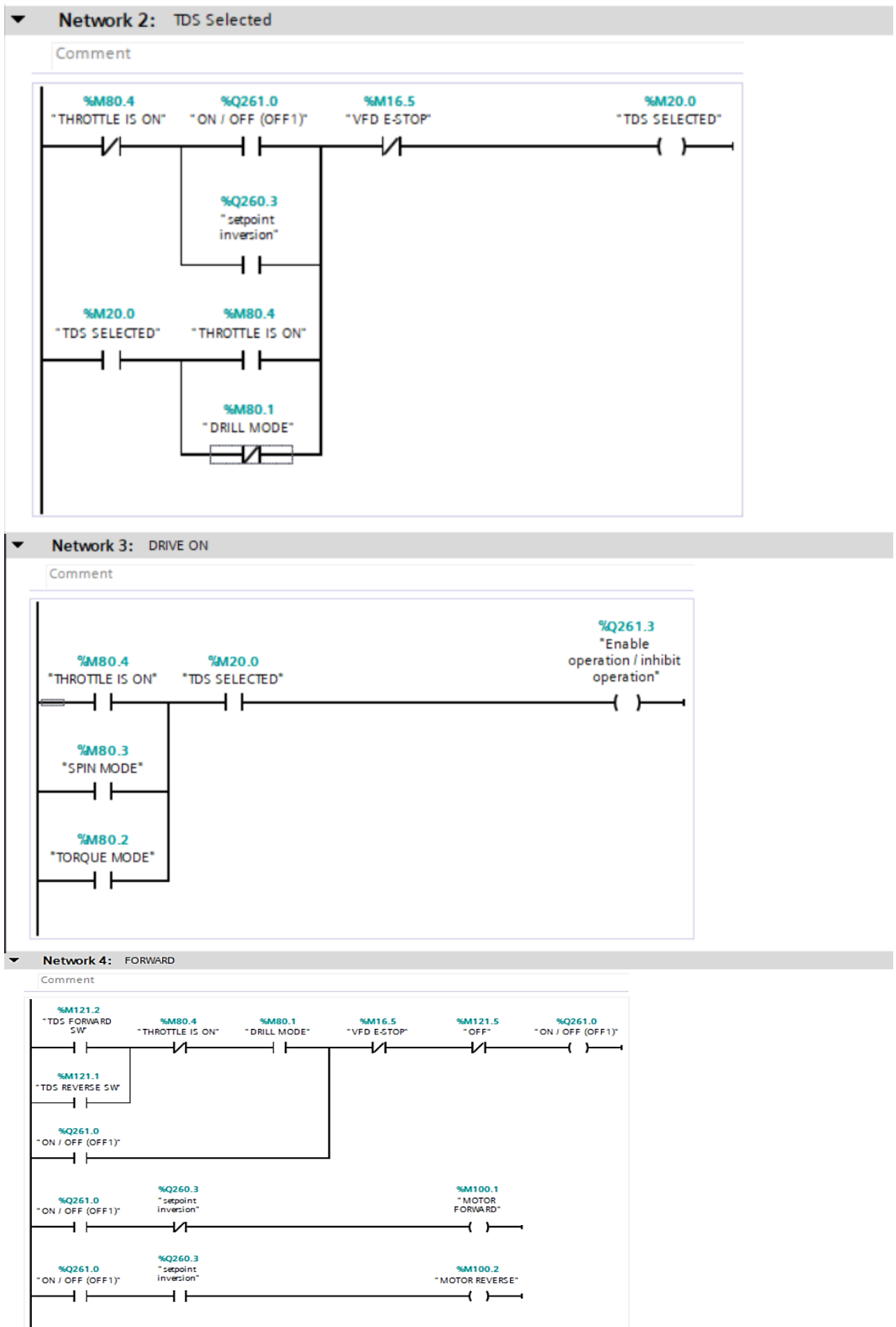


Figure 35: TDS AC Select function

Flowchart of TDS select:

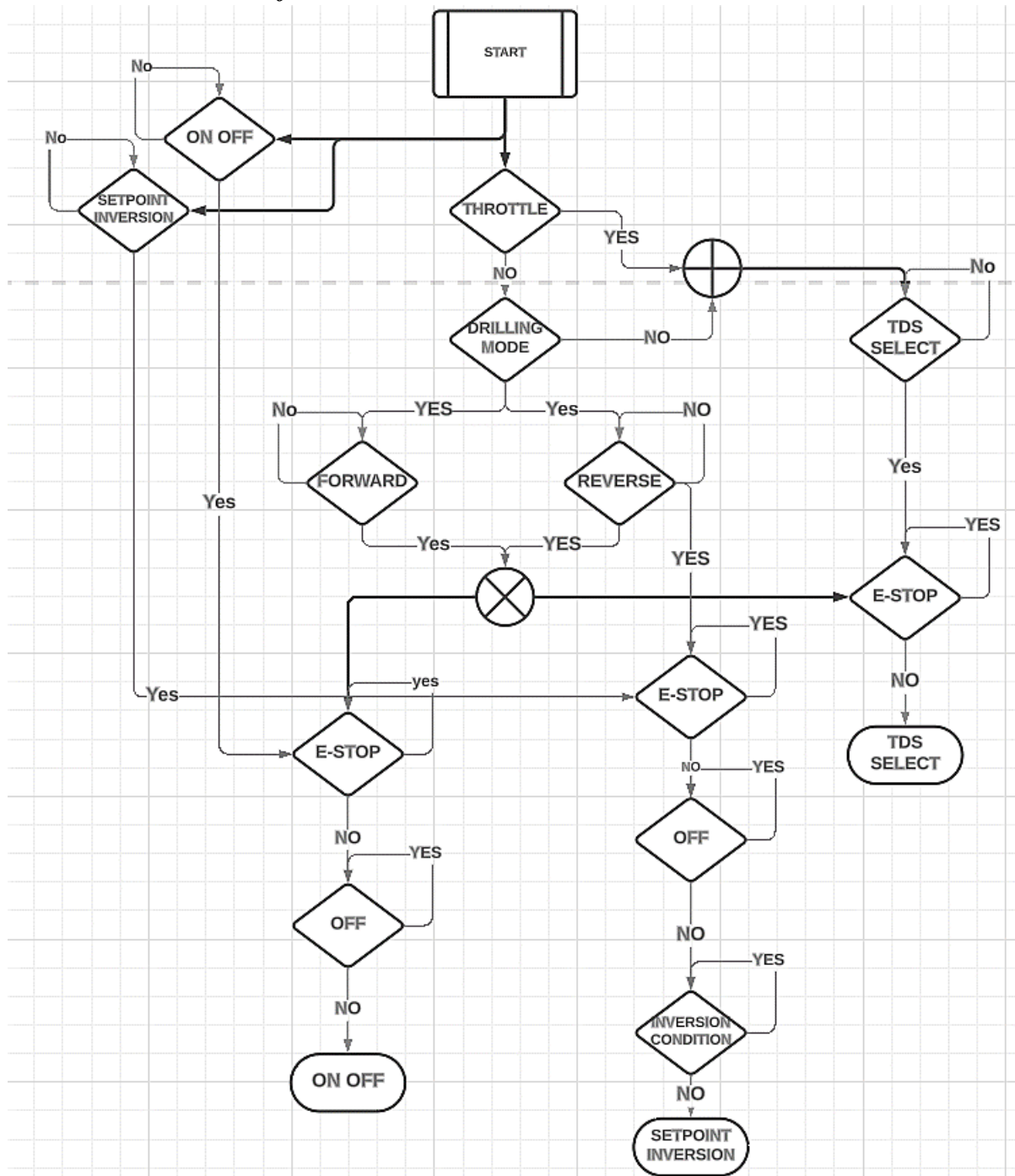


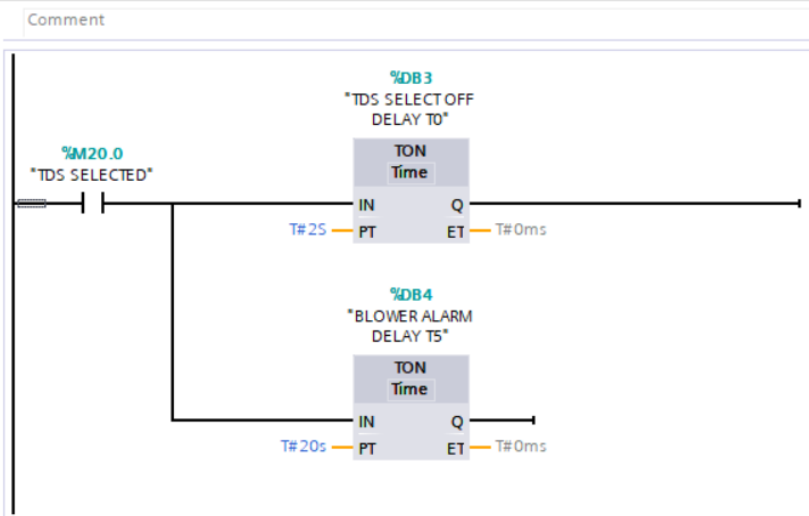
Figure 136: TDS flow chart

3.3 Blowers Function:

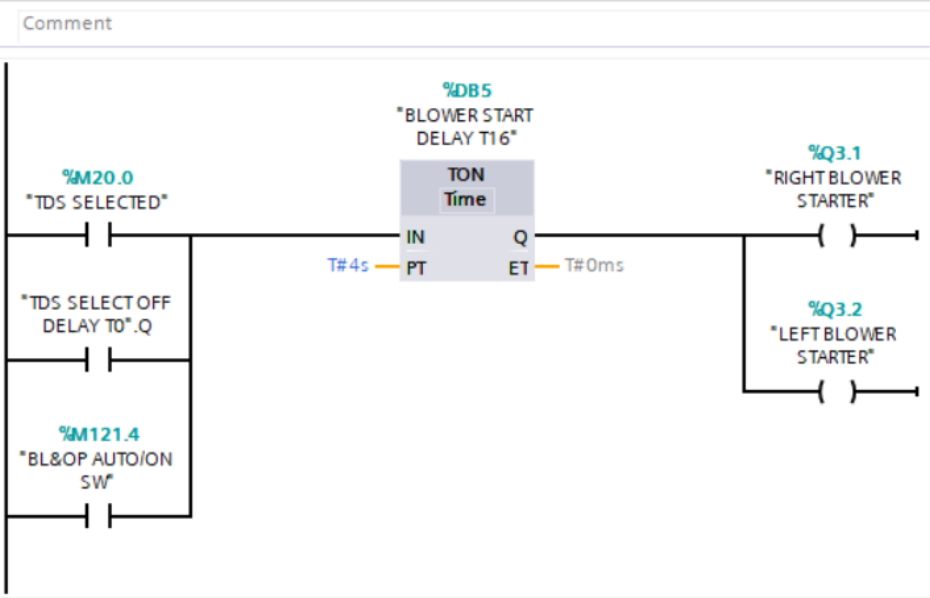
When the TDS is selected, it triggers three timers:

- Start the off-delay timer (TDS SELECT OFF DELAY) allows the TDS cooling and lube system to be selected for 2 seconds after it has been turned off. This will allow the blower and oil lube systems to remain on if you are just switching from forward and reverse.
- Assign an on-delay timer(BLOWER START DELAY) to start the blowers. it's also triggered by (TDS SELECT OFF DELAY) and (BL&OP AUTO/ON SW).
- Start on-delay timer (BLOWER ALARM DELAY) checks if there is air pressure in the Drive cooling intakes.
- The pressure switch check if the blowers are working properly, there are also temperature switch that detects the drive overheating.

Network 1: TDS SELECT DELAY



Network 2: BLOWER MOTOR



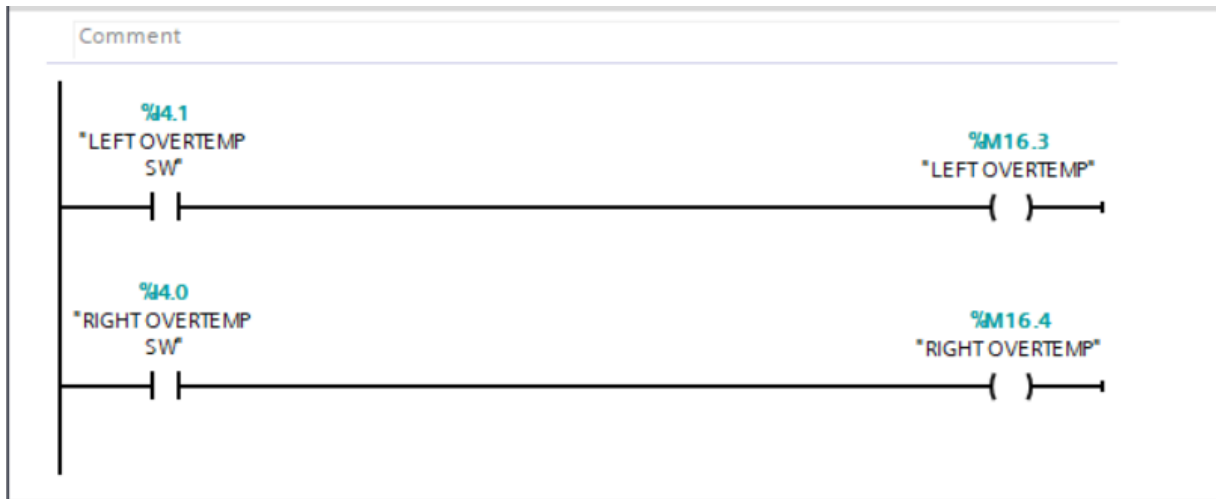


Figure 37: Blower function.

Flowchart Blower:

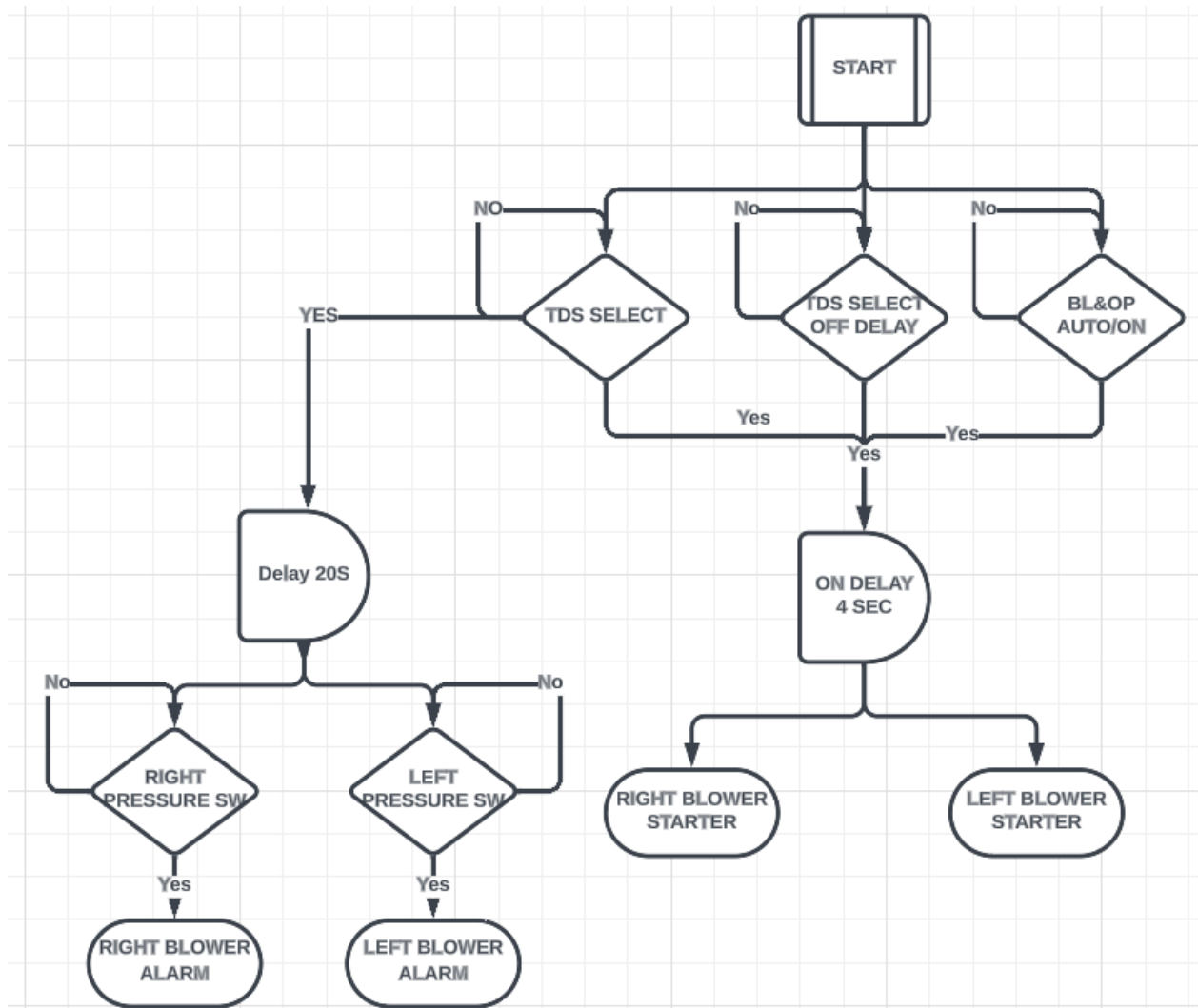


Figure 38: flowchart blower

3.4 Oil System Function:

When a top drive or "BL&OP AUTO/ON SW" is selected, the oil motor is turned ON, and it is turned OFF When "TDS CHOOSE OFF DELAY" is set to OFF. The "OIL PUMP TIMER" gives time for system pressure to rise before triggering an alarm if there is no pressure.

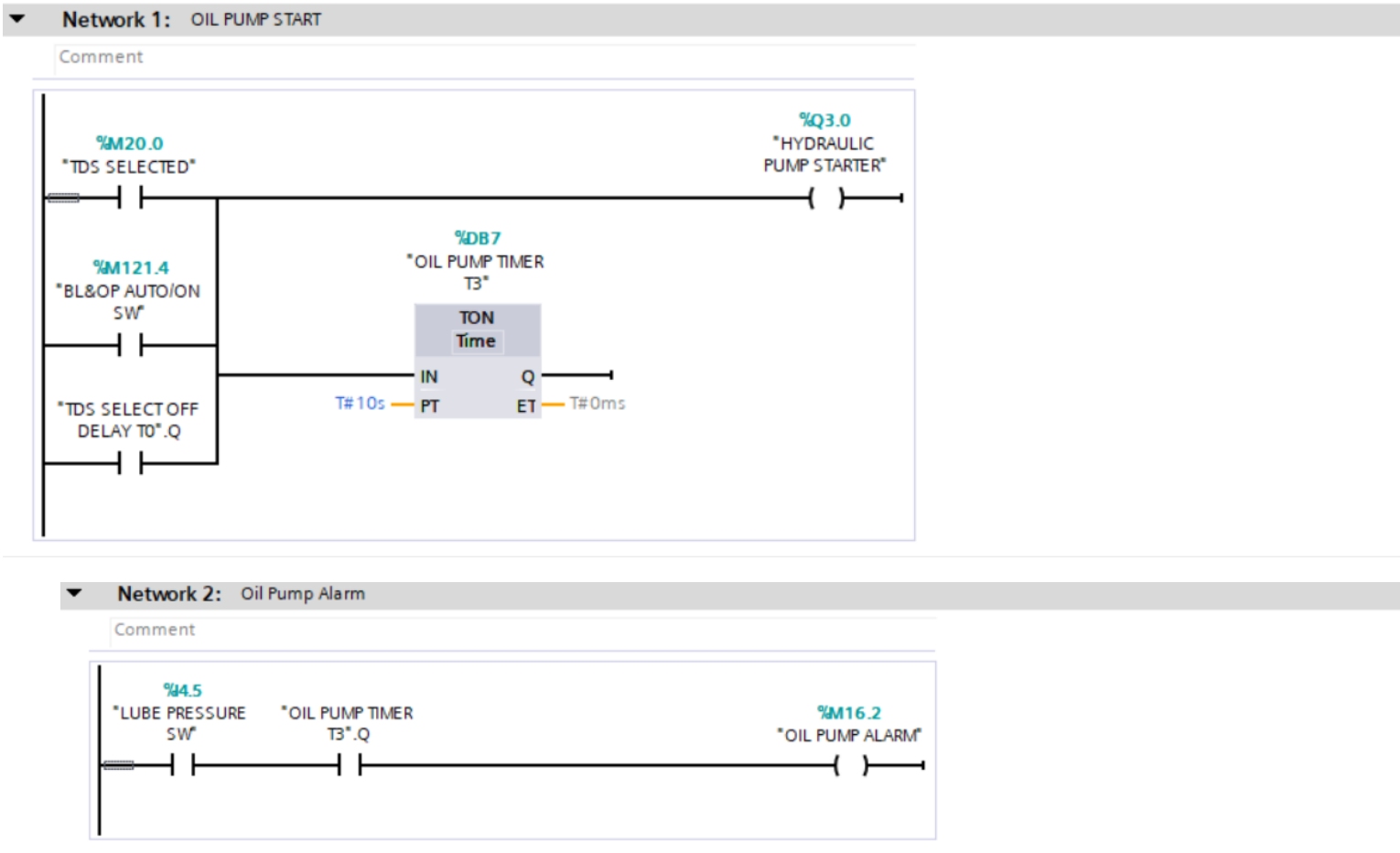


Figure 39: Oil System Function

Oil pump flowchart:

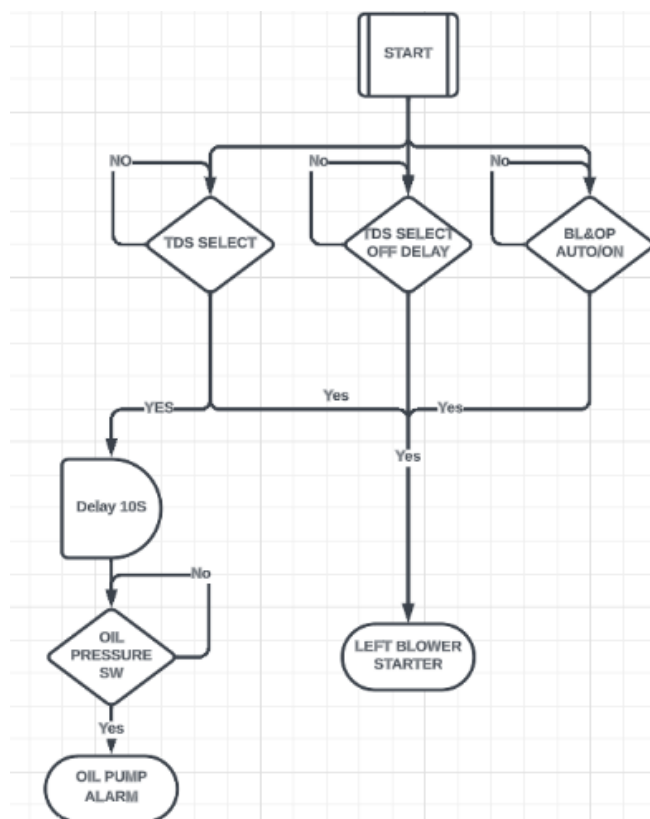


Figure 140: Oil pump flowchart.

3.5 IBOP Control:

When the switch is closed, energize the closed solenoid. Turn the indicator light on when the pressure switch indicates that the hydraulic is present for closing the valve (pressure switch is closed). Opening of the valve and pressure reduction are done hydraulically.

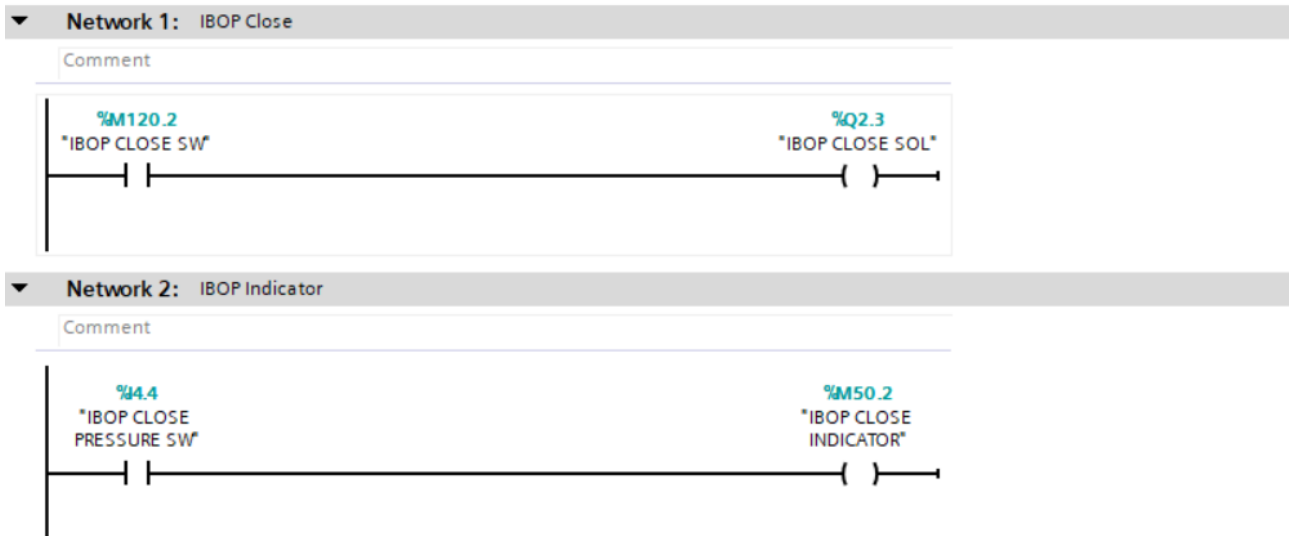


Figure 41: IBOP Control function

IBOP flowchart:

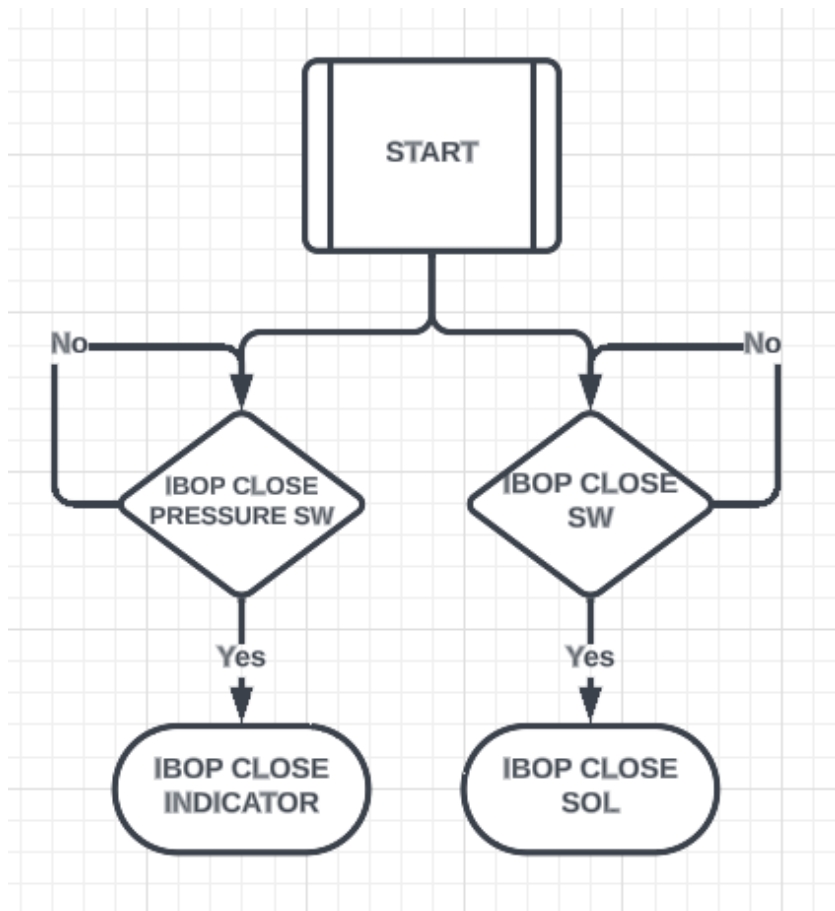


Figure 42: IBOP flowchart.

3.6 Torque Wrench:

The Torque Wrench Clamp and the Shot Pin solenoid are excited when the TW button is pressed, the throttle IS OFF and the Brake is released. Which triggers a (Start extended pulse timer) for 3 seconds for the rotating head to rotate intermittently.

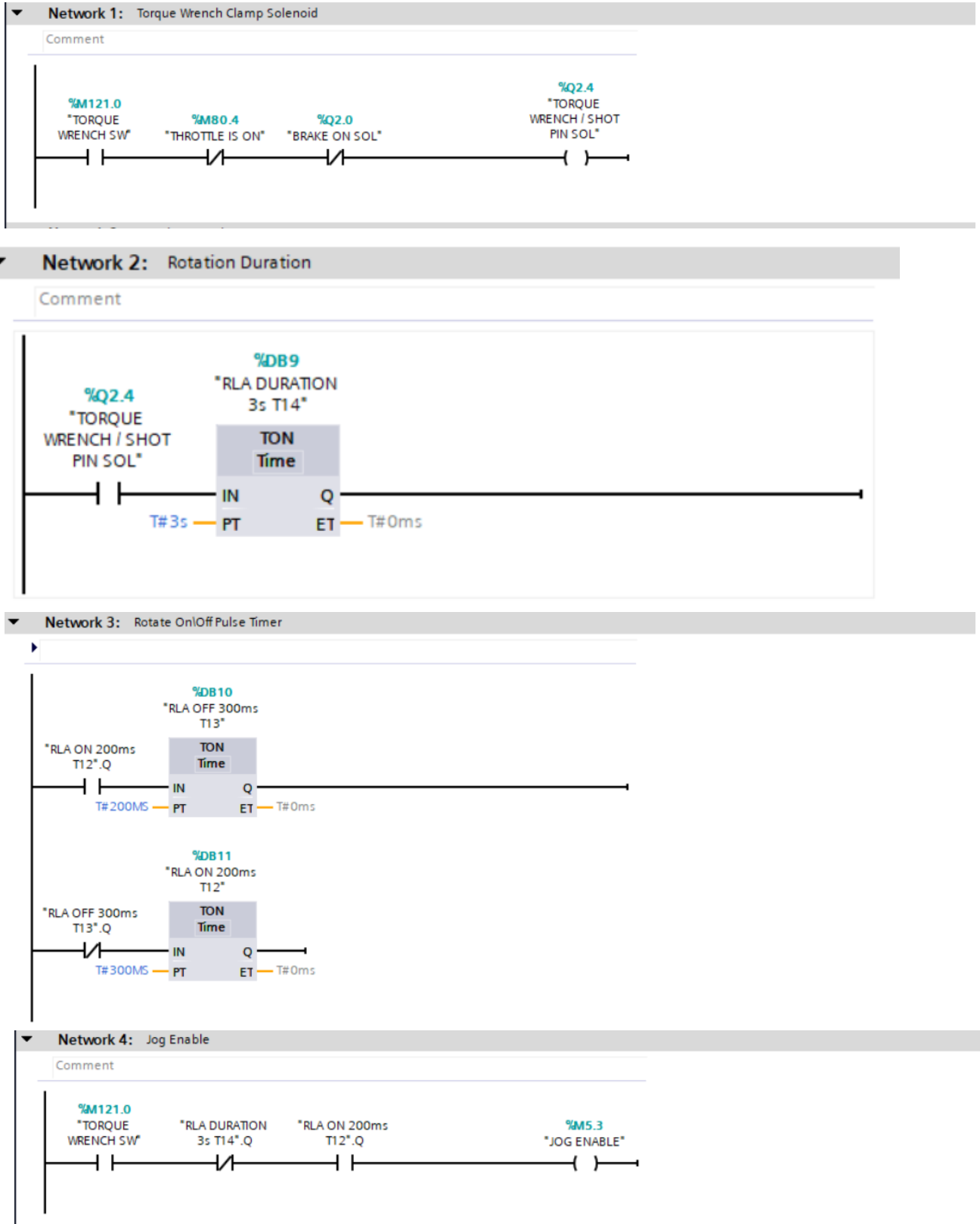


Figure 43: Torque Wrench function

Torque wrench flowchart:

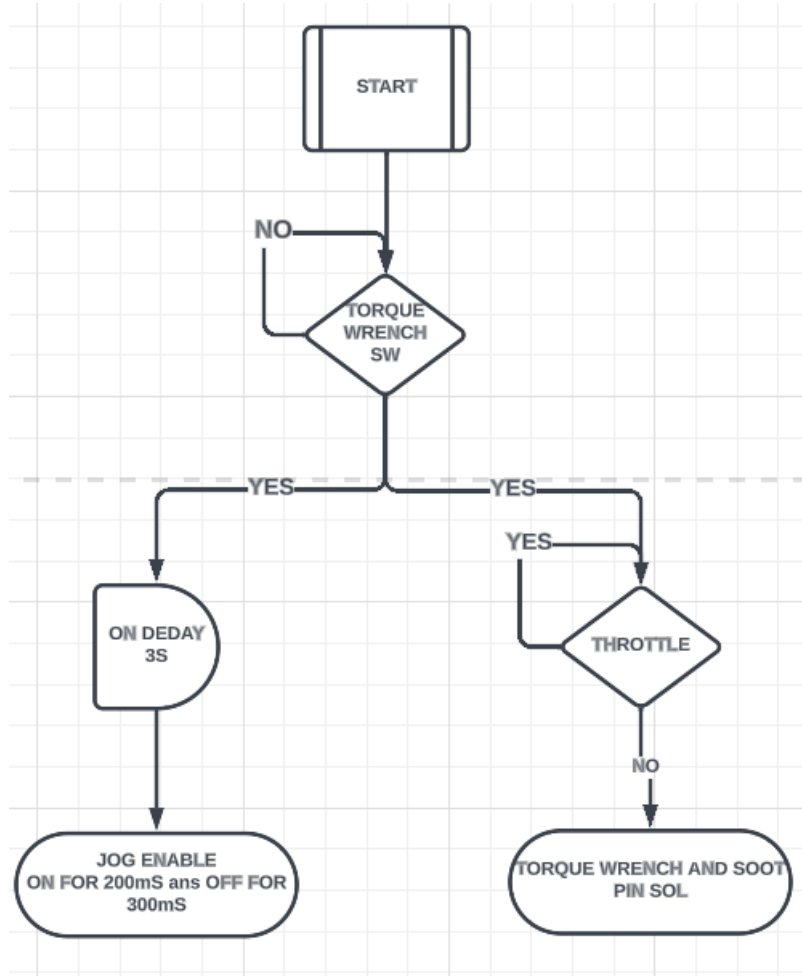
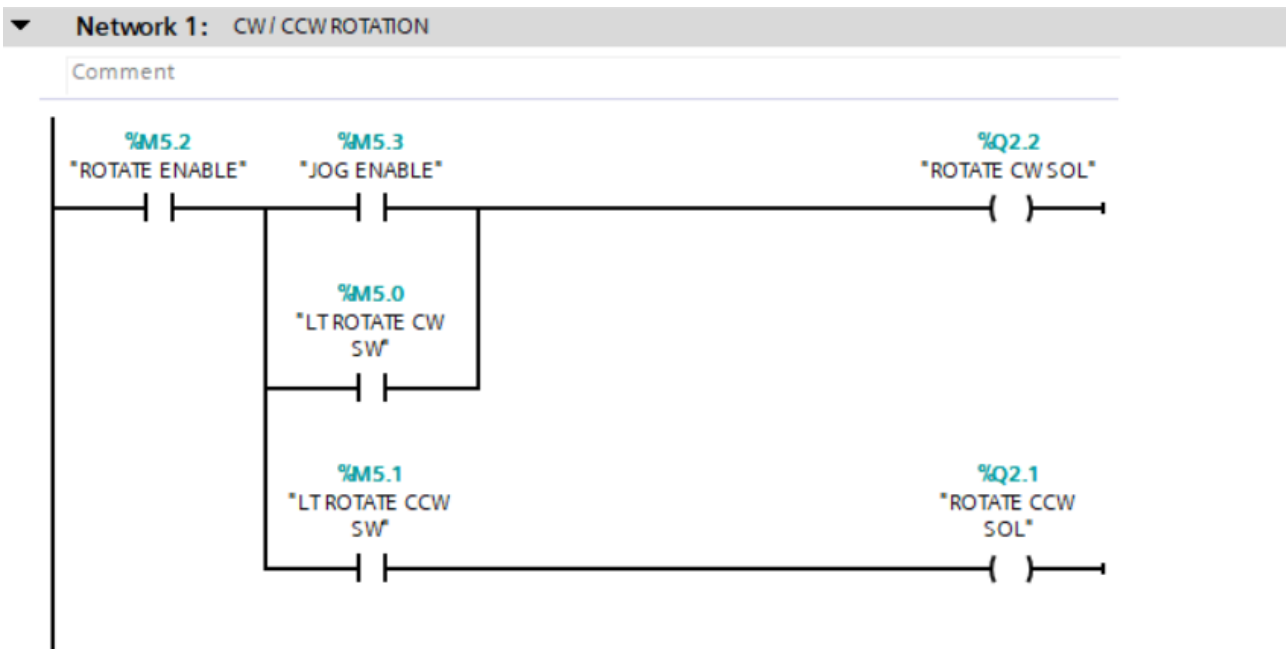


Figure 44: Torque wrench flowchart

3.7 Link Tilt Control:

The link tilt float delay (5 s) ensures that the links have been lowered (floated) before rotation can take place. This is for safety reasons; it is dangerous to rotate while links are extended. The jump stand allows the TDS to move slightly down by exciting the counterbalances solenoid.



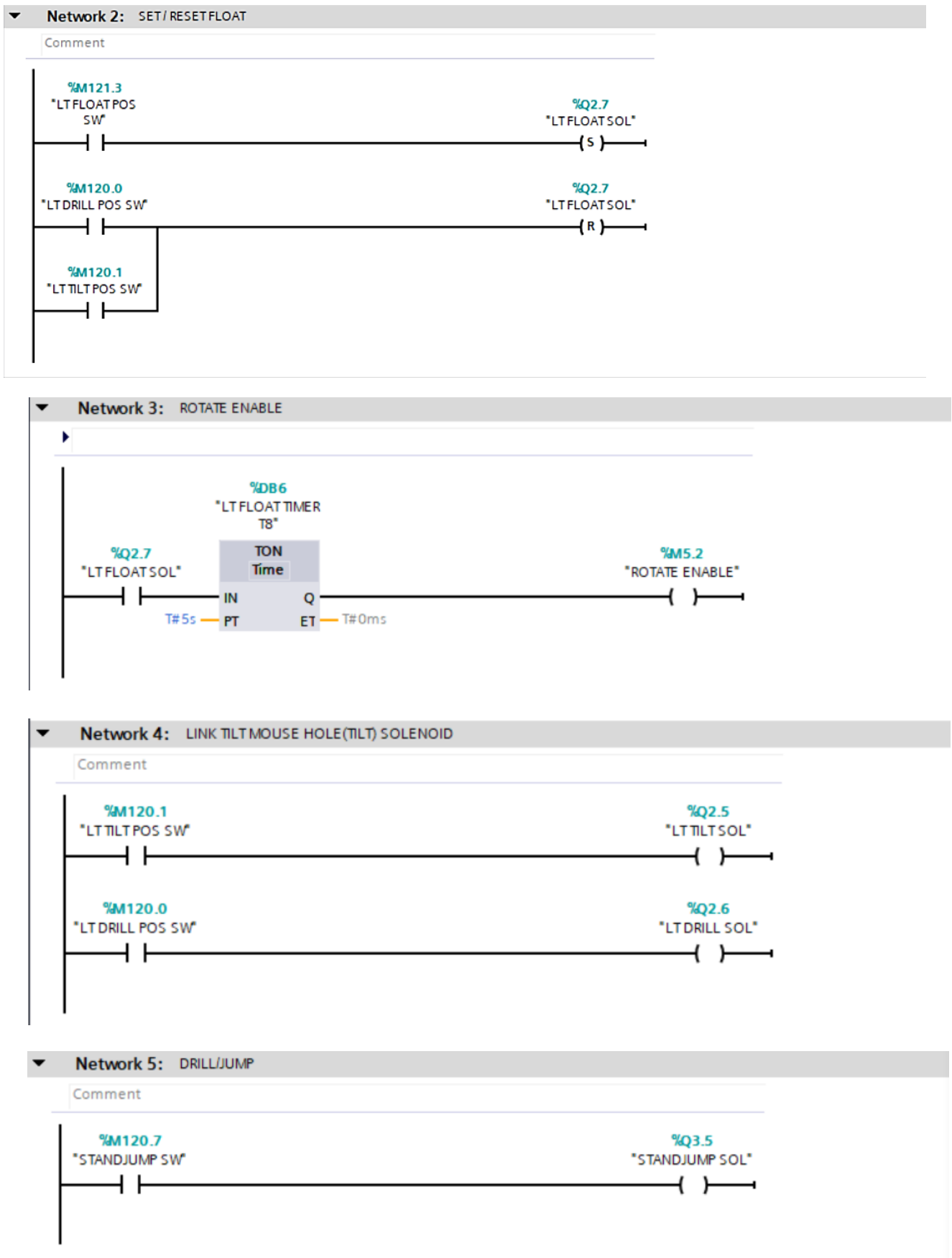


Figure 45: Link Tilt Function

Link Tilt flowchart:

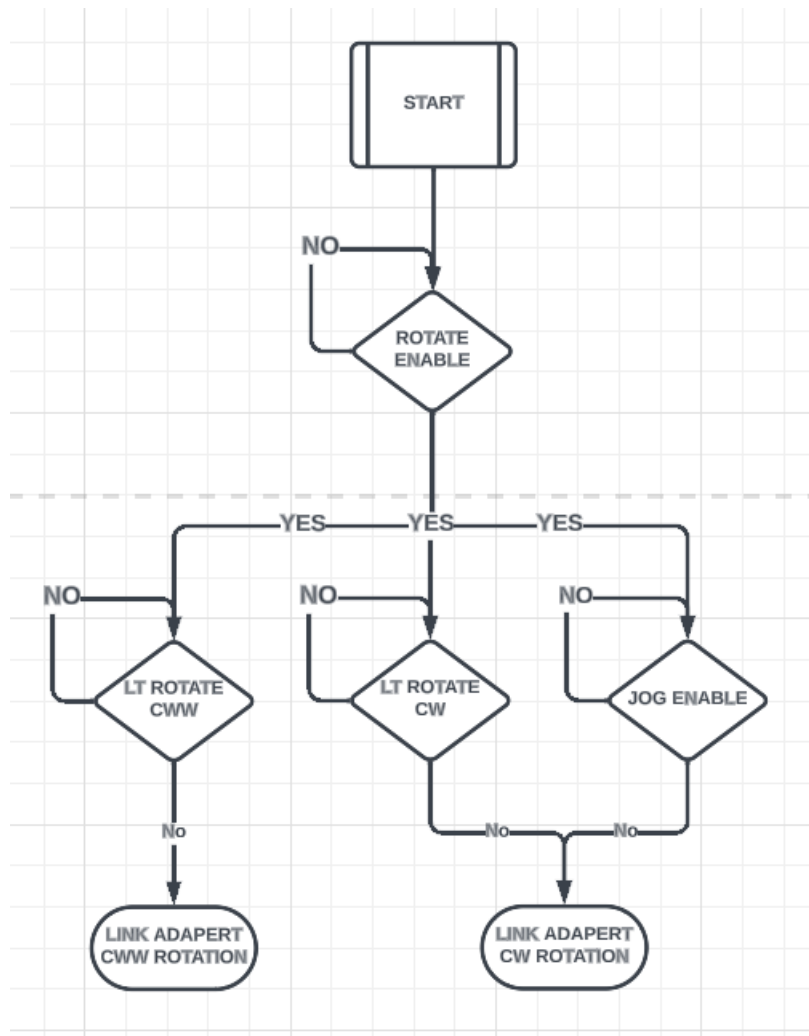


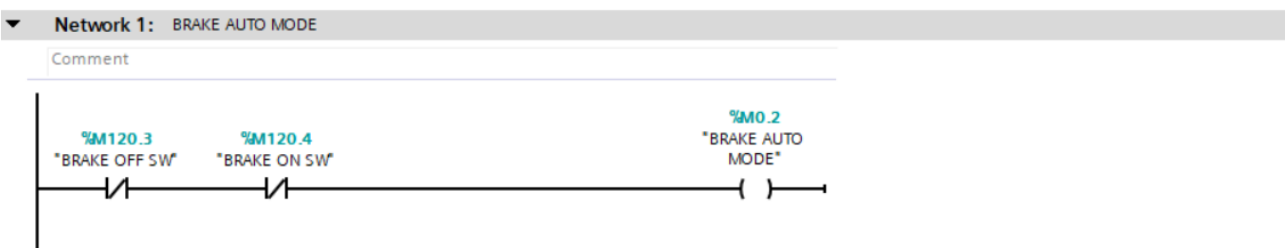
Figure 46:Linkt tilt Flowchart

3.8 Brakes:

Brakes are set for any of the following events:

- The brake switch is on.
- The brake switch is automatic, the throttle is off, and less than 10 rpm.
- if the torque sequence fails to reach the top of the ramp.
- If the AC drive fails and the speed is less than 10 rpm.
- E-stop is pushed down, and the brake is on and cannot be turned off.

If a variable frequency drive fault has occurred, the brakes will be set at the first fault. To reset the brakes again, we have to take control by bringing the brake to the ON position and taking control of the brake. It will rearm after all faults have been cleared and the brake is in the ON position. Until the faults are cleared, they will not rearm. This was done like this in case a fault could not be reset and we needed to rotate the TDS.



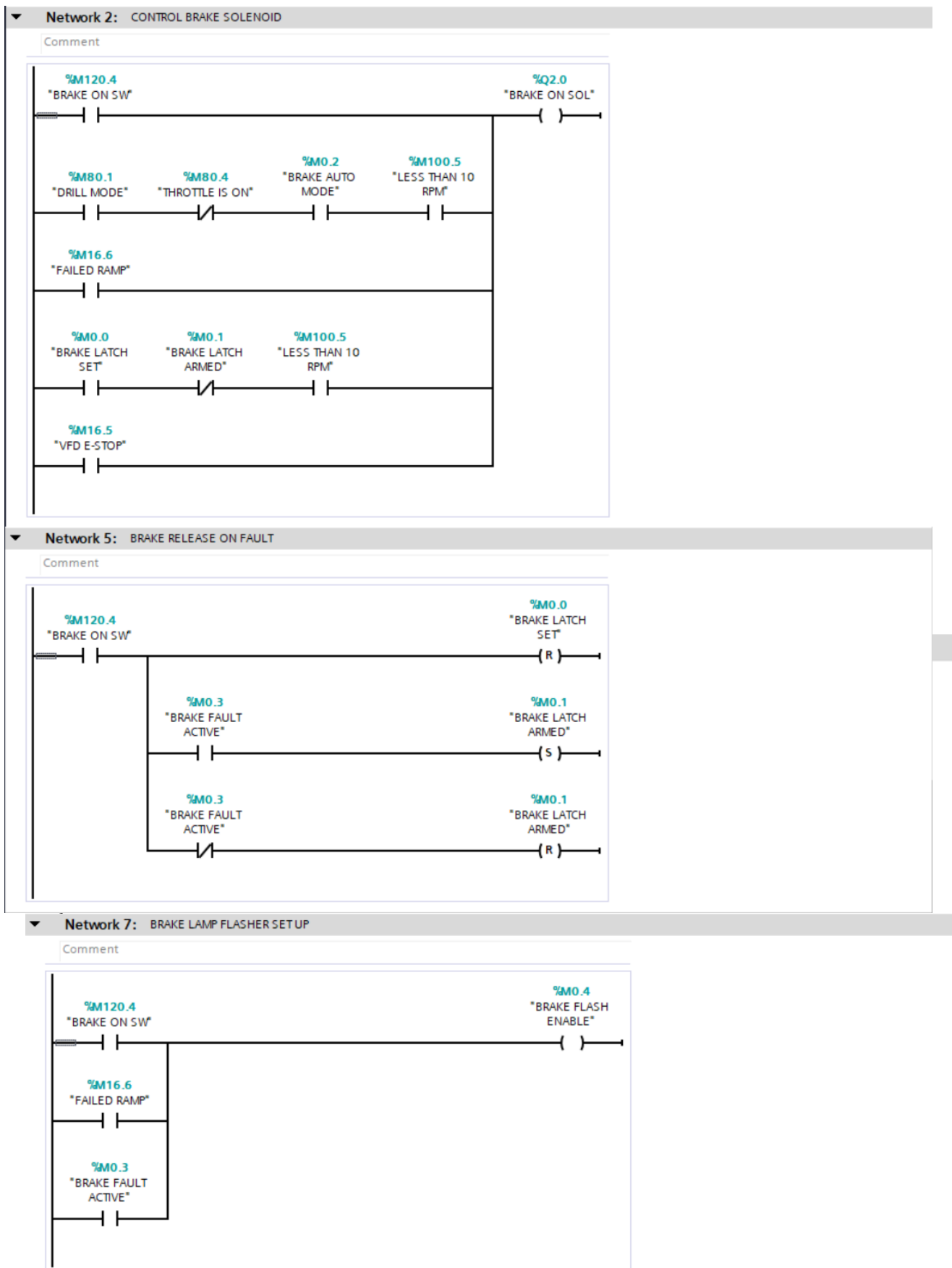


Figure 47: Brake dsc Function.

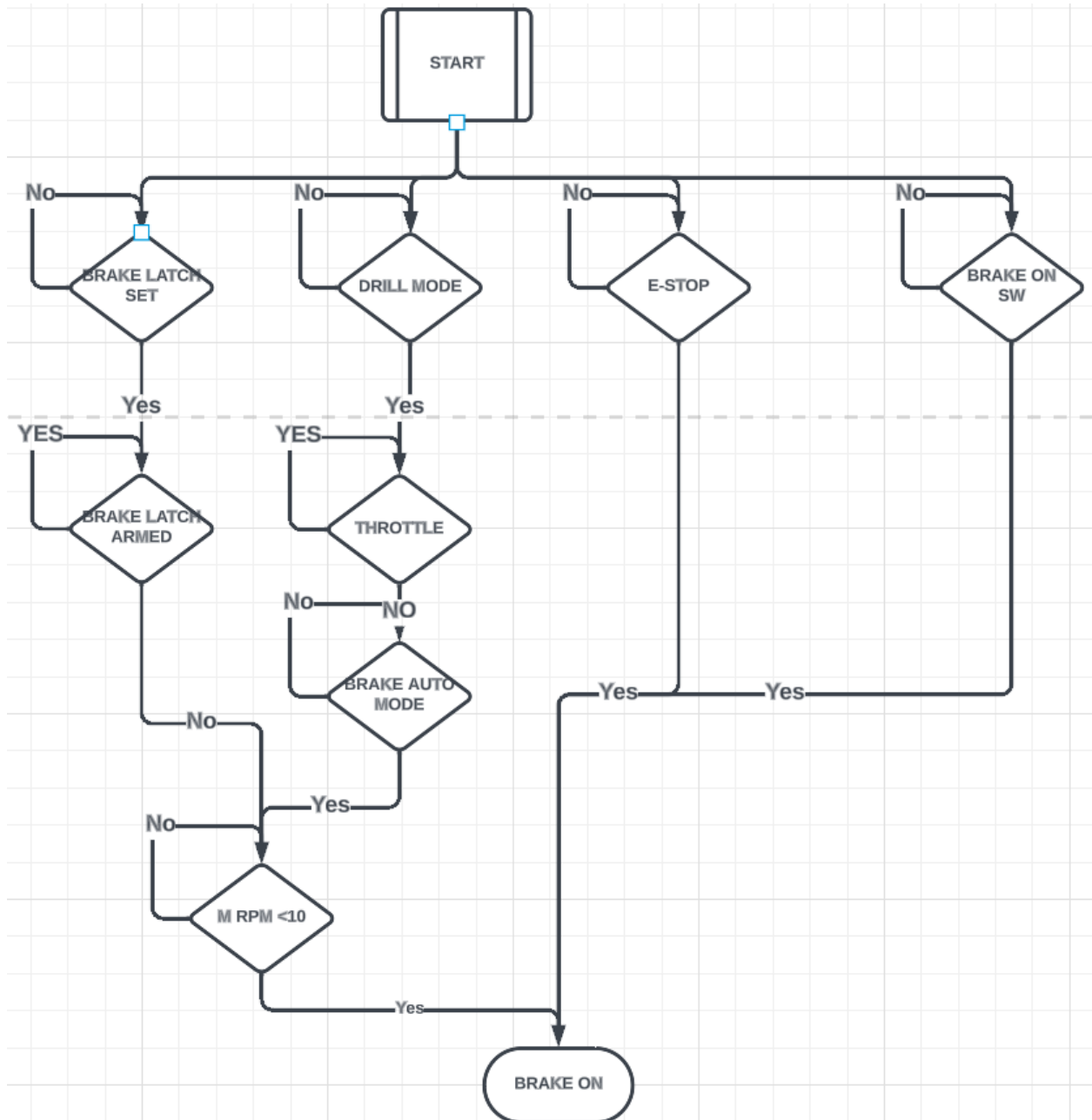
Brake flowchart:

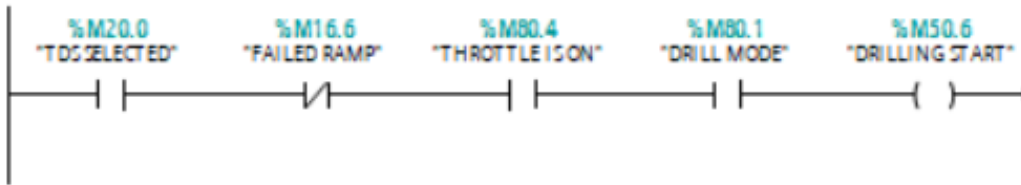
Figure 48: brake flowchart.

3.9 Torque and speed Command:

This function is in charge of the speed signal delivered to the VFD to achieve the desired torque limit. Each network, as shown in the pictures below describes a certain case. Network two send the speed single when the motor is stand still or when they are no torque limitation. Network 2 compare the actual torque received from the VFD with the DRILL TORQUE POT to adjust the speed so the actual torque in less than the limit torque. Network 5 send a speed signal when the TDS is in spin mode or torque mode. In Network 6, we find the conditions that must be achieved to start torqueing. in order to detect that we have reached the desired make up torque, ' top of ramp ' network will set its output and it can be reset by going to drill mode. One the safety features of this function is in network that detect the cases where the makeup torque has not reached the desire torque after going to torque mode.

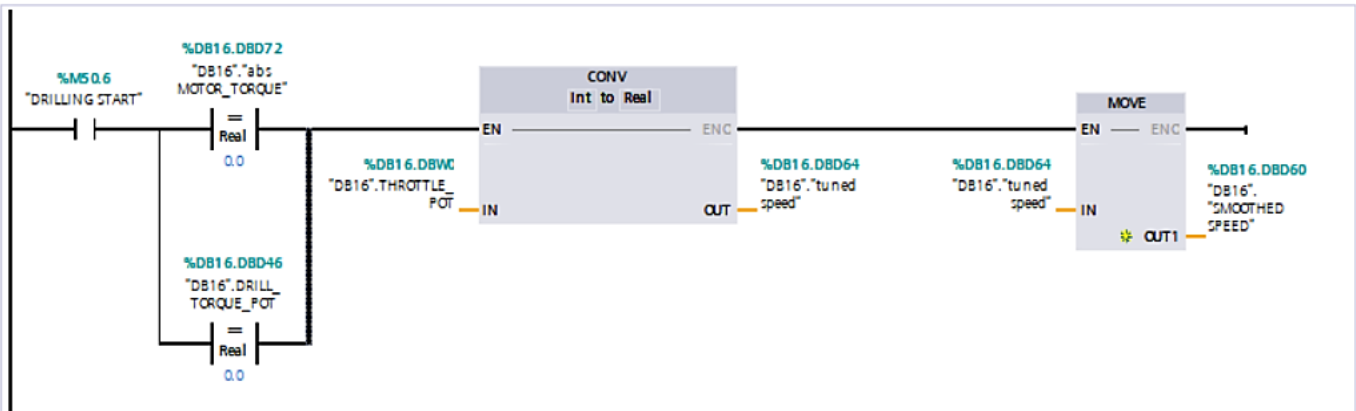
Network 1: DRILLING INITIATION

Comment



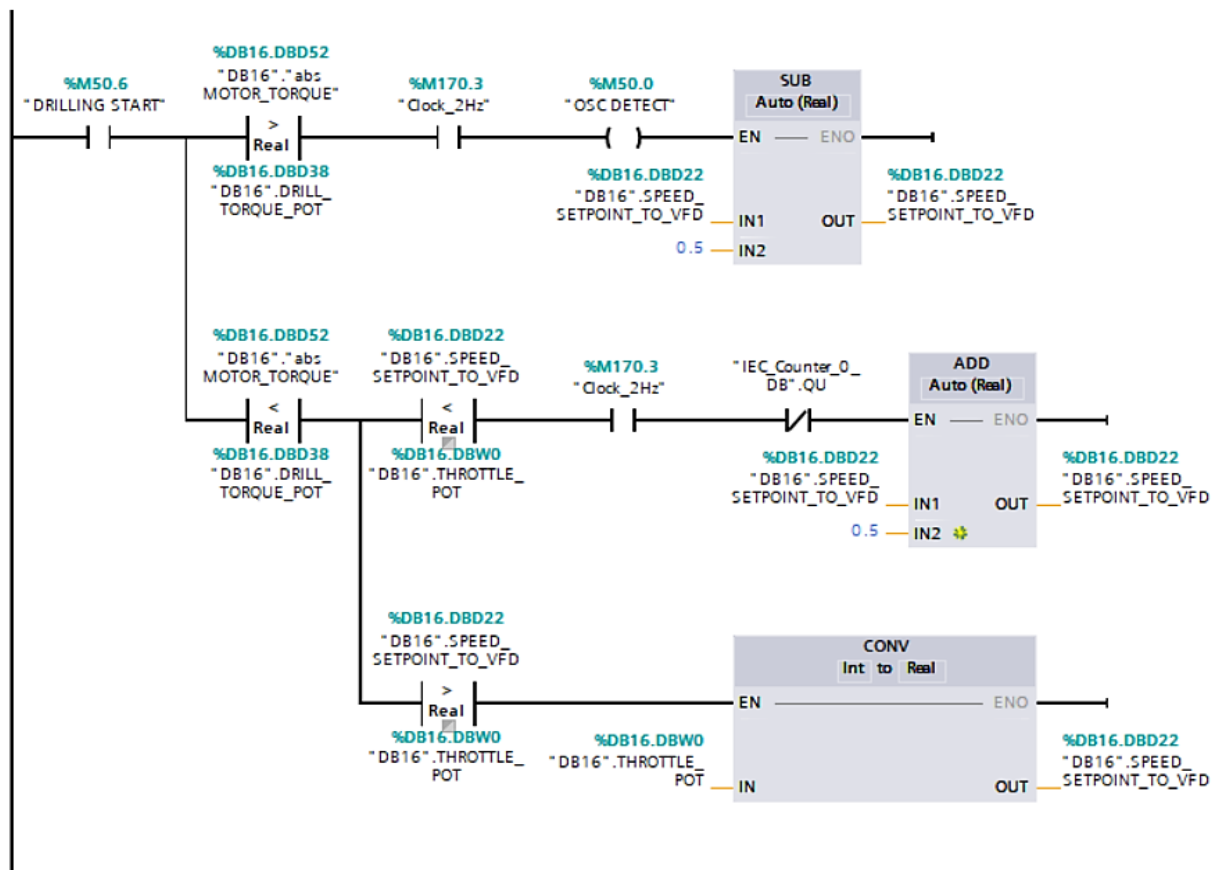
Network 2: DRILL REIN

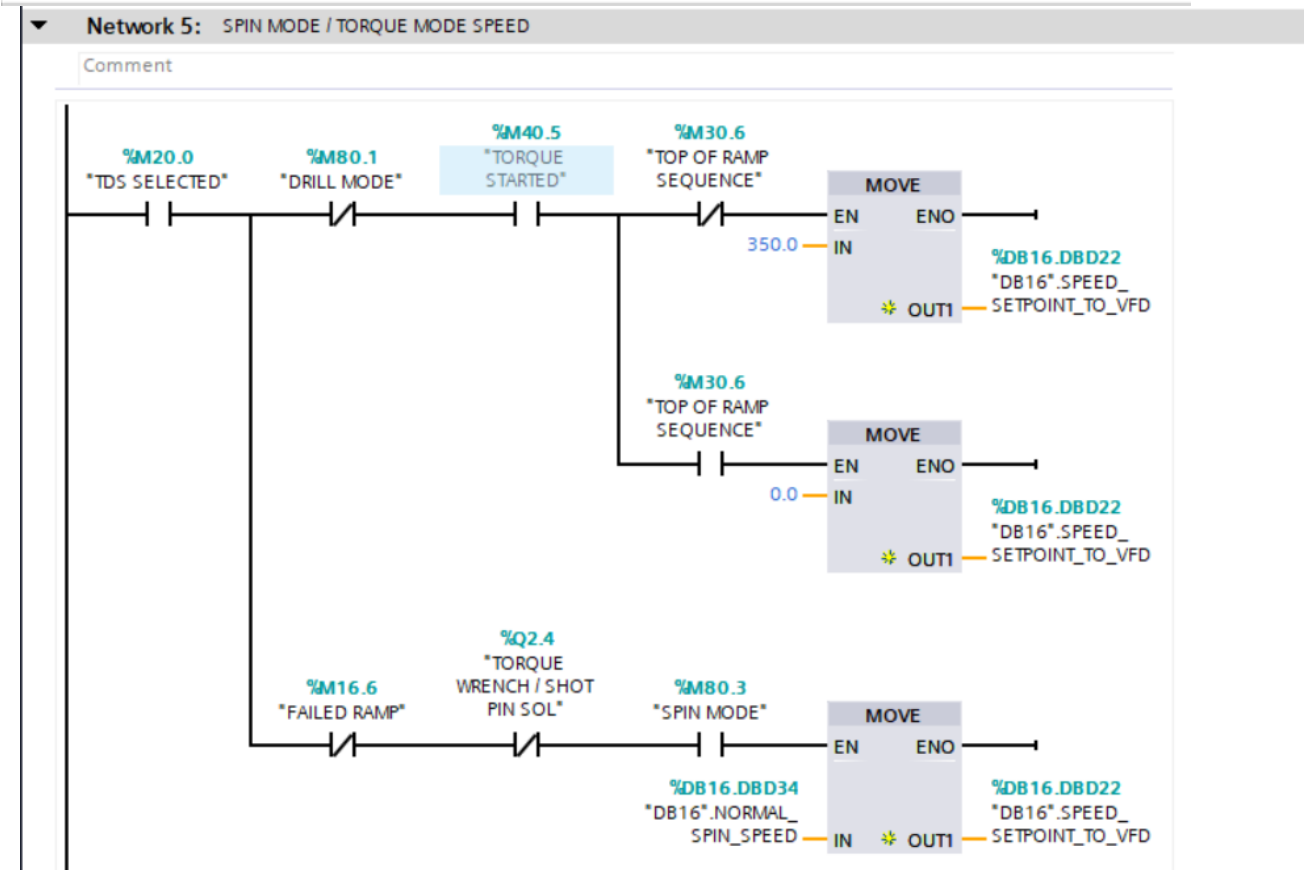
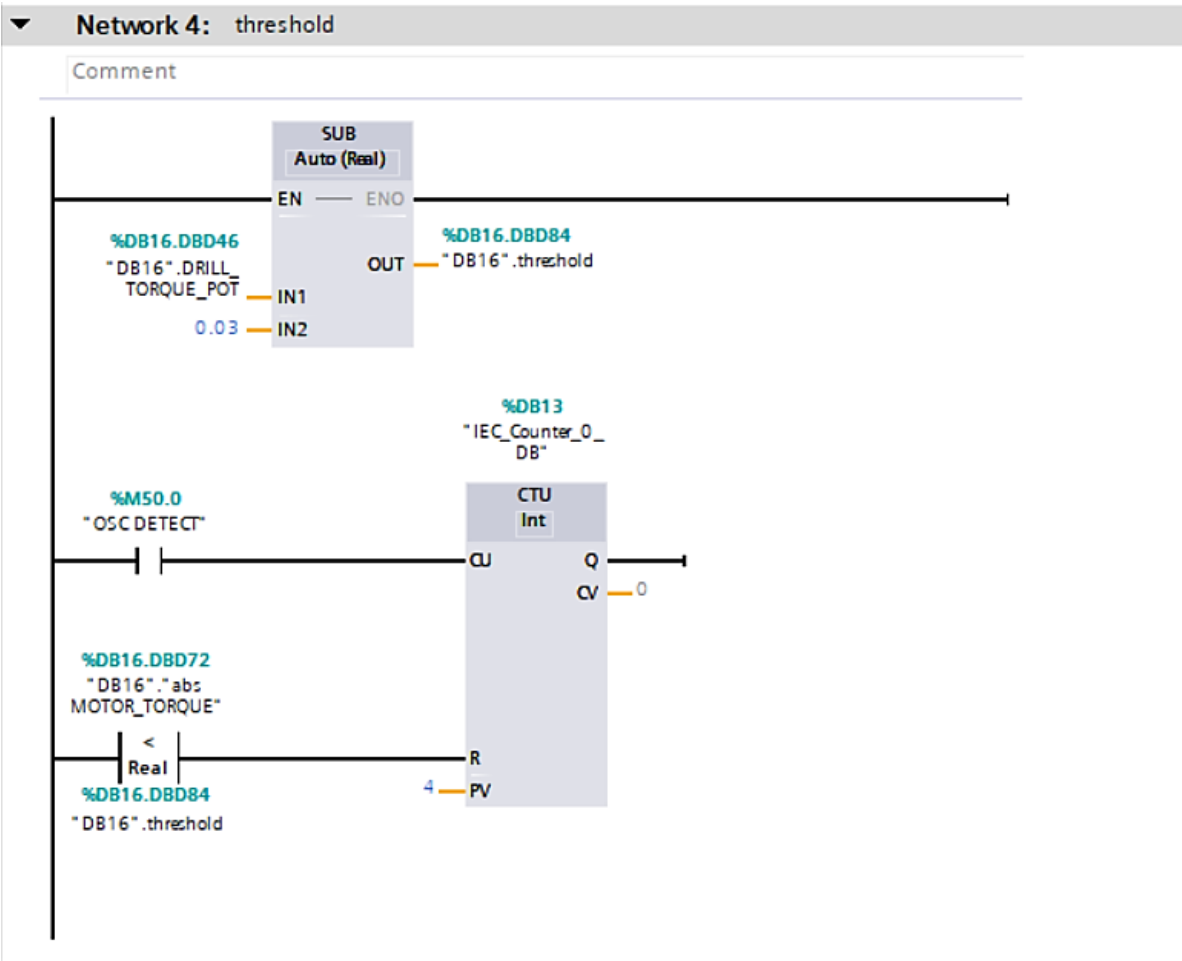
Comment

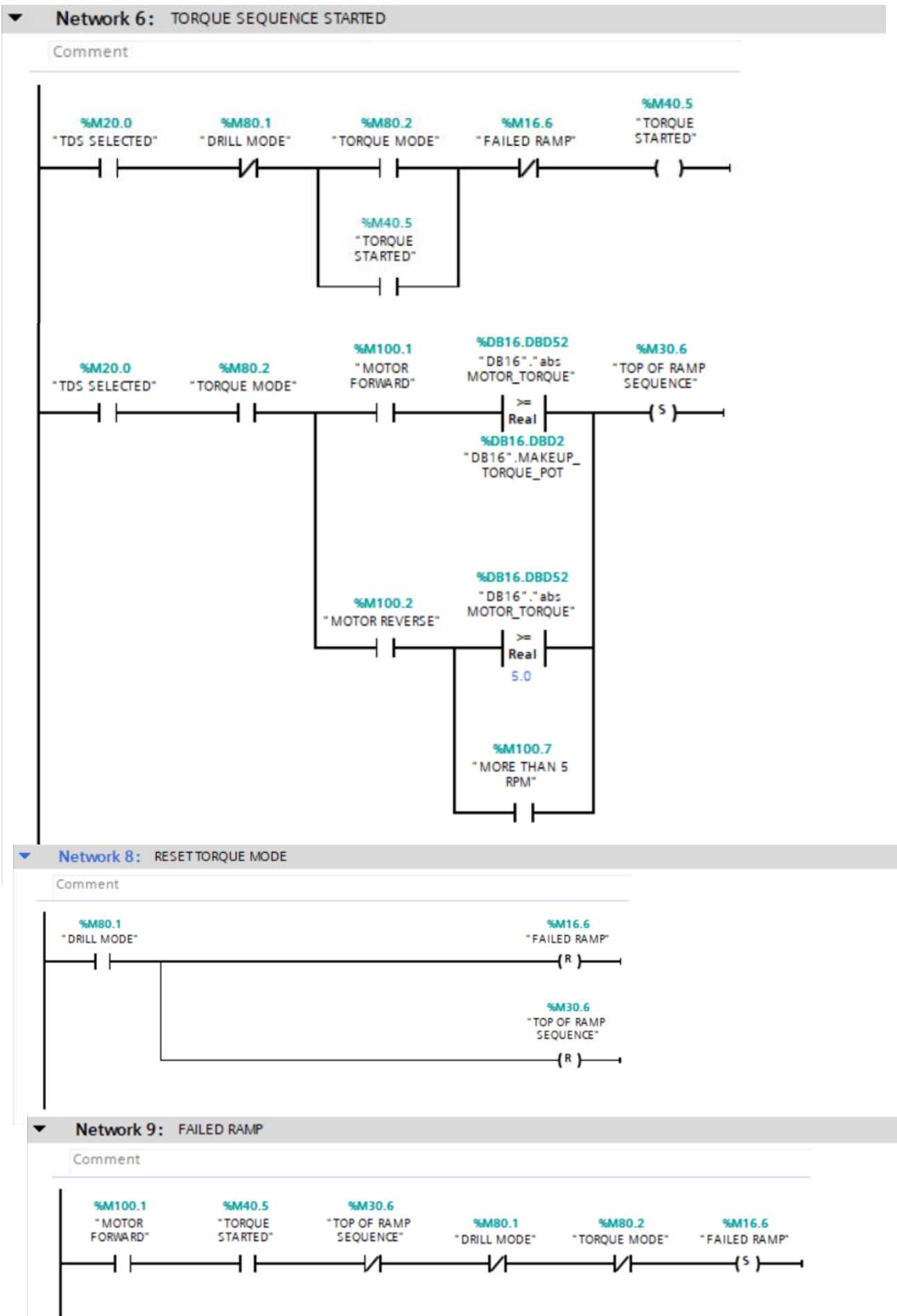


Network 3: RAMP UP / RAMP DOWN

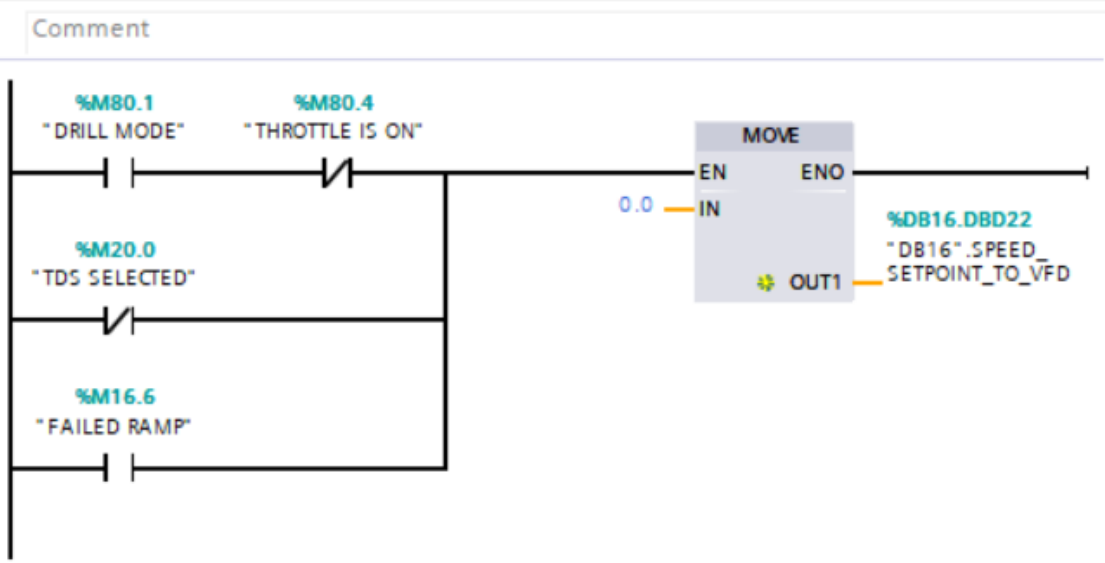
Comment







▼ Network 10: ZERO THROTTLE



▼ Network 11:

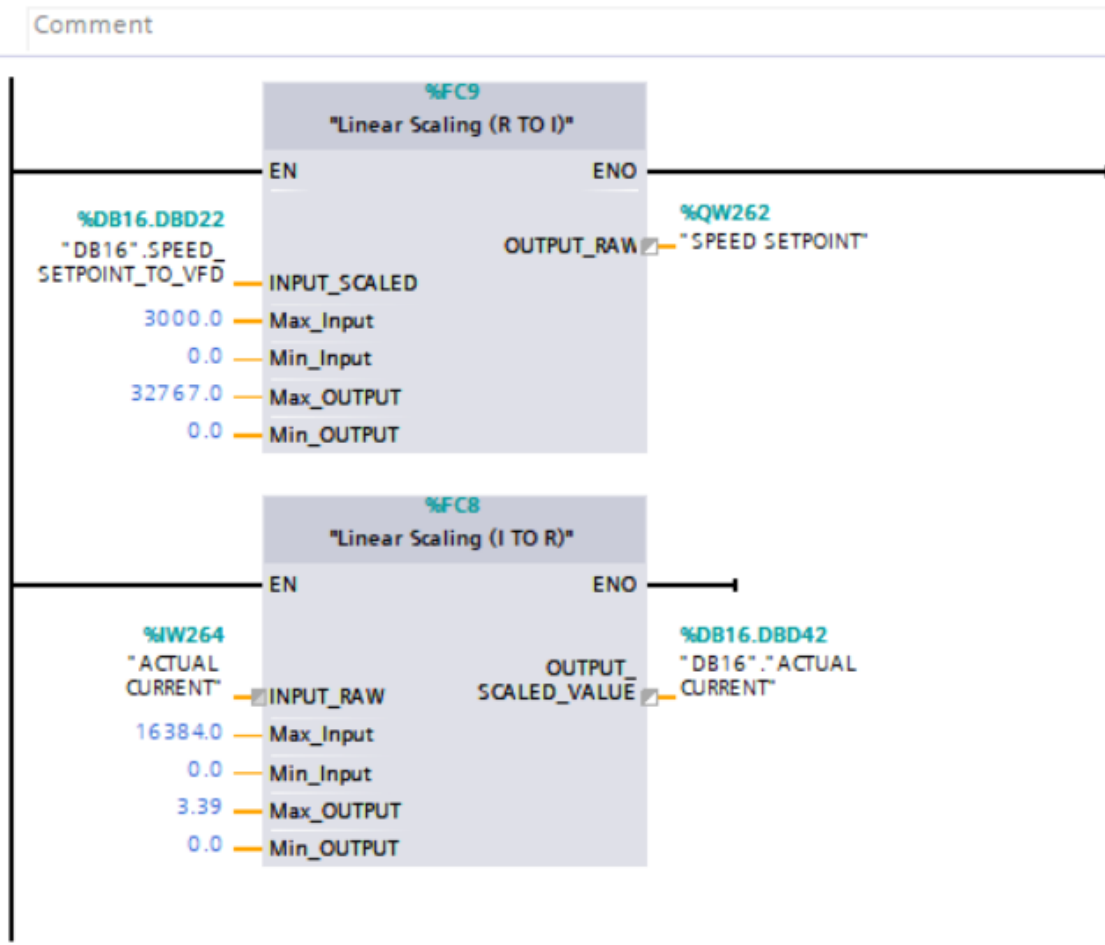


Figure 49: Torque and speed Command

Torque speed Command flowchart:

Figure 50: Comparator flowchart

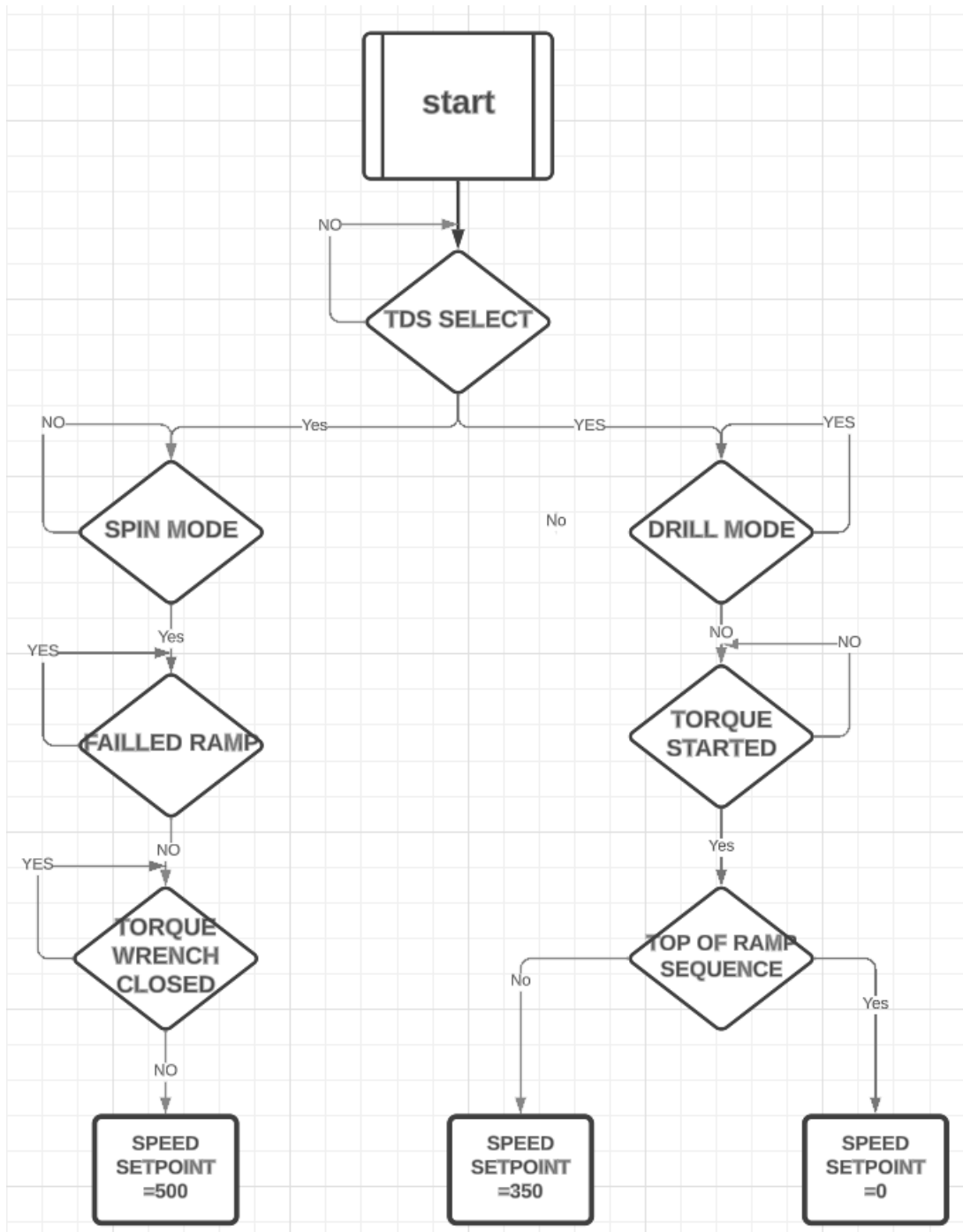


Figure 51: Spin mode torque command

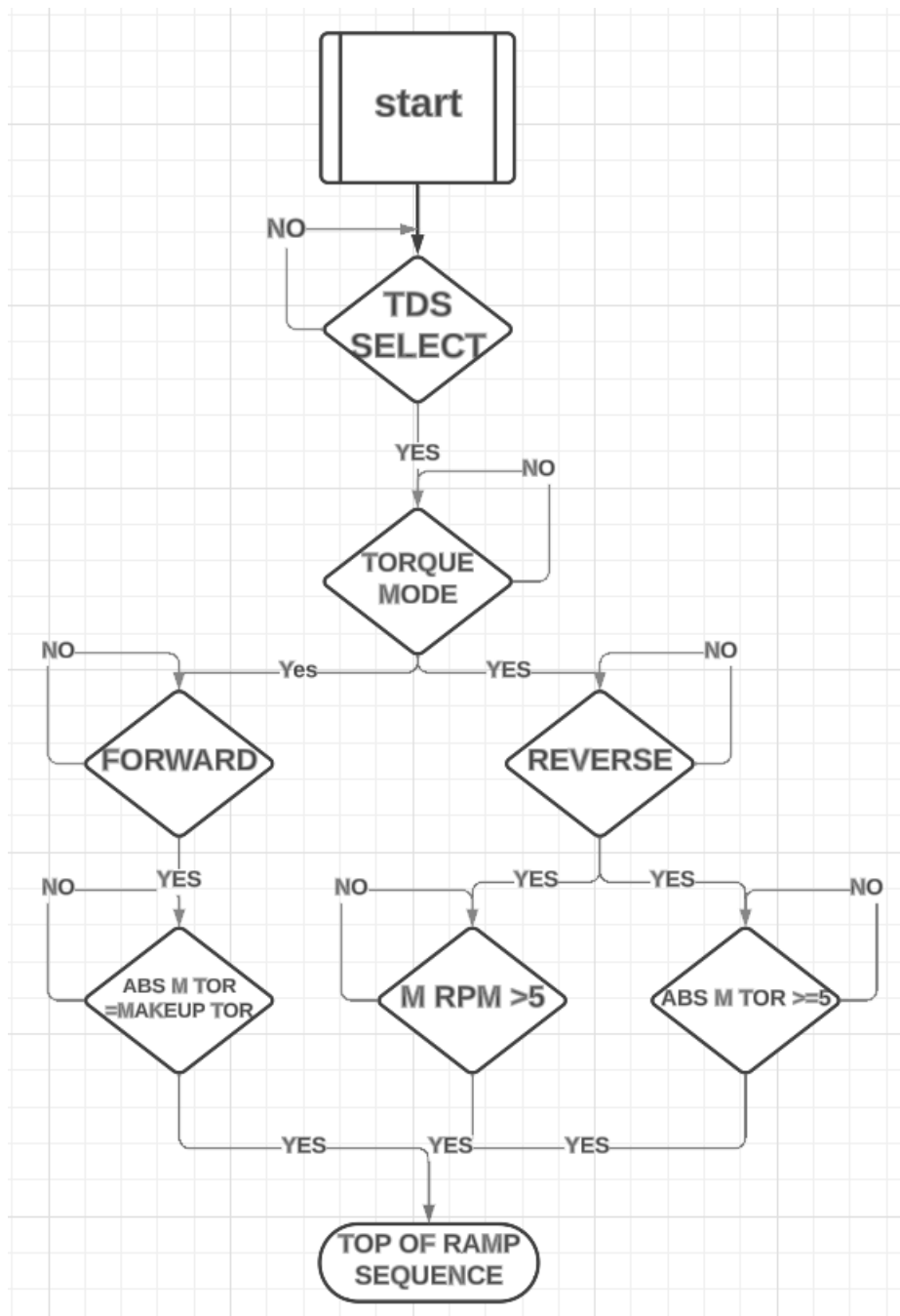


Figure 52: Top ramp torque command.

3.10 Torque Information:

In this function, we will see how we receive the actual torque signal from the VFD and display it on the HMI. In network 1, we map the signal from the analog value to the physical value and then range by multiplying it with the gear ratio and the efficiency and dividing it by 100. We also take some reference points that we are going to use in other functions.

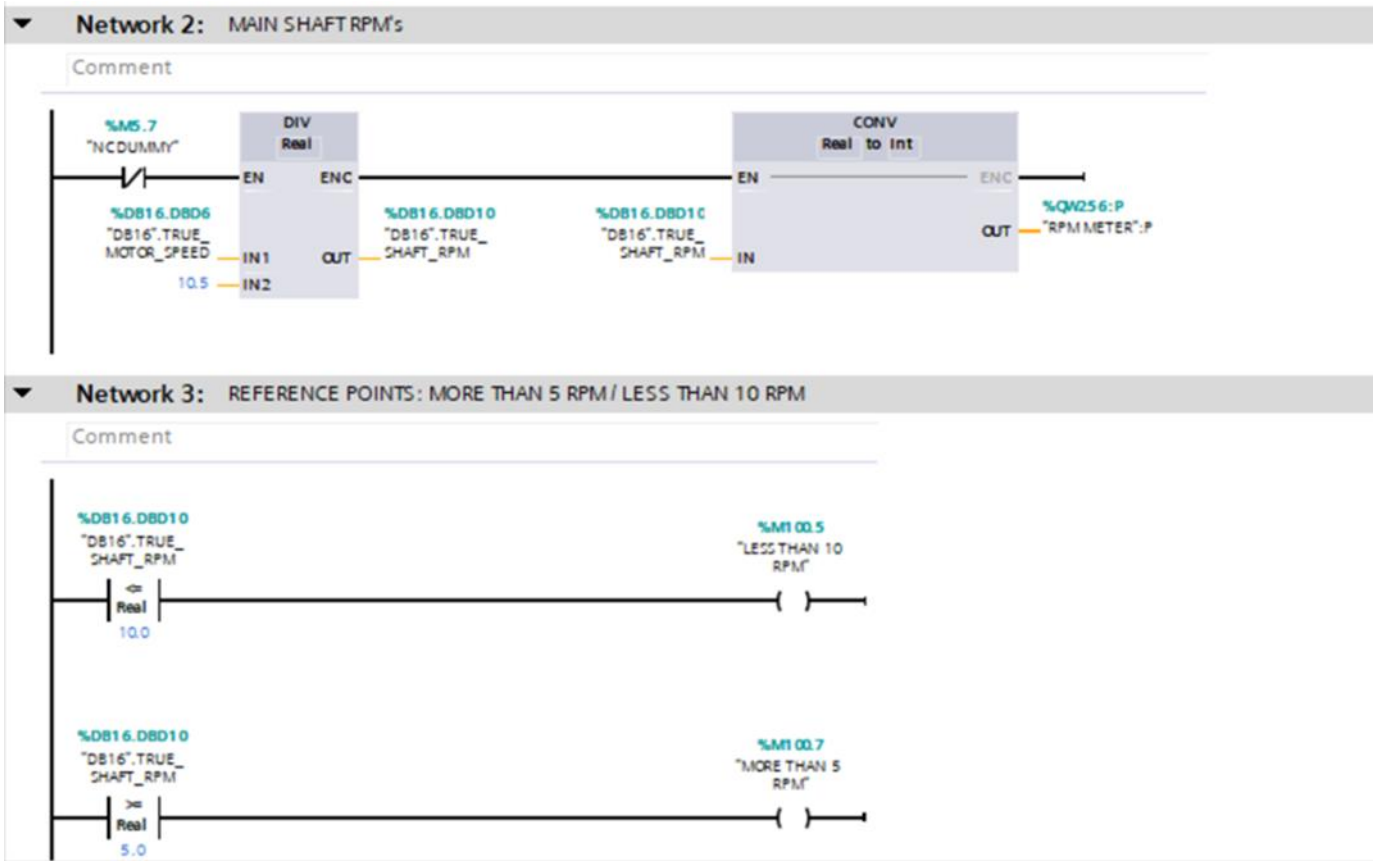


Figure 53: torque information function

3.12 RPM Indicator:

This function is in the process of converting the real speed signal received from the VFD into a physical range that will be displayed on the HMI. In network 1, we used the "Linear Scaling (I TO R)" function to transform the signal from analog to physical, then divided it by the gear ratio to get the shaft RPM. We also collect certain reference points that we will need in subsequent functions.

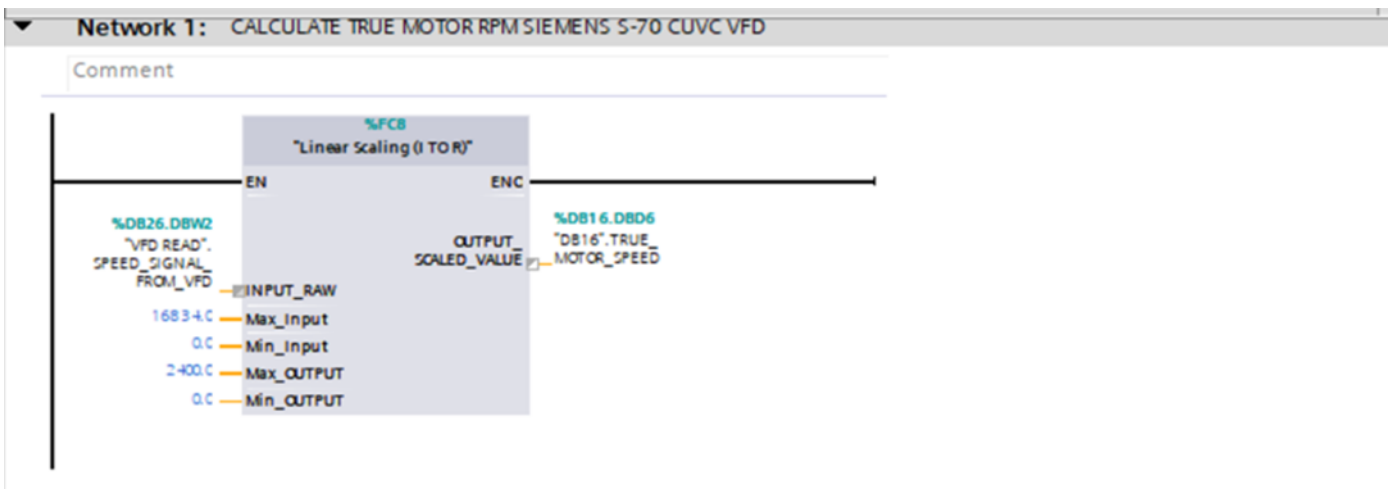


Figure 54: RPM indicator.

Linear scaling flowchart:

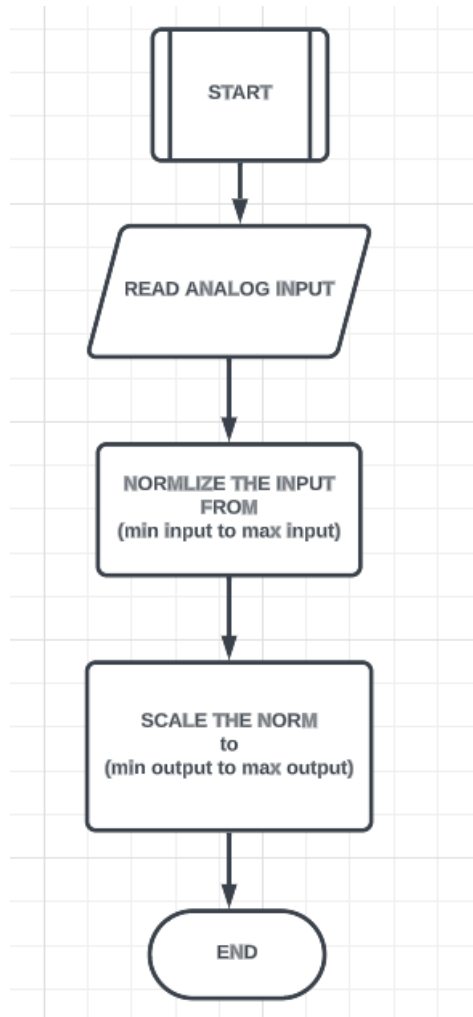
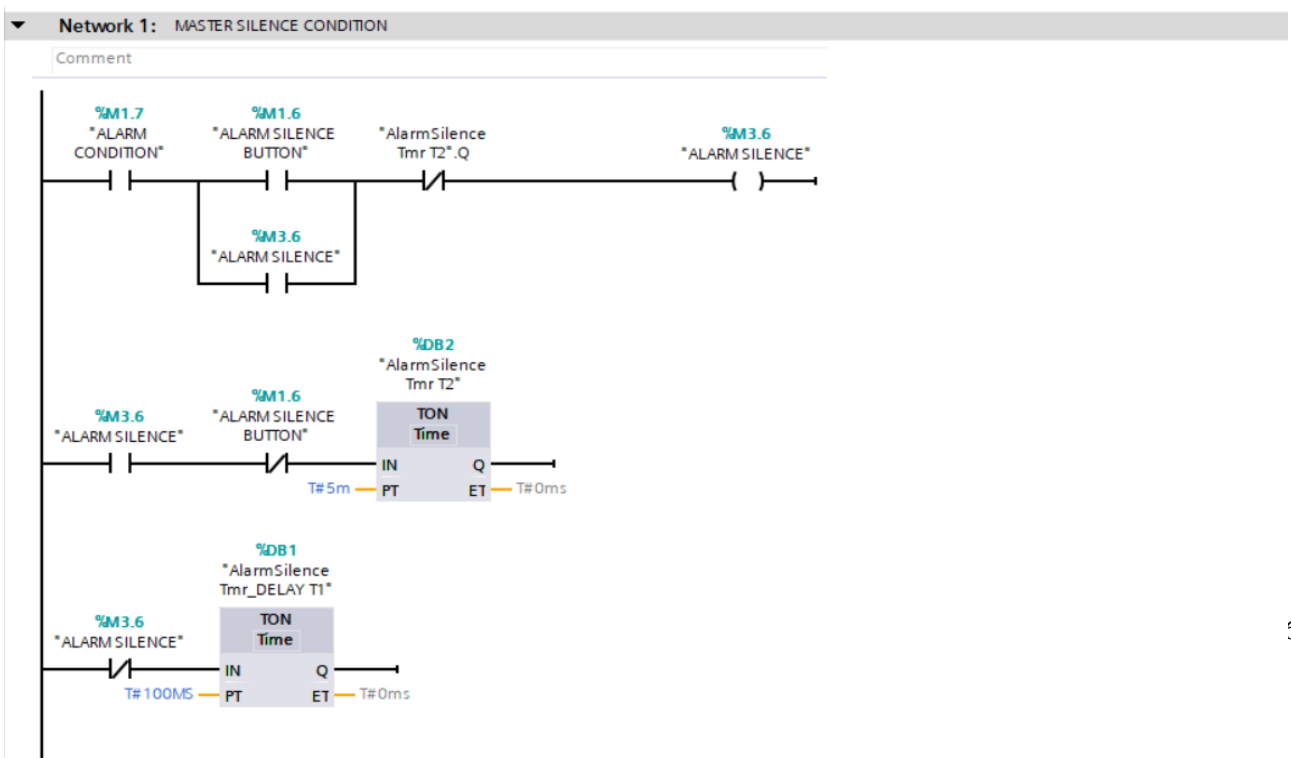


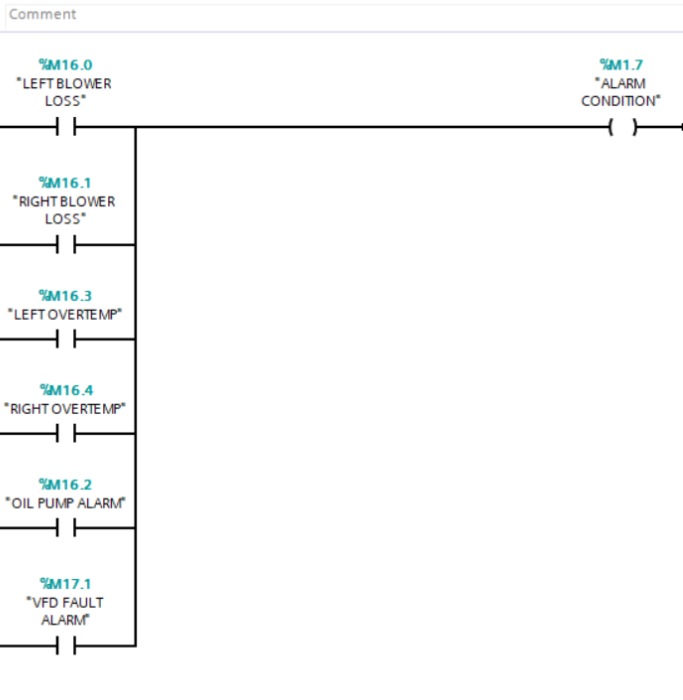
Figure 55: Linear scaling flowchart

3.13 Alarm function:

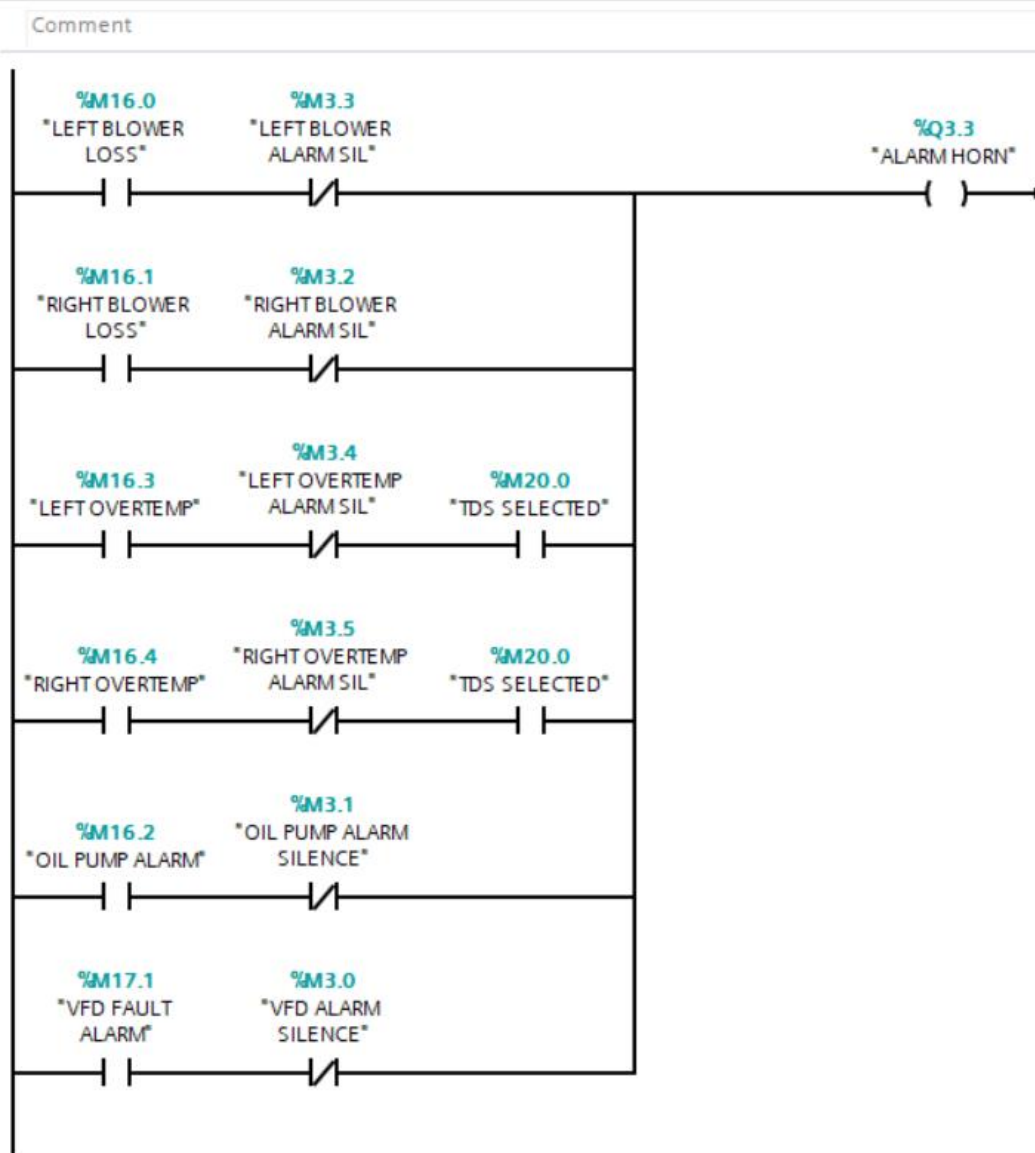
The three main Alarm signals are coming from the blower (left or, right), the over temperature, and the vd for any motor faults.



Network 2: Alarm Condition

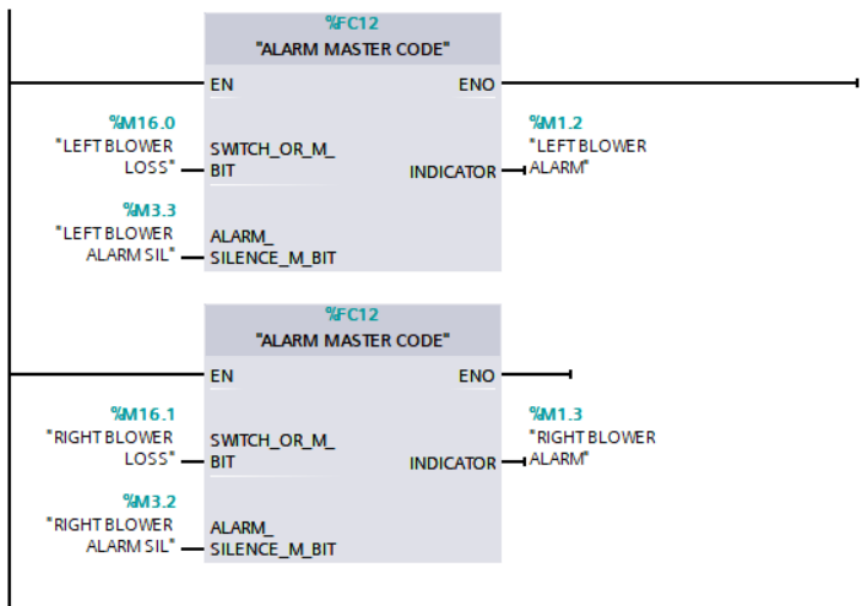


Network 3: Alarm Horn



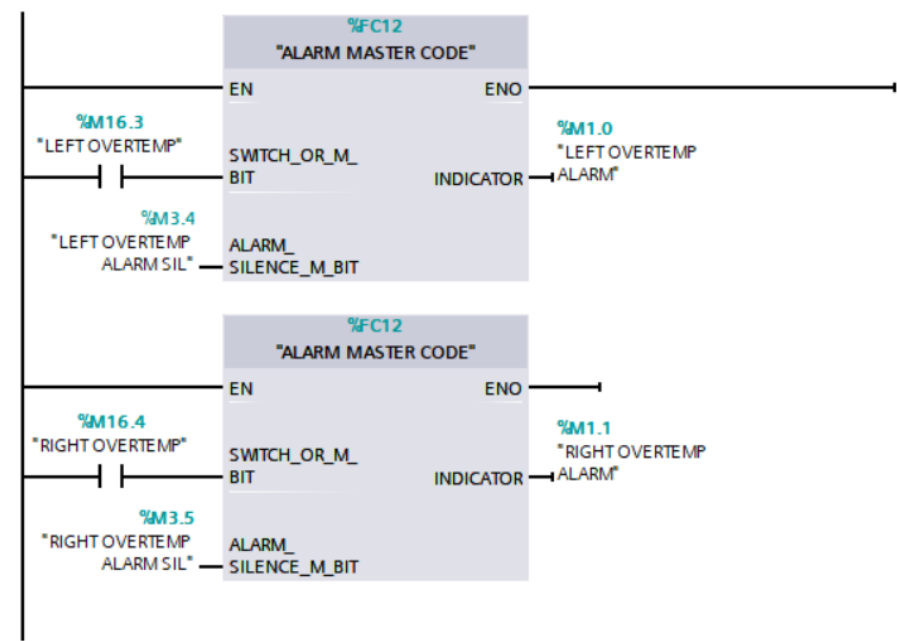
Network 4: BLOWER ALARM

▶ If blower has been ON for at least 10 seconds and the blower pressure ...



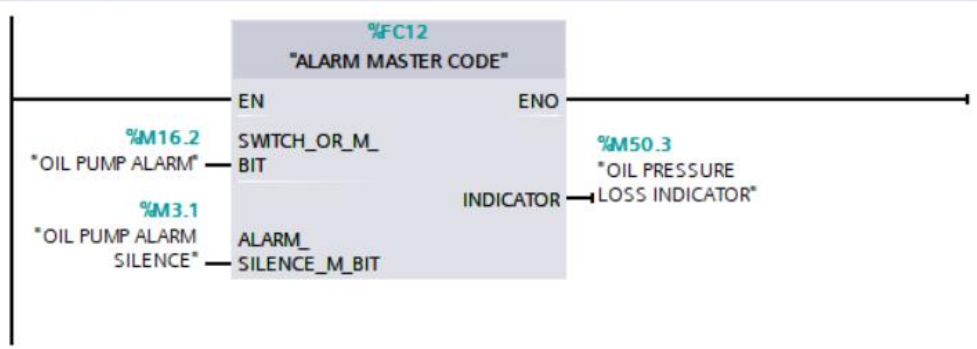
Network 5: OVER TEMP ALARM

Comment



Network 6: OIL LUBE ALARM

▶ If oil pump has ben ON for at least 10 seconds and the oil pressure switch ...



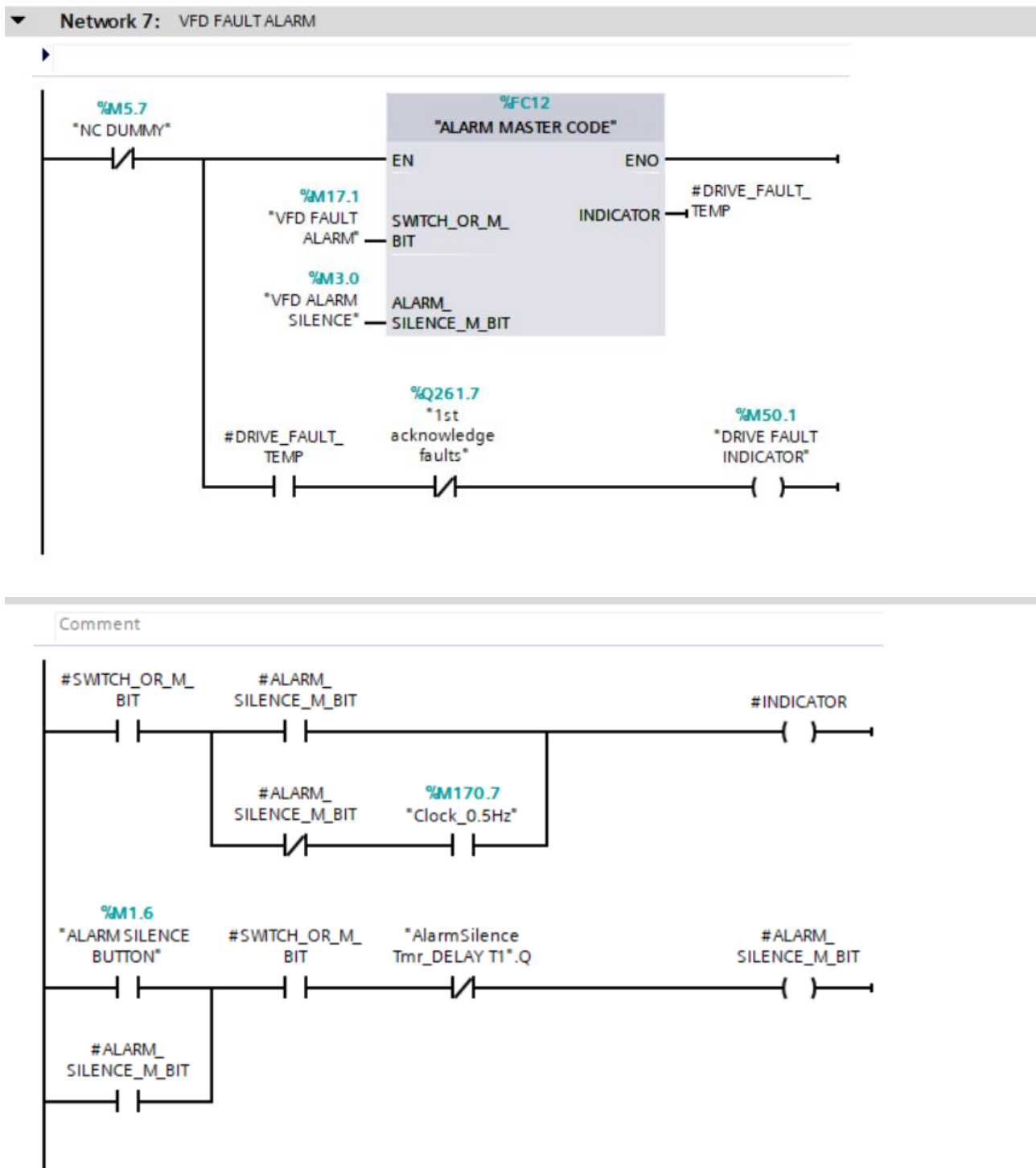


Figure 56: Alarm Function.

3.14 Horsepower limitation function:

For this function, a calculation of the real shaft horsepower founded by applied a physics law $p = T * \omega$ To be stored in DB16, next a horsepower limiter preventer added to protect both motors from exceeding the rated power.

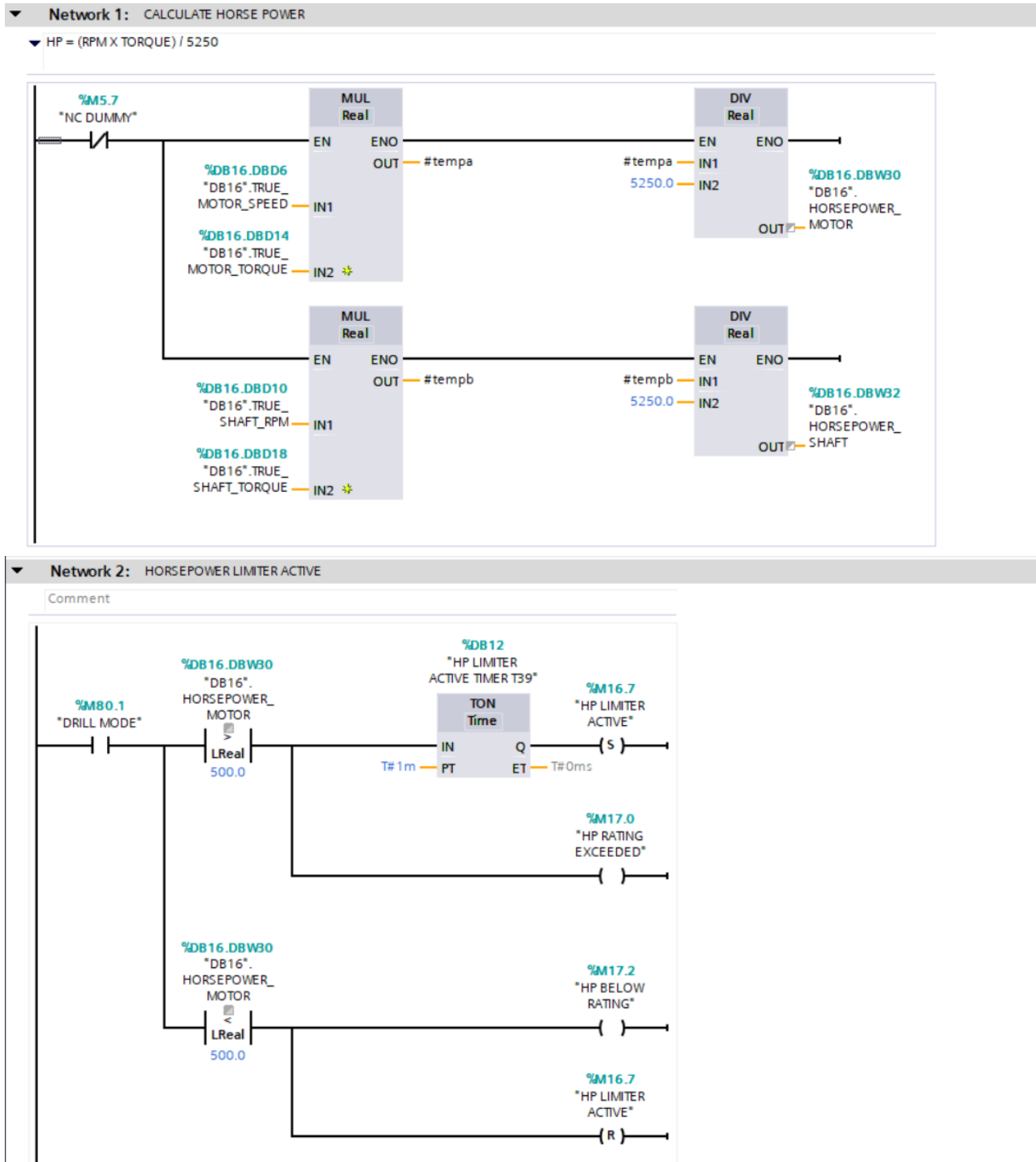


Figure 57: Horsepower limitation

Horsepower limitation flowchart:

The horsepower limitation function in a TDS/11 SA is used to prevent the top drive from exceeding its maximum horsepower rating. This is important to do in order to protect the top drive from damage and to ensure the safety of personnel.

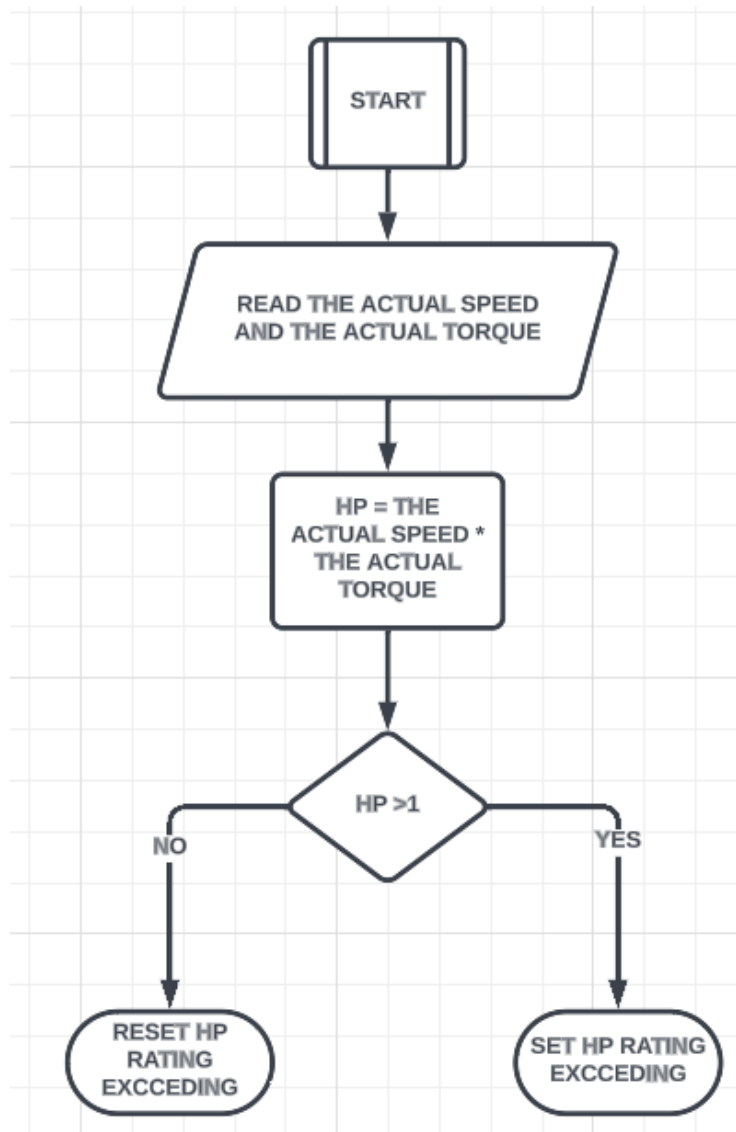


Figure 58: Horsepower limitation flow chart

4. HMI DESIGN:

HMI is an acronym for “human-machine interface”, which is a technology that allows humans to interact with machines. A communication interface lets an operator control a machine or system via numerous input and output devices. HMI is utilized in many industries for offering an intuitive and user-friendly interface via which operators can monitor and manage various parts of a machine or process. Temperature, pressure, speed, and other data may be included. Depending on the application, the interface may include a touchscreen, buttons, dials, voice instructions, or other forms of input and output devices.

For our project, we used the Siemens TP1200 Comfort PRO is intended to provide high capability and usability for industrial automation applications, including machine and plant engineering, process visualization, and data analysis. A 12-inch high-resolution touchscreen display, various communication ports (including Ethernet, USB, and RS232), and several built-in software tools for programming and visualization are among the primary characteristics of the Siemens TP1200 Comfort PRO. Advanced security measures, such as user authentication and data encryption, are also included to assist secure critical information and prevent unwanted access.

Main Screen:

The main screen has a variety of controls and feedback tools that allow the operator to select the various modes via a user interface. The operator can choose the desired speed and torque, as well as the direction of the TDS. Two gauges allow the operator to monitor the shaft torque and speed, as well as an emergency stop button in case of an accident

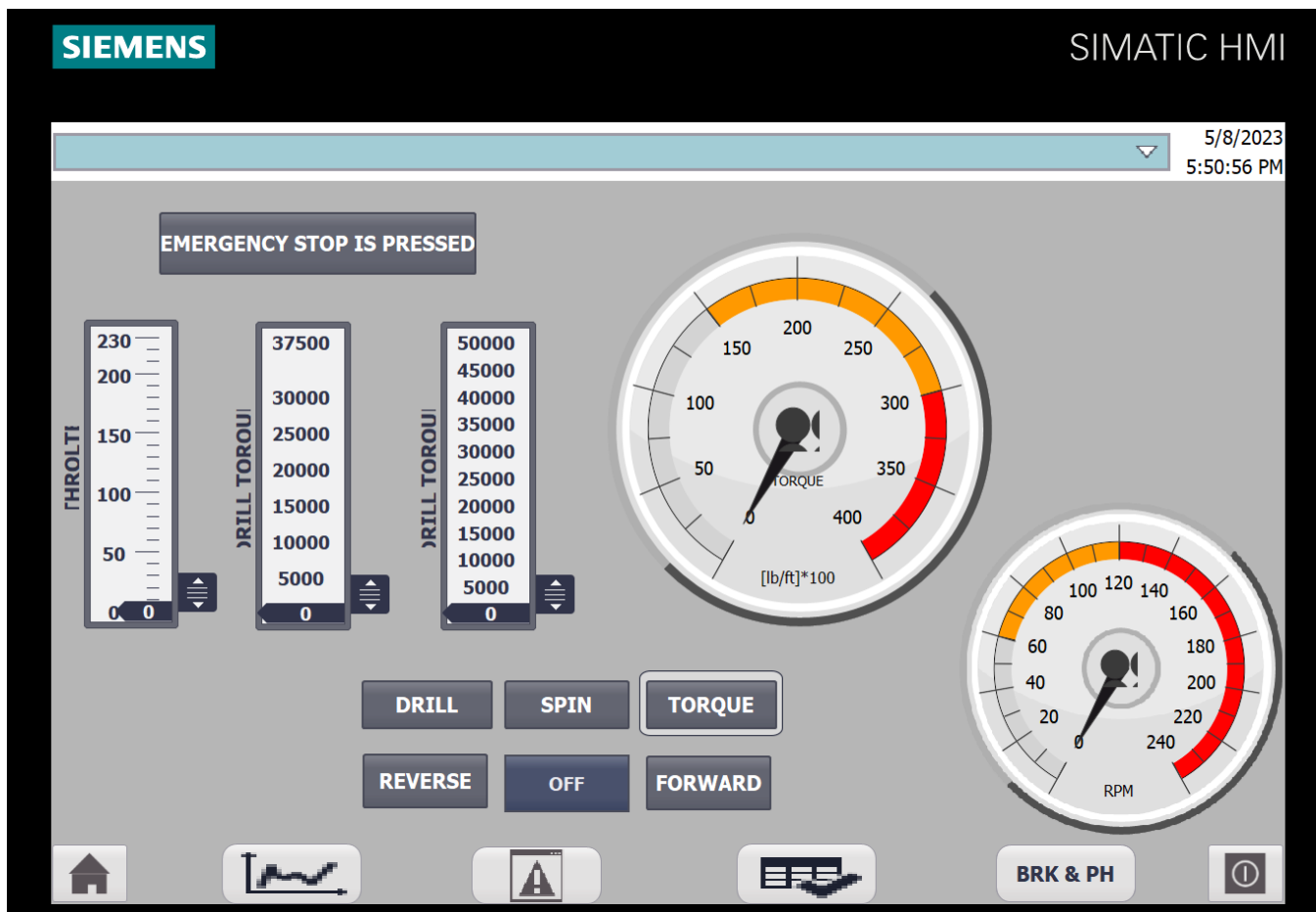


Figure 59: Main Graph Screen

4.1 The Graph screen:

The Trend View is a strong feature in the TIA Portal HMI tools that allows the user to monitor and analyze process data over time. It displays historical process data graphically, allowing operators to quickly recognize trends, patterns, and abnormalities in the process, which help the operator to develop strategies to optimize it. Users can define different colours for each data point, set up zooming and scrolling functions for better data analysis, and add annotations and comments to the trend view

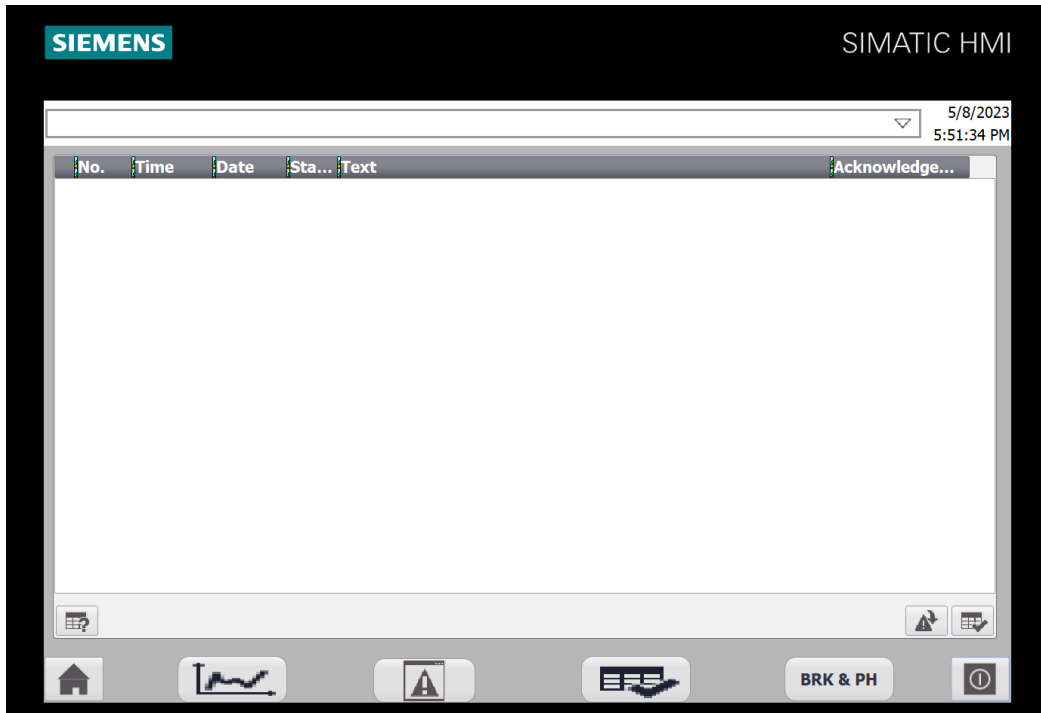


Figure 60: Graph Screen

4.2 The Alarm Screen:

The Alarm tool is another powerful feature that provides the ability to monitor and respond to the occurrences of alarms in real time. It alerts the operator visually when an aberrant situation arises in the process being monitored like motor overheating or exceeding the horsepower limits. It also is used to establish alarms based on predefined criteria such as process variables, time, and limit values. When an alarm occurs, the tool shows the alarm message on the HMI screen, as well as an auditory alert and a flashing visual cue. This allows operators to quickly determine the type and severity of an alert and take necessary action to remedy the problem.

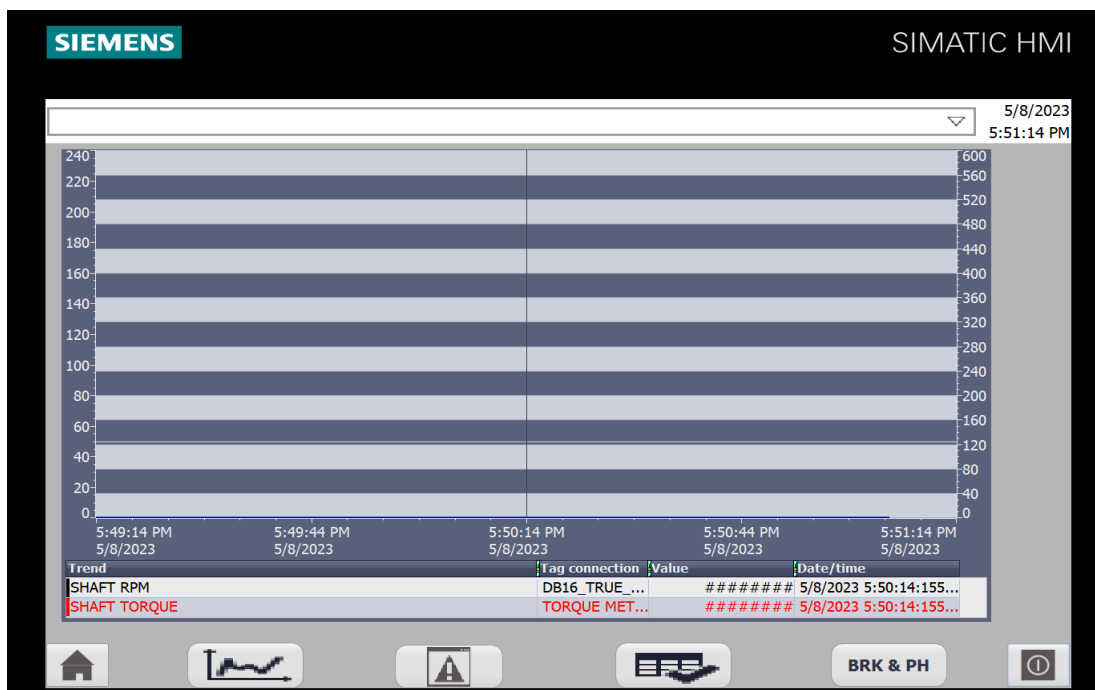


Figure 61: Alarm Screen

4.3 BRK&PH:

An acronym stands for BRAKES AND PIPE HANDLER. This screen provides the operator with the centralized control to regulate the TDS's critical functions, such as the brakes, LINK TILT POSITION, IBOP, and TORQUE WRENCH to ensure the safety and efficiency of drilling operations

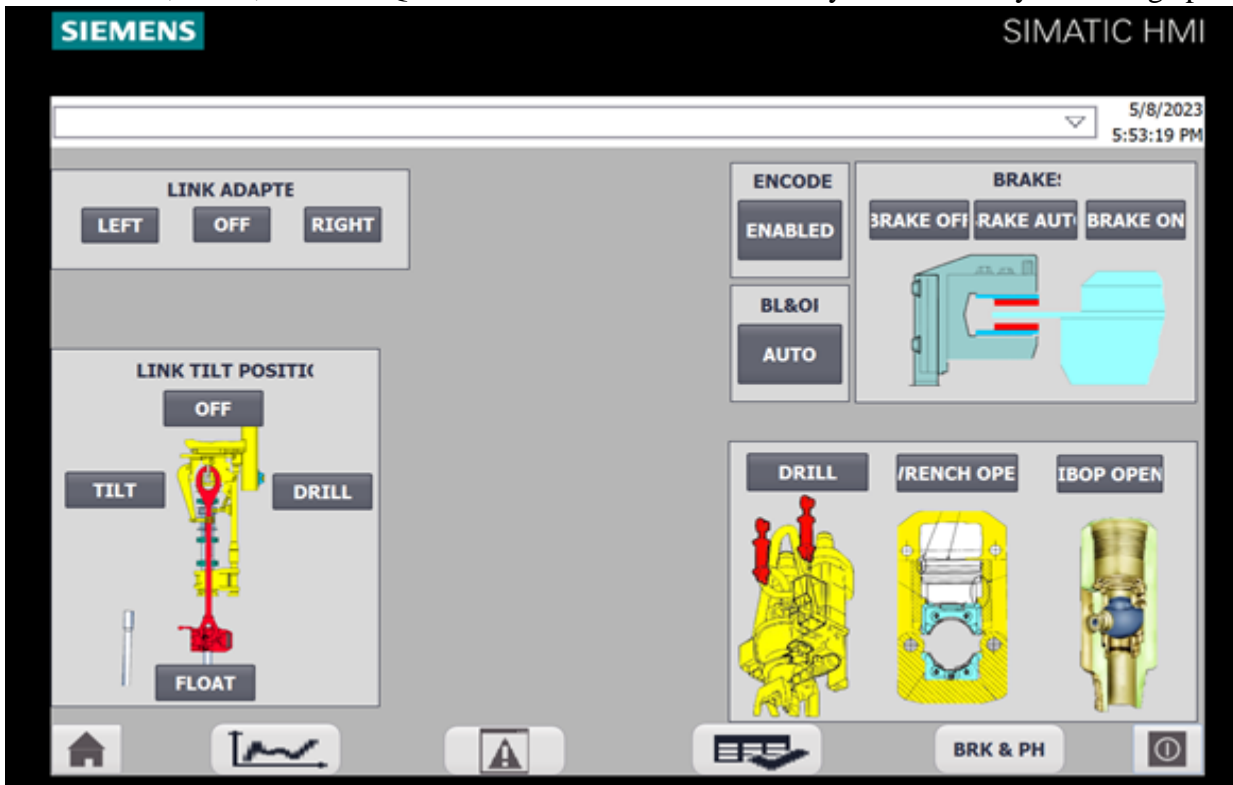


Figure 62: BRK&PH screen.

4.4 Makeup Torque Recipes:

The TIA Portal HMI software provides its users with a recipe tool that creates templates that define the structure of a recipe, including the types of data, variables, and values needed to produce a product. Once the template is created, users can then create individual recipes by filling in the required data and values for each step of the process.

The user can also change or delete according to the change in process. In our case, the driller can set the required makeup for each type or size of the drill pipes.

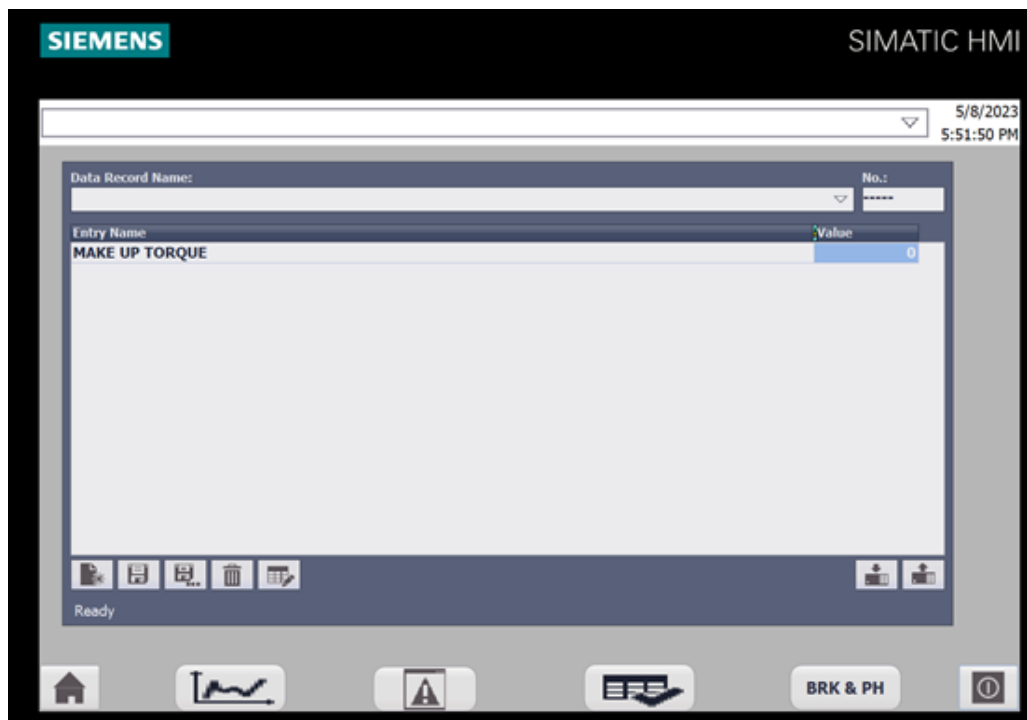


Figure 63: Make-up recipes.

5. Variable Frequency Drive (VFD):

A variable frequency drive (VFD) is one of the main pieces of equipment in the automation domain. It is used to regulate the speed of the induction motors. VFDs are utilized in many different applications, such as fans, pumps, conveyors, and machine tools. Their principle is converting the supplied alternating current to a direct current, which is then utilized to generate an alternating current with variable frequency according to an input signal. This change in frequency provides speed and torque control for the motors. VFDs have two main units: control and power units. Some of the advantages that the VFDs provide are:

- Improve efficiency due to the adjustable speed of the motor to match the load, which reduces the amount of wasted power.
- Provide a smooth acceleration and deceleration, which reduces noise level and the mechanical stress of the motor.
- Due to the speed control that the VFDs provide, the motor can be operated in a variety of applications.

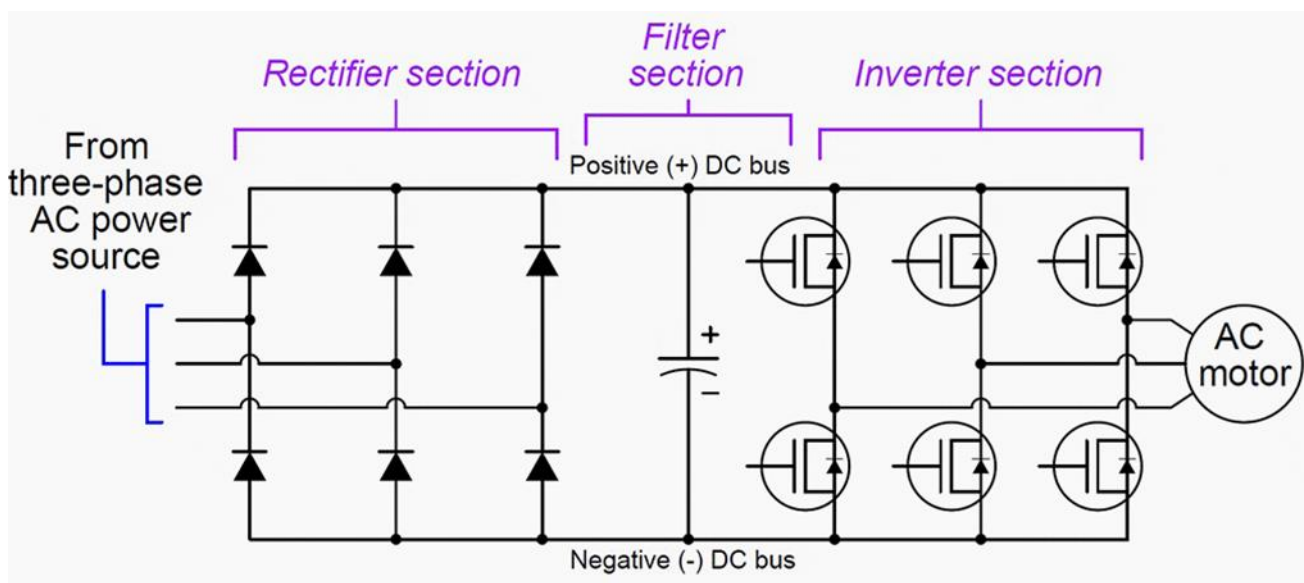


Figure 64: VFD schematics diagram [20]

5.1 VFD Control Methods:

5.1.1 Scalar control methods:

Scalar VFD control is a method of controlling the speed of an AC motor by varying the voltage and frequency of the power supplied to the motor. The voltage and frequency are adjusted in a way that maintains a constant ratio between them, which keeps the strength of the magnetic field in the motor constant. This, in turn, ensures that the motor produces a constant torque regardless of its speed.

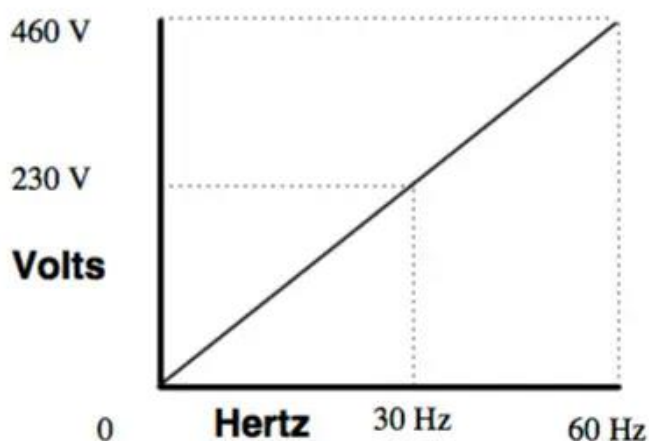


Figure 65: V/F relation in VFD

5.1.2 Vector Control Method:

Vector control is a variable-frequency drive (VFD) control method in which the stator currents of a three-phase AC or brushless DC electric motor are identified as two orthogonal components that can be visualized with a vector. One component defines the magnetic flux of the motor, and the other the torque. The control system of the drive calculates the corresponding current component references from the flux and torque references given by the drive's speed control. Typically proportional-integral (PI) controllers are used to keep the measured current components at their reference values.

Vector control is a more sophisticated control method than scalar control, and it offers several advantages, including:

- Improved speed control.
- Reduced motor heating.
- Increased motor efficiency.
- Improved dynamic response

Note:

The used method in our project scope is Scalar Control because it's Simple and easy to implement Inexpensive, Reliable, Widely available.

5.2 Siemens G120 variable frequency drive:

In our project, we used the SINAMICS CU240E-2 PN as the control unit and the SINAMICS PM 240-2 as a power unit. The VFD has the following characteristics [13]:

- Wide power range - from 0.55 to 2.50 kW.
- Three variants of frequency converters with voltages of 200V, 400V, and 690 V.
- Additional security features: Sinamics G120 can be equipped with two types of safety packages - STARTER or Start drive.
- The system is easily combined with a diversity of applications.
- Modular design with easy connection and building.
- IP20 / IP55 Enclosure rating.
- From 4 to 11 digital inputs
- 1-2 analog inputs.
- The main advantages of using Sinamics G120 are an integrated security function with a set of innovative features, a system for returning excess electricity to the power network, as well as a new principle of cooling and compatibility with any kind of automation.

Siemens VFD g120 is an innovative range of frequency modular inverters with smart access and easy integration with the main controlling applications in automated processes [13].

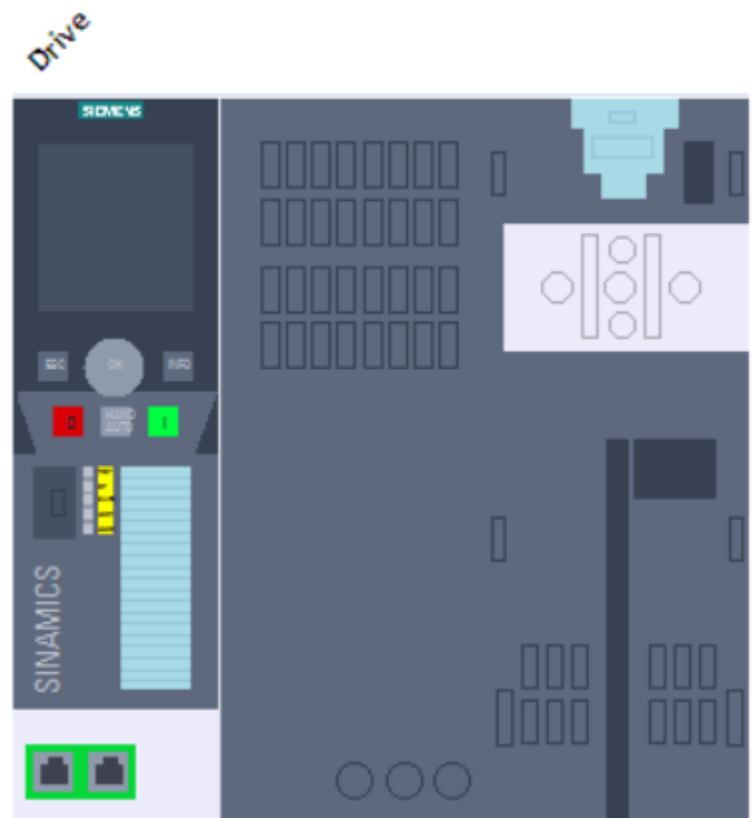


Figure 66: SINAMICS CU240E-2 PN VFD

6. Industrial Communication protocol:

Industrial communication is the process of exchanging data between devices in an industrial setting. It is used to control and monitor machines, collect data, and improve efficiency.

Industrial communication networks can be wired or wireless, and they use a variety of protocols to communicate like Modbus, Profibus, Profinet, OPC UA, and Ethernet/IP.

6.1 Profinet:

PROFINET is an open, standard-based communication technology for industrial automation based on Ethernet. It enables real-time communication between devices at the field level, the control level, and the management level. PROFINET is used in a wide range of applications, including machine tools, assembly lines, and process automation.

PROFINET offers several advantages over other industrial communication technologies, including:

- Real-time performance: PROFINET is capable of delivering data under tight time constraints, which is essential for many industrial applications.
- Open standard: PROFINET is an open standard, which means that it is supported by a wide range of manufacturers. This makes it easier to integrate PROFINET devices into existing systems.
- Scalability: PROFINET can be used to create scalable networks, from small machine tools to large production lines.
- Security: PROFINET includes several security features to protect data from unauthorized access.

6.2 Telegram:

Siemens standard telegrams are a series of communication protocols that Siemens drives utilize to communicate seamlessly with programmable logic controllers (PLCs). These telegrams allow essential data to be exchanged at regular intervals, resulting in a cyclic communication protocol. Drives and PLCs can transmit information such as drive status (such as motor speed, torque, and temperature), drive parameters (such as set point, current limit, and acceleration), and error codes by using Siemens standard telegrams. In our case, we used the STANDARD TELEGRAM 352, which send and receive six words

6.2.1 PLC to VFD:

In this standard telegram the first two word are preset and cannot be changed:

- Word 1 is the control word, which is a binary value or particular bit pattern transmitted by the PLC to the VFD that controls different elements of the motor's functioning. The control word is sent by the PLC to start, stop, accelerate, decelerate the motor speed, and execute other control operations on the VFD.
- Word 2 is the speed setpoint which is a crucial feature for VFD-controlled motors because it allows for exact control of motor speed

6.2.2 VFD to PLC:

The six words of this message are preset by the manufacture ,Returns feedback data to the PLC.

- Word 1 is status word, which is a data field that carries information on the current status and operating conditions of the VFD and the motor it controls. The status word is composed of several bits or flags, each of which represents a particular state or situation. We can see the status word of this this VFD in the appendix (tag table ‘RECIEVE’)
- Word 2 is the actual speed of the motor
- Word 3 is the actual current drawn by the motor
- Word 4 is the actual torque
- Word 5 is the warning code
- Word 6 is the fault code.

Table 6: Telegram used in the project

Telegram 352, speed control for PCS7

STW1	NSOLL_A	Process data for PCS7			
ZSW1	NIST_A GLATT	IAIST_ GLATT	MIST_ GLATT	WARN_ CODE	FAULT_ CODE

7. Experimental Implementation:

In our study, we implemented some of the functionality of the TDS 11/SA using laboratory-provided materials, such as the VFD G120, Schneider HMI, and Siemens 1212 PLC. Our model consisted of an AC induction motor coupled with a generator, which was connected to a variable resistor load. This allowed us to test the prototype under different load conditions.

We first tested the system at low loads to ensure that it could operate smoothly and efficiently. We then increased the load gradually to validate the torque limit make-up function. We found that the system was able to handle a wide range of torque limit values without any problems.

We also tested the three system modes drill, spin, and torque under different load conditions. We found that the system was able to perform the required operations quickly, regardless of the load.

After that, the auxiliary part like braking, torque wrench, link tilt, and pipehandler was tested with other modes

Here are some additional details about the components of the model:

7.1 The G120VFD:

In the model, we used the G120 VFD as shown previously, with parametrization of the laboratory induction motor. This allowed us to accurately simulate the real-world system and to conduct more realistic tests. The commissioned variables are:

Table 7: the commissioning VFD parameters

Motor rated voltage	Motor rated power	Motor rated Current	Max speed	Min speed	Ramp uptime	Ramp down time
400 v	1.5 KW	2.26 A	30000 rpm	1000 rpm	10 s	10 s

7.2 Schneider HMI:

The HMI GXU3512 can be used to control and monitor a wide variety of industrial processes. It can be used to display information, such as machine status, production data, and alarms. It can also be used to enter commands, such as start/stop, speed, and torque. The HMI GXU3512 can be used to improve the efficiency and productivity of industrial processes. It can also be used to improve the safety of industrial processes by providing operators with real-time information about the process [14]

7.3 The Siemens 1212 PLC:

The Siemens 1212 is also a cost-effective PLC, making it a good choice for many top drive applications.

Here are some of the benefits of using the Siemens 1212 in top drive programming:

- **Versatility:** The Siemens 1212 can be used to control a wide variety of top drive functions, including speed control, torque control, and sensor monitoring.
- **Power:** The Siemens 1212 is a powerful PLC that can handle the demanding requirements of top drive applications.
- **Cost-effectiveness:** The Siemens 1212 is a cost-effective PLC that is a good value for many top drive applications.



Figure 67: 1212 dc/dc/rlly

7.4 The motor-coupled generator:

A motor-coupled generator test bench for a top drive system can be used to simulate the ground and subsurface earth layer by using a variable resistor load to simulate the varying resistance of the ground. It can be adjusted to simulate different depths of drilling, different types of soil, and different drilling conditions

Here are some additional details about the use of a motor-coupled generator test bench to simulate the ground and subsurface earth layer for a top drive system:

- The motor is used to drive the generator at a desired speed.
- The load bank is used to simulate the varying resistance of the ground.
- The VFD output is fed back to PLC to ensure torque is within the desired range.
- The tests are run for a variety of depths, soil types, and drilling conditions.
- The results of the tests are used to identify any potential problems with the top drive system.

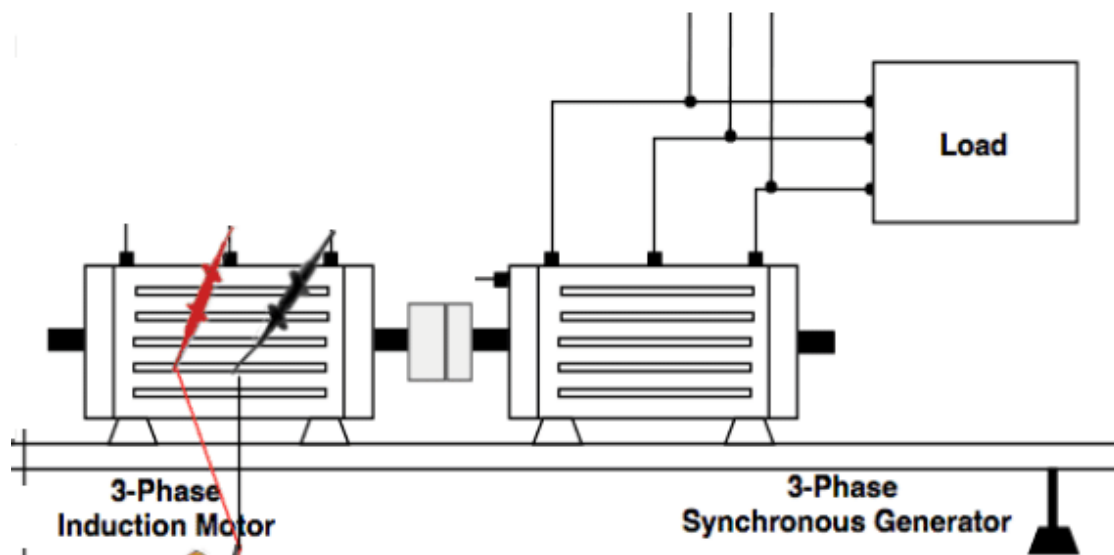


Figure 68: Motor coupled generator test bench

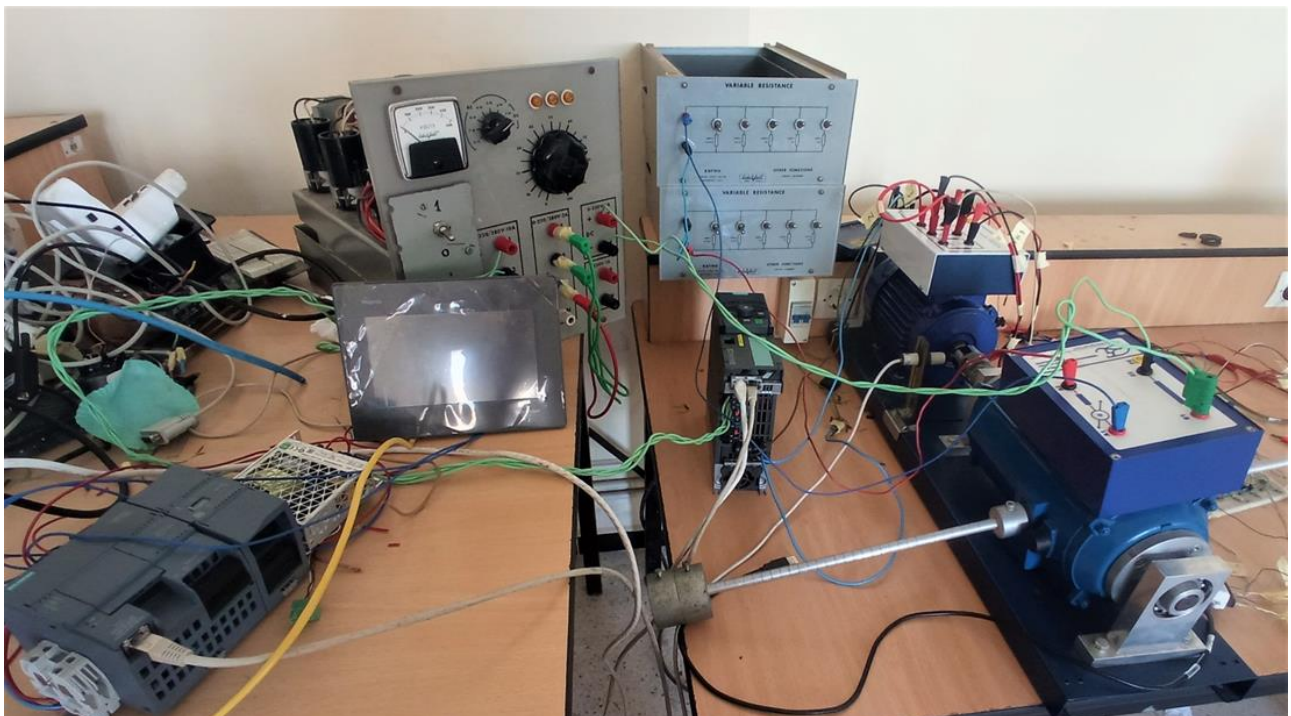


Figure 69: Test bench lab image.

Conclusion:

In this chapter, we have described the various software and hardware components used in automatic control systems. Then we delve into the programming of Top drive TDS 11/sa by going over all its function blocks and Database. We design our HMI screens based on the existing physical console, and then we specify the appropriate drivers to connect them with a particular VFD top-drive motor. Lastly, we verify the viability of our whole project by running it through experimental implementation simulations.

General Conclusion

This final year project aimed at the automation and supervision of a TDS/11SA within the company ENTP. The project focused on developing robust software for the automation of this machine. The main objective was to automate the operations that were previously done manually. As well as monitoring and supervision of various machine functions. The project started by collecting information about the machine and its components. The next step was to design and develop a user-friendly HMI Interface, which would be able to automate the operations of TDS/11SA.

The familiarization with Siemens TIA Portal allowed us to program the operations of TDS 11/SA and to obtain the states of the variables of interest to create HMI using the features of SIMATIC WinCC (TIA Portal) to manage graphical user interfaces with up-to-date visualizations and animations. Then with the starter TIA portal, we commissioned our G120 VFD for the appropriate motor parameters.

The period spent in the internship within ENTP Company enabled us to learn the fundamentals of Oil&gas Drilling and give us a solid understanding of the control system used with a better understanding of the project's scope and received insight into the engineer's responsibilities.

For future vision, a complete top drive prototype will be implemented with Hardware in the loop extension to validate the automation and supervision and make it closer to the real environment

We hope that this work will solve the problem by being a valuable contribution to the company and serve as a stepping-stone to future promotions.

References:

- [1] A.Rezaiguia, "Les émetteurs notice ENTP," Cosobédition, 26/06/2005..
- [2] BAMECO, "AUOCAD drawing," 2009. [Online]. Available: <https://www.shorturl.at/nqMTY>.
- [3] ENTP, "TP 232 technical Data-sheet paper," BAMCO, 200*. [Online]. Available: <https://www.shorturl.at/ntD13>.
- [4] "Petroleum Extraction Engineering," [Online]. Available: https://www.researchgate.net/publication/322987413_Petroleum_Extraction_Engineering.
- [5] C. Generator, "Operation Manuel," [Online]. Available: <https://shorturl.at/mqx36>.
- [6] "What is a Top drive," [Online]. Available: <https://www.drillingformulas.com/what-is-top-drive-system/>.
- [7] "PDF Drive," [Online]. Available: <https://t.ly/ePI7>.
- [8] "Pdfdrive," [Online]. Available: <https://t.ly/FFR3>.
- [9] N. n. O. Varco, "TDS 11SA," [Online]. Available: https://t.ly/olt_.
- [10] varco, "TDS-11SA drilling system detailed," [Online]. Available: <https://rb.gy/t8234>.
- [11] Siemens, "Siemens S7-1200 1217c Manual," [Online]. Available: https://tn-supply.com/wp-content/uploads/2021/08/6ES72171AG400XB0_datasheet_en.pdf.
- [12] Siemens, "industry.siemens," [Online]. Available: https://cache.industry.siemens.com/dl/files/040/90885040/att_970576/v1/81318674_Programming_guideline_DOC_v16_en.pdf.
- [13] Siemens, "SINAMICS G120 standard inverters," [Online]. Available: https://eltra-trade.com/files/uploads/pdf/Siemens_drives/Siemens-sinamics-g120-manual.pdf.
- [14] Schneider, "Schneider Magelis HMI manuel," [Online]. Available: <https://seniadz.net/catalogue/schneider/HMIGXU3512.pdf>.
- [15] "BOP Stack Organization and BOP Stack Arrangement," [Online]. Available: <https://www.drillingformulas.com/bop-stack-organization-and-bop-stack-arrangement/>.
- [16] "oil field team," [Online]. Available: <https://oilfieldteam.com/en/a/learning/Components-of-the-drill-string>.
- [17] "sciencedirect," [Online]. Available: <https://www.sciencedirect.com/topics/engineering/crown-block>.
- [18] "Oil Drilling Rig Diesel Power-plant Fuel Efficiency," [Online]. Available: <https://t.ly/TXqK>.
- [19] M. Cipek, "Laboratory Prototyping of Control System Retrofitting Designs for Oil Drilling Applications," [Online]. Available: https://www.researchgate.net/publication/325846095_Laboratory_Prototyping_of_Control_System_Retrofitting_Designs_for_Oil_Drilling_Applications.
- [20] M. Aymen, "Inside Variable frequency Drive," [Online]. Available: <https://electrical-engineering-portal.com/variable-frequency-drive-vfd-panel-configuration-schematics-troubleshooting>.

Appendix A:

**Documents and some pictures
inside the Drilling rig.**



Figure A.1: TDS 11/SA



Figure A.2: IBOP

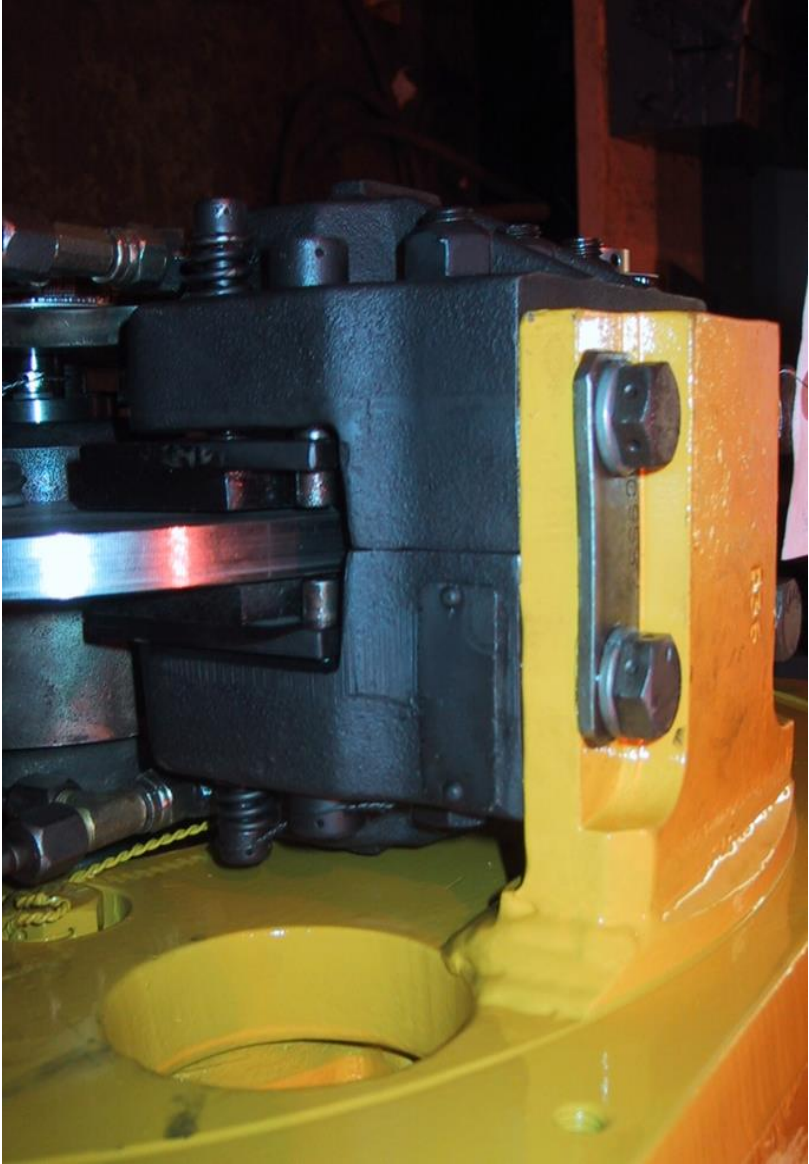


Figure A.3: brake disc.



Figure A.4: Shot pin of Link Adapter

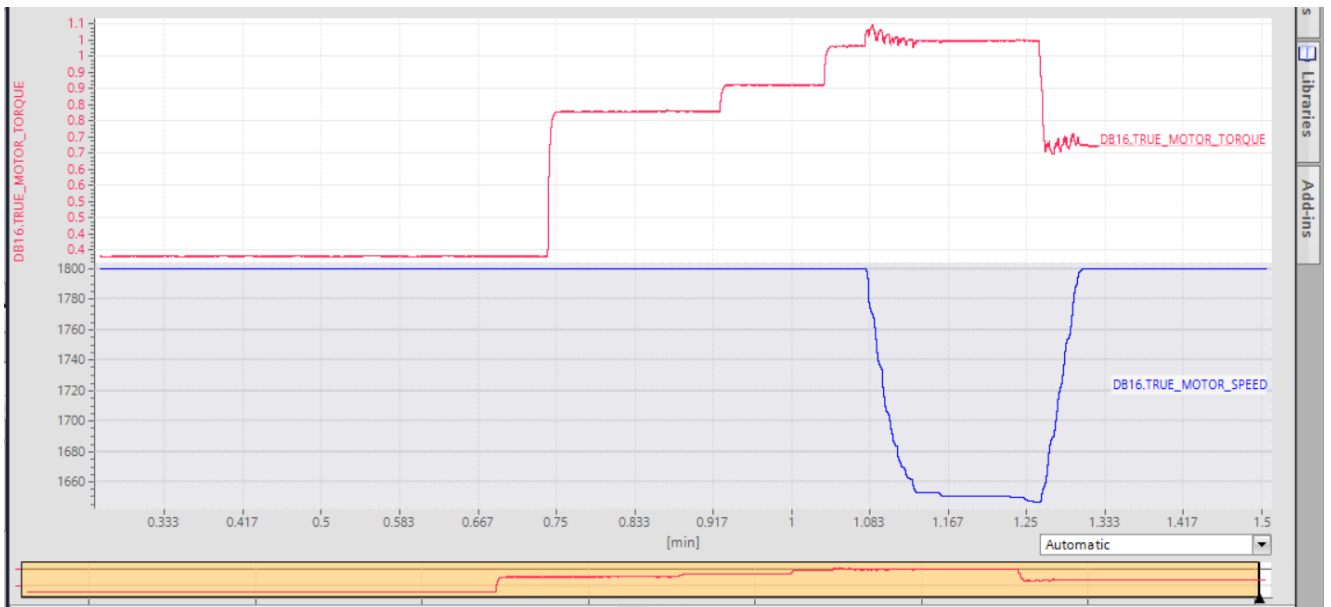


Figure A.5: Torque/Speed Graphs



Figure A.6: Current graph from HMI



SIMATIC HMI TP1200 Comfort, Comfort Panel, touch operation, 12" widescreen TFT display, 16 million colors, PROFINET interface, MPI/PROFIBUS DP interface, 12 MB configuration memory, Windows CE 6.0, configurable from WinCC Comfort V11

General information	
Product type designation	TP1200 Comfort
Display	
Design of display	TFT
Screen diagonal	12.1 in
Display width	261.1 mm
Display height	163.2 mm
Number of colors	16 777 216
Resolution (pixels)	
• Horizontal image resolution	1 280 pixel
• Vertical image resolution	800 pixel
Backlighting	
• MTBF backlighting (at 25 °C)	80 000 h
• Backlight dimmable	Yes; 0-100 %
Control elements	
Keyboard fonts	
• Function keys	
— Number of function keys	0
— Number of function keys with LEDs	0
• Keys with LED	No
• System keys	No
• Numeric keyboard	Yes; the Onscreen keyboard
• alphanumeric keyboard	Yes; the Onscreen keyboard
Touch operation	
• Design as touch screen	Yes; Analog-resistive
Expansions for operator control of the process	
• DP direct LEDs (LEDs as S7 output I/O)	
— F1...Fx	0
• Direct keys (keys as S7 input I/O)	
— F1...Fx	0
• Direct keys (touch buttons as S7 input I/O)	40
Installation type/mounting	
Mounting position	vertical
Wall mounting/direct mounting	No
Mounting in portrait format possible	Yes
Mounting in landscape format possible	Yes
maximum permissible angle of inclination without external ventilation	35°
Supply voltage	
Type of supply voltage	DC

Schneider HMI GXU3512



Main

Range of product	Magelis Easy GXU
Product or component type	Advanced touchscreen panel
Display type	LCD touch screen
Display colour	65536 colours
Display resolution	800 x 480 pixels WVGA
Display size	7 inch

Complementary

Backlight lifespan	20000 hours
[Us] rated supply voltage	24 V DC
Software designation	Vijeo Designer Basic (configuration software)
Memory description	Internal, 48 MB for application Internal DDR, 128 MB Internal, 128 kB for backup
Integrated connection type	USB type mini B COM1 serial link : 9-way male SUB-D connector, RS232C protocol COM2 serial link : 9-way male SUB-D connector, RS422/RS485 protocol USB type A Ethernet 10/100BASE-TX
Cut-out dimensions	190 x 135 mm

Environment

Quality labels	CE
Ambient air temperature for operation	0...50 °C

Environment

Quality labels	CE
Ambient air temperature for operation	0...50 °C
Ambient air temperature for storage	-20...60 °C
IP degree of protection	IP65 (front panel)

Siemens G120 VFD



SINAMICS G120 technical information

Voltage	1AC /3AC 200 ... 240V; 3AC 380 ... 480V; 3AC 500 ... 690V
Power range	0.55–250 kW (0.75–400 hp)
Degree of protection	IP20
Environmental class	3C2 (3C3 is possible with SIPLUS Control Unit — for frames D, E, F)
Ambient temperature	–10° C to +60° C (up to +40° C with derating)
EMC	According to EN 61800-3 up to Category C2
Standards	CE, UL, cUL, c-Tick
Safety technology	Safety Integrated: STO (up to SIL 3, PL e, Cat. 3), SS1, SBC, SLS, SDI, SSM, PROFIsafe
Communication	PROFINET, PROFIBUS, USS, Modbus, Ethernet/IP, BACnet
Closed-loop control modes	V/f, flux current control (FCC), vector control with and without encoder
Functions	Basic positioning function with EPos, energy recovery using efficient infeed technology, PROFInergy, PROFIdrive

Highlights at a glance

- + **Space savings** in the control cabinet as a result of increased power density, as well as side-by-side mounting
- + **Increased ruggedness** through longer motor cable lengths and by meeting increased environmental requirements such as now having a SIL3 rating (frame size D, E, F only) and extended standard temperature ranges
- + **Improved safety** integrated into the drive
- + **Lower costs** for installation and maintenance through an optimized connection system
- + **Lower system costs** by eliminating the input line and output reactors — plus, shield plates are included with each drive
- + **Compatibility** with Siemens TIA (Totally Integrated Automation) and IDS (Integrated Drive Systems) integration



SIEMENS

Data sheet

6ES7217-1AG40-0XB0



SIMATIC S7-1200, CPU 1217C, compact CPU, DC/DC/DC, 2 PROFINET ports onboard I/O: 10 DI 24 V DC; 4 DI RS422/485; 6 DO 24 V DC; 0.5A; 4 DO RS422/485; 2 AI 0-10 V DC, 2 AO 0-20 mA Power supply: DC 20.4-28.8V DC, Program/data memory 150 KB

General information	
Product type designation	CPU 1217C DC/DC/DC
Firmware version	V4.5
Engineering with	
<ul style="list-style-type: none"> Programming package 	STEP 7 V17 or higher
Supply voltage	
Rated value (DC)	
<ul style="list-style-type: none"> 24 V DC 	Yes
permissible range, lower limit (DC)	20.4 V
permissible range, the upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Load voltage L+	
<ul style="list-style-type: none"> Rated value (DC) permissible range, lower limit (DC) permissible range, the upper limit (DC) 	24 V 20.4 V 28.8 V
Input current	
Current consumption (rated value)	600 mA; CPU only
Current consumption, max.	1 600 mA; CPU with all expansion modules
Inrush current, max.	12 A; at 28.8 V DC
I^2t	0.5 A ² ·s
Output current	
For backplane bus (5 V DC), max.	1 600 mA; Max. 5 V DC for SM and CM
Encoder supply	
24 V encoder supply	
<ul style="list-style-type: none"> 24 V 	L+ minus 4 V DC min.
Power loss	
Power loss, typ.	12 W
Memory	
Work memory	
<ul style="list-style-type: none"> integrated 	150 byte
Load memory	
<ul style="list-style-type: none"> integrated Plug-in (SIMATIC Memory Card), max. 	4 Mbyte with SIMATIC memory card
Backup	
<ul style="list-style-type: none"> present maintenance-free without battery 	Yes Yes Yes
CPU processing times	
for bit operations, type.	0.08 μs; / instruction
for word operations, typ.	1.7 μs; / instruction

Appendix B:
Tables of Tags and Variables
(PLC, VFD).

System Tags:

Table 8: System tags.

Name	Data Type	Logical Address
MORE THAN 5 RPM	Bool	%M100.7
NC DUMMY	Bool	%M5.7
OIL PUMP ALARM	Bool	%M16.2
OIL PUMP ALARM SILENCE	Bool	%M3.1
TOP OF RAMP SEQUENCE	Bool	%M30.6
TORQUE MODE	Bool	%M80.2
TORQUE STARTED	Bool	%M40.5
TORQUE WRENCH / SHOT PIN SOL	Bool	%Q2.4
HP BELOW RATING	Bool	%M17.2
HP LIMITER ACTIVE	Bool	%M16.7
VFD ALARM SILENCE	Bool	%M3.0
VFD FAULT ALARM	Bool	%M17.1
ROTATE CCW SOL	Bool	%Q2.1
ROTATE CW SOL	Bool	%Q2.2
ROTATE ENABLE	Bool	%M5.2
DRILL MODE	Bool	%M80.1
LEFT BLOWER STARTER	Bool	%Q3.2
LEFT OVERTEMP ALARM	Bool	%M1.0
LEFT OVERTEMP ALARM SIL	Bool	%M3.4
LEFT OVERTEMP SW	Bool	%I4.1
LESS THAN 10 RPM	Bool	%M100.5
LT DRILL SOL	Bool	%Q2.6
ALARM SILENCE	Bool	%M3.6
BRAKE AUTO MODE	Bool	%M0.2
BRAKE FAULT ACTIVE	Bool	%M0.3
BRAKE FLASH ENABLE	Bool	%M0.4
BRAKE LATCH ARMED	Bool	%M0.1
ALARM CONDITION	Bool	%M1.7
ALARM HORN	Bool	%Q3.3
LT FLOAT SOL	Bool	%Q2.7
LT TILT SOL	Bool	%Q2.5
LUBE PRESSURE SW	Bool	%I4.5
IBOP CLOSE PRESSURE SW	Bool	%I4.4
IBOP CLOSE SOL	Bool	%Q2.3
SPIN MODE	Bool	%M80.3
STANDJUMP SOL	Bool	%Q3.5
SUCCESSFUL TORQUE	Bool	%M5.6
TDS SELECTED	Bool	%M20.0
THROTTLE IS ON	Bool	%M80.4
HP RATING EXCEEDED	Bool	%M17.0
HYDRAULIC PUMP STARTER	Bool	%Q3.0
FAILED RAMP	Bool	%M16.6
RIGHT BLOWER ALARM	Bool	%M1.3
RIGHT BLOWER ALARM SIL	Bool	%M3.2

Appendix

RIGHT BLOWER LOSS	Bool	%M16.1
RIGHT BLOWER PRESSURE SW	Bool	%I4.2
RIGHT BLOWER STARTER	Bool	%Q3.1
RIGHT OVERTEMP ALARM	Bool	%M1.1
RIGHT OVERTEMP ALARM SIL	Bool	%M3.5
RIGHT OVERTEMP SW	Bool	%I4.0
BRAKE LATCH SET	Bool	%M0.0
BRAKE ON SOL	Bool	%Q2.0
JOG ENABLE	Bool	%M5.3
LEFT BLOWER ALARM	Bool	%M1.2
LEFT BLOWER ALARM SIL	Bool	%M3.3
LEFT BLOWER LOSS	Bool	%M16.0
LEFT BLOWER PRESSURE SW	Bool	%I4.3
VFD E-STOP	Bool	%M16.5
LEFT OVERTEMP	Bool	%M16.3
RIGHT OVERTEMP	Bool	%M16.4
VFD FAULT RESET	Bool	%M20.1
OFF	Bool	%M121.5
reverse condition	Bool	%M30.3
MOTOR FORWARD	Bool	%M100.1
MOTOR REVERSE	Bool	%M100.2

HMI tags:

Table 9: HMI tags.

Name	Path	Data Type	Logical Address
LT DRILL POS SW	HMI's Tags	Bool	%M120.0
LT TILT POS SW	HMI's Tags	Bool	%M120.1
IBOP CLOSE SW	HMI's Tags	Bool	%M120.2
BRAKE OFF SW	HMI's Tags	Bool	%M120.3
BRAKE ON SW	HMI's Tags	Bool	%M120.4
ALARM SILENCE BUTTON	HMI's Tags	Bool	%M1.6
LT ROTATE CCW SW	HMI's Tags	Bool	%M5.1
LT ROTATE CW SW	HMI's Tags	Bool	%M5.0
TORQUE WRENCH SW	HMI's Tags	Bool	%M121.0
TDS REVERSE SW	HMI's Tags	Bool	%M121.1
TDS FORWARD SW	HMI's Tags	Bool	%M121.2
BL&OP AUTO/ON SW	HMI's Tags	Bool	%M121.4
LT FLOAT POS SW	HMI's Tags	Bool	%M121.3
STANDJUMP SW	HMI's Tags	Bool	%M120.7
BRAKE ON INDICATOR	HMI's Tags	Bool	%M0.5
DRIVE FAULT INDICATOR	HMI's Tags	Bool	%M50.1
IBOP CLOSE INDICATOR	HMI's Tags	Bool	%M50.2
OIL PRESSURE LOSS INDICATOR	HMI's Tags	Bool	%M50.3

Appendix

SEND VFD data-base:

Name	Path	Data Type	Logical Address
reserved	SEND	Bool	%Q260.0
reserved_1	SEND	Bool	%Q260.1
control by PLC	SEND	Bool	%Q260.2
setpoint inversion	SEND	Bool	%Q260.3
reserved_2	SEND	Bool	%Q260.4
motorized potentionmeter setpoint raise	SEND	Bool	%Q260.5
motorized potentionmeter lower setpoint	SEND	Bool	%Q260.6
reserved_3	SEND	Bool	%Q260.7
ON / OFF (OFF1)	SEND	Bool	%Q261.0
No coast-down / coast down (OFF2) signal source 1	SEND	Bool	%Q261.1
No Quick stop / Quick stop (OFF3) signal source 1	SEND	Bool	%Q261.2
Enable operation / inhibit operation	SEND	Bool	%Q261.3
Enable rapm function	SEND	Bool	%Q261.4
Continue ramp function	SEND	Bool	%Q261.5
Enable setpoint	SEND	Bool	%Q261.6
1st acknowledge faults	SEND	Bool	%Q261.7
SPEED SETPOINT	SEND	UInt	%QW262
TORQUE LIMIT	SEND	Int	%QW264

RECEIVE VFD database:

Table 10: Receive VFD DB.

Name	Path	Data Type	Logical Address
speed setpoint - actual value deviation in tolerance t_off	RECIEVE	Bool	%I260.0
control request	RECIEVE	Bool	%I260.1
F or N comparision value reached or exceeded	RECIEVE	Bool	%I260.2
torque limit reached (inverted)	RECIEVE	Bool	%I260.3
open holding brake	RECIEVE	Bool	%I260.4
Alarm motor overtempreture (inverted)	RECIEVE	Bool	%I260.5
n_act>=0	RECIEVE	Bool	%I260.6
alarm power unit thermal overload (inverted)	RECIEVE	Bool	%I260.7
Ready for switching on	RECIEVE	Bool	%I261.0
Ready	RECIEVE	Bool	%I261.1
Operation enabled	RECIEVE	Bool	%I261.2
Fault present	RECIEVE	Bool	%I261.3
NO coasting active	RECIEVE	Bool	%I261.4
NO quick stop active	RECIEVE	Bool	%I261.5
Swithching on inhibited active	RECIEVE	Bool	%I261.6
Alarm present	RECIEVE	Bool	%I261.7
ACTUAL SPEED	RECIEVE	Int	%IW262
ACTUAL CURRENT	RECIEVE	Int	%IW264
ACTUAL TORQUE	RECIEVE	Int	%IW266
ACTUAL ALARMS	RECIEVE	Int	%IW268
ACTUAL FAULTS	RECIEVE	Int	%IW270

DB16 (Torque parameters database):

Table 11: DB 16.

Variables	Data-type	default-value	initial value	real value	set value
THROTTLE_POT	Int	0	0	0	
MAKEUP_TORQUE_POT	Real	2	0	0	
TRUE_MOTOR_SPEED	Real	6	0	0	
TRUE_SHAFT_RPM	Real	10	0	0	
TRUE_MOTOR_TORQUE	Real	14	0	0	
TRUE_SHAFT_TORQUE	Real	18	0	0	
SPEED_SETPOINT_TO_VFD	Real	22	0	0	
HORSEPOWER_MOTOR	Real	26	0	0	
HORSEPOWER_SHAFT	Real	30	0	0	
NORMAL_SPIN_SPEED	Real	34	500	500	500 RPM's
DRILL_TORQUE_POT	Real	38	0	0	
ACTUAL CURRENT	Real	42	0	0,00124146	
TORQUE SETPOINT_1	Int	46	0	0	
abs MOTOR_SPEED	Real	48	0	0	
abs MOTOR_TORQUE	Real	52	0	0	
threshold	Real	56	0	-0,03	