International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 05 | May – 2025 DOI: 10.55041/ISJEM03952
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

TANK SIMULATOR

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Abstract - The **Tank Simulator** project focuses on the development of a virtual model that accurately replicates the behavior, control, and logistics of a fuel or cargo tanker system. The aim is to simulate real-world operational conditions such as load balancing, fluid dynamics, navigation, and safety protocols in a controlled digital environment. This simulation provides an efficient platform for testing strategies in transportation, distribution, and risk mitigation without the need for physical deployment.
Using advanced simulation tools and physics engines, the model replicates:

1. **Fluid movement within tanker compartments** under various acceleration and deceleration conditions.
2. **Navigation and maneuvering dynamics** in constrained or open environments.
3. **Load management** and real-time stability monitoring
4. **Emergency handling protocols** for leaks, overflows, or fire scenarios.

This simulation model serves as a training, planning, and validation tool for engineers, operators, and researchers. It helps optimize design, improve safety measures, and reduce costs associated with physical testing. The **Simulation Tanker** project is particularly relevant in sectors like oil and gas, logistics, maritime operations, and industrial safety engineering.

1. INTRODUCTION

Basic Introduction

A **Tank Simulator** is an VFD(Variable-Frequency drive) electronic device used to control the speed and torque of electric motors by varying the input frequency and voltage. It is used with **AC motors**, particularly **induction motors**, to optimize performance, energy efficiency, and process control.

It allows precise control over motor operation, making it highly efficient for applications like pumps, fans, conveyors, and HVAC systems.

Tank Simulator works by converting fixed-frequency AC power to DC and then inverting it back to variable-frequency AC power, enabling flexible and efficient motor operation.

Tank Simulator are used in applications ranging from small appliances to large compressors. By utilizing this, systems can be more effective than hydraulic systems, such as fan systems with pumps and damper control.

Why use Tank Simulator?

Traditionally, AC motors run at a fixed speed determined by the supply frequency. However, many applications (like fans, pumps, conveyors) do not always need motors to run at full speed. **Tank Simulator** allows for:

1) **Speed control** for process optimization.
2) **Energy savings** by reducing motor speed during low-demand periods.
3) **Soft start and stop**, reducing mechanical stress.
4) **Improved the lifespan of the motor** and the reliability of the system.

Power electronics technology has been able to reduce VFD cost and size, as well as improve performance through advances in semiconductor switching devices, drive topologies simulation and control techniques, and control hardware and software since the 1980s.

Purpose

The **main purpose** of a **Variable Frequency Drive (VFD)** is to control the speed, torque, and direction of an AC electric motor by adjusting the frequency and voltage of the power supplied to the motor.

Key Objectives:

- **Speed Control**

1) Adjust motor speed to match process requirements.
2) Useful in fans, pumps, conveyors, and more.

- **Energy Efficiency**

1) Reduces energy consumption, particularly in loads with variable torque.
2) Lower operating costs by avoiding running motors at full speed unnecessarily.

- **Soft Start and Stop**

Gradual ramp-up and ramp-down reduce mechanical stress and prevent electrical surges.

- **Process Optimization**

Improves product quality and process control by fine-tuning motor operation

- **Extended Equipment Life**

Reduces wear and tear on motors and connected machinery.

- **Reduced Maintenance Costs**

Minimizes downtime and extends service interval

2. Body of Paper

Traditional AC motors operate at a constant speed, which often results in **energy inefficiency**, **mechanical stress**, and **lack of process flexibility** in applications requiring variable speed control. This results in excessive energy consumption, shortened equipment lifespan, and higher operational expenses. There is a need for an efficient method to control motor speed and torque dynamically.

Electric motors are utilized in industrial applications to push mechanical systems like pumps, fans, conveyors, and compressors. The speed of these motors, particularly induction motors, is traditionally determined by the line frequency. However, many applications require variable speed operation to enhance process control, reduce energy consumption, and extend equipment life.

The inability to control motor speed precisely leads to energy inefficiencies, mechanical stress, and decreased operational flexibility. For example, in HVAC systems, operating fans at full speed continuously results in excessive energy usage even when lower airflow is sufficient. Similarly, in pump applications, controlling flow by throttling rather than adjusting motor speed wastes energy and increases maintenance requirements.

A Variable Frequency Drive (VFD) addresses this problem by adjusting the frequency and voltage supplied to an electric motor, thereby enabling efficient speed and torque control. However, the design and implementation of VFDs pose several challenges, including harmonic distortion, torque instability at low speeds, protection mechanisms, and the need for user-friendly interfaces.

- **LCD Control Keyboard**

The following content describes the function and operation of the control keyboard. The control keyboard can be used to control the drive, read the status data and set the parameters. To learn more about electrical and mechanical installation, refer to the [Hardware manual] for additional features.

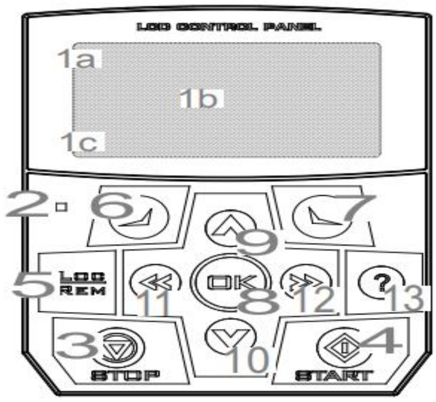
Features

- Control keyboard equipped with LCD display text, digital and graphic multi element display.

- Parameter can be copied to the control keyboard memory, to be able to transfer these parameters to other drives in the future, or for a specific system backup.

- Rich text tips and help.

- Real-time monitor drive DC bus voltage.



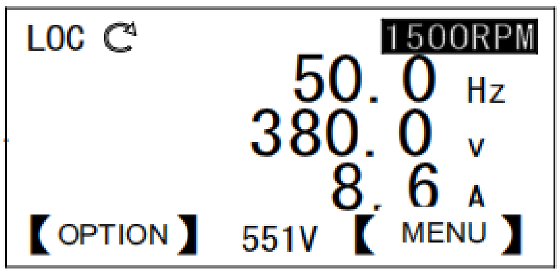
Layout

The information displayed on the LCD panel is the basic status of the drive.

- **Operation Instructions**

Users can use the menu and buttons to help control the operation of the keyboard. These buttons include the left and the right two functional keys. The current functions of the functional keys are displayed respectively in the bottom of the LCD on the left and right sides.

Initially, the control keyboard is in the main interface, as shown in Figure 1. The upper right corner of the LCD shows the current value given. The LCD shows up to 3 signals in one page for real time monitoring to the drive. 3 signals constitute one monitoring page. Up to 8 pages, 24 signals can show. Each signal can be flexible



When a fault or warning occurs, the information of fault or warning pops up, as shown in figure two, Press the left functional key to reset the fault. Then the right functional key loses its effect.

Press the navigation keys (up and down for four direction keys), you can hide faults or warning messages. If it lasts 3 seconds (fault) or 30 seconds (alarm) and no keys act, the fault or warning message will pop up again. Meanwhile, the warning messages will disappear automatically after the warning end.

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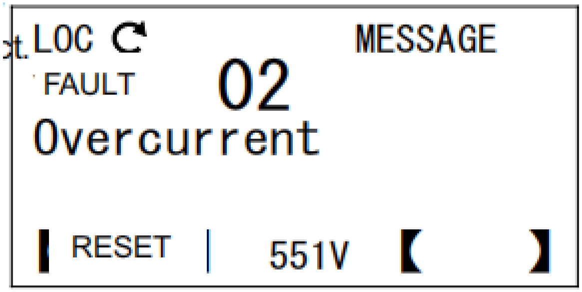
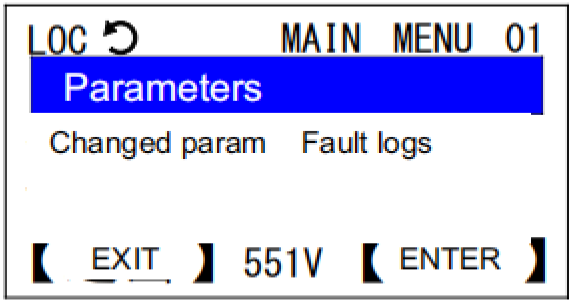


In the main interface, press the right functional key to enter the main menu as shown in Figure 3. There are 8 submenus in the main menu including: parameter list, modified parameters, fault log, parameter change log, assistant, parameter backup, system information and settings. Each submenu implements a specific function, for example, parameter list is used to view

and edit the drive parameter; the fault log is used to view the recent failures of the drive, as well as to see the fault diagnosis information.



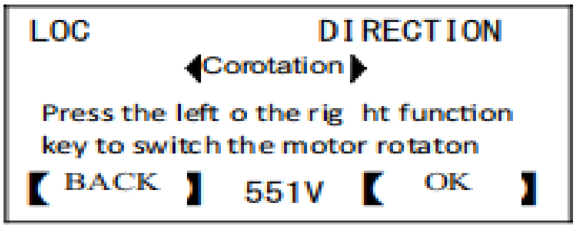
Enter the main menu or options menu, use the up and down arrows keys, or use the left and right arrows to perform actions until the specified menu page, or a list of contents is selected. **Press the right functional key or confirm key to enter the next menu. Press the left functional key to return to the previous menu.** When entering the last menu to edit the selected items, such as access to the parameter edit menu to modify the parameter value. **Press the right function all key or confirm key to save for changes. Press the left functional key to abandon the modifications.** However, it will be returned to the previous menu by pressing in any one of the three. At the same time, press the left functional key and hold, it can gradually return to the previous menu until to the main interface. Under any mode, the user can control drive start and stop in local control mode, or switch between local control mode and remote-control mode. Meanwhile, if the help information exists, users can press the help button to view the help information.

- **OPTION MENU MODE**

In this mode, the basic operation is the same as the main menu mode. Before reading this part, please read carefully the front chapters.

Local Given - This option is used to edit the local given value. User must press the right function key or the OK button to save, then the change will take effect. If and only when the drive is in a local control mode or a given source selection control keyboard is given, can the users use this option. For specific operation please refer to "how to modify value of the numerical type parameters" section.

Motor Rotation Direction - This option is used to switch the rotation direction of the motor. As shown on the right picture, the center of the LCD screen shows the current motor rotation direction (Forward represents Corotation, Reverse represents Reversion) A line of prompt is shown below to tell the user to press the left or the right direction key to switch the direction.



When the drive alarms, the LED screen displays the warning code, such as A-01. Alarm information will pop up once every 10 seconds, and last for 3 seconds (flashing 3 hypo) then automatically hidden. **Press the up and down or so four direction keys and the OK button to hide the fault or alarm message. When the control panel is in the main interface, press the OK button to enter the parameter menu to view or modify the parameter values.** The parameter menu is a three-level menu. The first level menu for selecting parameter group, the second menu for selecting parameter index, and the third menu for editing parameter value. Press the upward key to increase the parameter group, the index or the parameter value; press the downward key to decrease them. After editing is finished, press the OK button to save the parameter values and return it to the previous menu, or you can press the ESC key to give up the edit. If there is not any keystroke in 1 minute, the Menu automatically exits. **To view or modify the local given value, press the up or down arrow key in the main interface to enter the local given menu.** At this time, all digital tubes synchronously flash, press the up or down arrow key again to increase or decrease the local value given. If no keying action in 3 seconds, the menu automatically exit. If you need to quickly modify the local given value, press the OK button to enter the parameter menu to modify the local given value.

【Key Function Description】

Key	Functon
【OK】 Confirm key	Enter into the parameter menu and save the parameter values step by step.
【RES/ESC】 key	When the screen displays failure code (E-XX), Reset fault. Other cases, exit the menu step by step , Cancel edit.
【Upward】 key	Increase the parameter address (group, index), parameter values; Enter local given menu, Increase local given value.
【Downward】 key	Reduce the parameter address (group, index), parameter values; Enter local given menu, Reduce local given value.
【Lefward 】 key	Backward to switch the monitoring signal (main interface), move the cursor left (menu interface).
【Rightward】 key	Forward to switch the monitoring signal (main interface), move the cursor right (menu interface).
Loc/REM,STOP,START	For functon introduccon please refer to the content of the previous LCD button secti n.

- **PROGRAM FUNCTION**

The Local/ Remote button on the control keyboard can switch between the two modes of local and remote.

Local Control is used for site debugging, maintenance or simple applications. At this point the system start-stop control is decided by the START and STOP button of the LCD panel.

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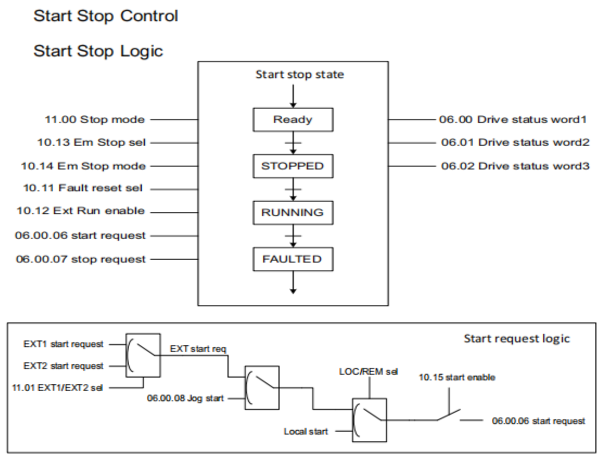
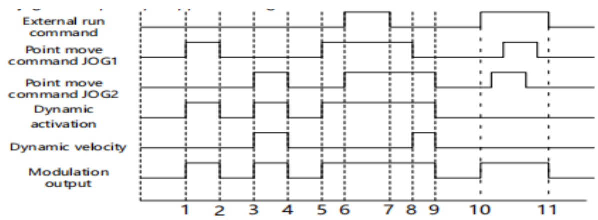
With the Parameter 16.00 Local lock (local control locking) to ban the use of control mode switching to local control.

Remote Control When remote control mode is used for practical applications, the system start-stop depends on the terminal input or communication instruction, etc.; Speed given depends on analog input, or communication instruction, or process PID control output, Muto segment speed set, etc. It can provide two remote control places, EXT1 and EXT2. With two kinds of external control place, users can select the control signal (for example, start & stop) and the control mode. According to the user's choice, EXT1 or EXT2 can be activated. Users can select EXT1/EXT2 by digital input or field-bus control.



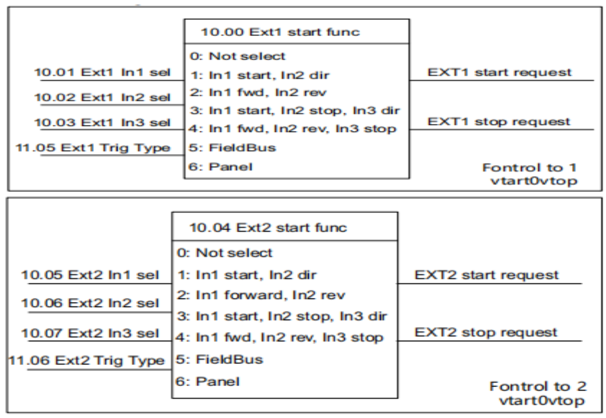
Jog Start - Jog start has two signal sources; they are respectively as 10.08 Jog1 start (Jog1 start) and 10.09 Jog2 start (Jog2 start). When the two jog commands are effective at the same time, the jog command JOG1 is prioritized. User can enable or disable the jog function with the parameter

When the jog signal is valid, and if the drive is stopped, then jog the start command signal will also start the drive; When the drive is already in operation, the command will not be executed. When the jog command is activated, the start command signal from external control place will not be executed until the jog is completely stopped. See figure below



- **EXTERNAL CONTROL PLACE**

The system provides two completely independent external controls, each of which corresponds to a startup function, speed/ torque control mode, as well as the speed/ torque given, can be configured flexibly to meet the field application. The startup signal combination n mode of the two controls depends on the parameters of 10.00 Ext1 start function and 10.04 Ext2 start function, which include the two-wire control, three-wire control, communication control, panel control, see figure as below.

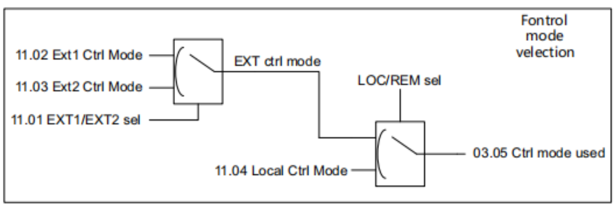


Terminal Two -wire, Three-wire Control

Take external control 1 as an example, choose 1 or 2 for the parameter of 10.00 Ext1 start function (External control 1 startup function), the corresponding terminal is two-wire control system; Choose 3 or 4, the corresponding terminal is three-wire control system. The signal source for two-wire or three-wire control is selected by the parameters of 10.01 Ext1 In1 sel, 10.02 Ext1 In2 sel, 10.03 Ext1 In3 sel. User can edit the pointer which will be designated as any one of the digital input terminals, also can be specified for any timer or any signal. The parameter of 11.05 Ext1 Trig Type is used for seeing the signal type of In1, In3 should be edge signal or level signal. This parameter is for two-wire control only; three-wire control is always the edge trigger.

Speed/Torque Control

For local control, the user can only select the speed or torque control mode. The external control mode can be specified as speed, torque, speed and torque combination, positioning and other modes. The parameter of 11.02 Ext1 Ctrl Mode is used for the control mode of specified external control 1; the parameter of 11.03 Ext2 Ctrl Mode is used for the control mode of specified external control 2; the parameter of 11.04 Los Ctrl Mode is used for the control mode of local control. The actual implementation n of the control mode can be checked by the parameters of 03.05 Ctrl mode used. The selection and switching for speed torque control mode is as shown below



- **CONTROL INTERFACE**

Digital Input Logic (DI1~DI7) - Within the digital input module, each input port accommodates the autonomous configuration of positive and negative logic (refer to parameter 14.22 DI logic), alongside independent simulation capabilities (see parameter 14.24 DI simulation data and parameter 14.23 DI simulation enable). This design facilitates debugging and diagnostic processes, while concurrently supporting independent filtering time settings (from parameter 14.00 DI1 Ton delay to parameter 14.13 DI7 Toff delay). The

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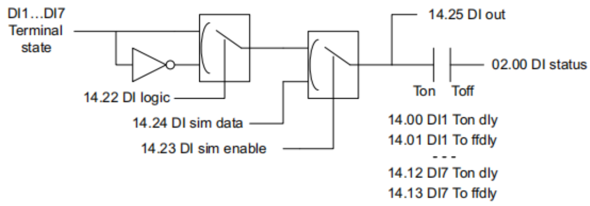
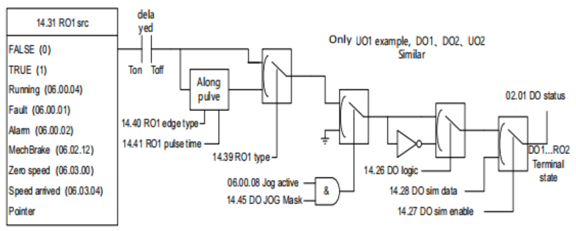
initial state of the digital input is preserved within the parameters of 14.25 DI output, whereas the delayed state is recorded in 02.00 DI status. Users can directly access any specific bit of this parameter through the bit pointer.



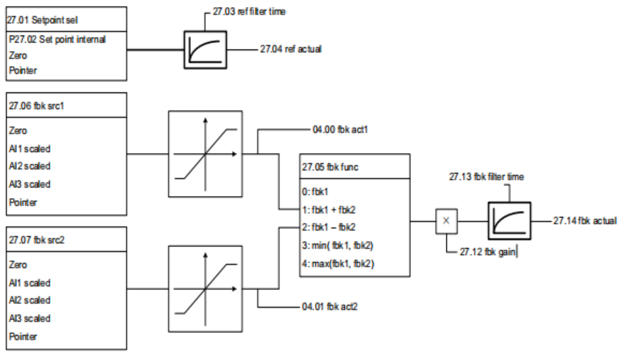
Digital Output Logic (DO1, DO2, RO1, RO2) - In the digital output module, each output port possesses the capability to independently designate its signal source (parameters of 14.29 DO1 src, 14.30 DO2 src, 14.31 RO1 src, 14.32 RO2 src), as well as to independently configure the delay time (14.14 DO1 Ton dly, 14.21 RO2 To fiddly). Simultaneously, users can select.



PROCESS PID CONTROL

Process PID control is widely employed in various domains such as position, temperature, flow, pressure, and other process management applications. The PID framework encompasses several fundamental components: the set-point, feedback, error amplification, limitation, and feedback disconnection detection. The PID is defined by the selection of parameter 27.01, the set point selection. The default parameters correspond to 27.02, representing the internal set point (the internal PID reference). Users have the flexibility to customize these parameters through panel input, analog input, communication input, and other avenues. The filtering time for the input is established via parameter 27.03, the reference filter time. The actual real-time input values are recorded in parameter 27.04, the reference actual.

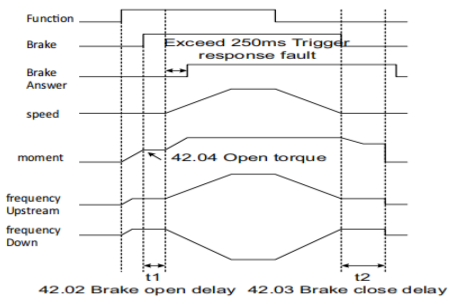
The PID feedback mechanism supports two signals for conducting synthesis, which are identified as parameters 27.06 fk src1 and 27.07 fk src2, respectively. Users are granted the liberty to modify these pointers at their discretion. The real-time values of the two feedback signals are documented in parameters 04.00 fk act1 and 04.01 fk act2, allowing users to ascertain the normalcy of external feedback by monitoring these parameters. The feedback synthesis operation is dictated by parameter 27.05 fk func, which encompasses operations such as summation, difference, maximum, minimum, and others. The feedback gains subsequent to the completion of the operation (as indicated by parameter 27.12 fk gain) and filtering (parameter 27.13 fk filter time) is conditioned, with the resultant data stored in parameter 27.14 fk actual.



LIFTING FUNCTION

The lifting function is predominantly employed in the contexts of tower cranes, bridge cranes, elevators, and similar apparatuses. The essence of the open loop lifting mechanism lies in brake logic and torque management at low speeds. Upon activation of the lifting system (parameter 42.00 crane active), the output of the brake control will seamlessly connect to RO1, while concurrently shielding against over-voltage stall incidents. Upon receiving the operational command, the drive will generate torque in accordance with the established settings of the brake opening torque (parameter 42.04 Open torque). Once the torque reaches the predetermined threshold, a request to release the brake is initiated, corresponding to RO1 activation. Given that the brake release necessitates a specific duration (parameter 42.02 Brake open delay), acceleration may commence only after this interval.

Upon receipt of the stop command, the drive will commence a gradual reduction of speed until it ultimately reaches a complete halt. At this juncture, a request to close the brake is initiated, signified by RO1 recovery. It is important to note that the closure of the brake also requires a designated time frame (parameter 42.03 Brake close delay), allowing the user to deactivate the PWM modulation output following this delay.



EDITABLE LOGIC FUNCTION

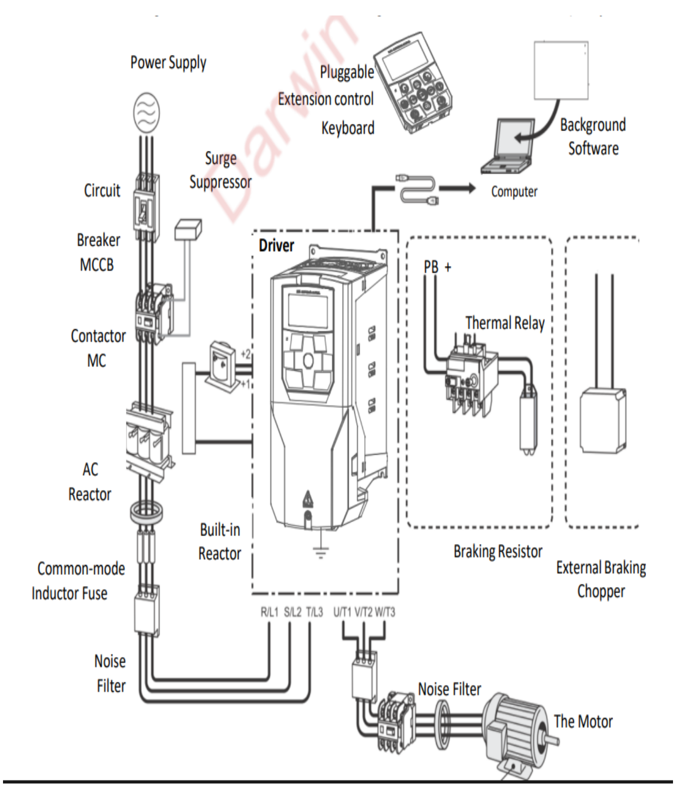
Level Timer The system is equipped with three level timers; for the purpose of this discussion, we shall focus solely on the first. The timing input signal source (parameter 34.55 On-time src) can be designated at will. The timing will commence upon the validation of the signal and will reset when the signal becomes invalid. The results of the timing are recorded in the 34.57 On-time output. The timing comparison is established as parameter 34.56 On-time limit; when the timing result exceeds the predetermined threshold, the timer output is activated.

Edge Counter There are three edge counters; here, we will examine the first counter as a representative example, while the remaining counters exhibit analogous functionality. Users have the flexibility to designate any input signal source (parameter 34.02 edge1 src). The counting mode (parameter 34.04 edge1 type) may be configured to detect a rising edge, a falling edge, or both. The reset mechanism of the counter offers the option to utilize an external reset signal (parameter 34.03 edge1 rst) or to facilitate an automatic reset through the internal maximum count value (parameters 34.07 edge1 auto reset and 34.06 edge1 max). The real-time counting results of the counter are recorded in the parameter 34.01 edge1 counter. Upon reaching the designated set point (parameter 34.05 edge1 cmp), the status word 34.00.00 status: edge1 is set to 1; otherwise, it remains at 0. Users can reference the status bit in other modules via the bit pointer.

- **Programmable Arithmetic Function**

Process on Version The process control quantity conversion is employed to transform the process quantity into the dimensions specified by the user. The system offers three general process control volume conversions; here, we will consider the first as a case in point. The input for the process conversion can be selected via parameter 35.00 PrcsVar1 src. If the objective is solely to convert the amplitude size, one must activate the absolute value operation (parameter 35.06 PrcsVar1 abs). The correlation between the conversion input and output is delineated by parameters ranging from 35.02 PrcsVar1 src max to 35.05 PrcsVar1 out min. The conversion results are recorded within the parameters of 35.01 PrcsVar1 out. The units and decimal precision of the conversion results displayed on the panel can be specified through parameter 35.07 Linear1 y dec and parameter 35.08 Linear1 y unit.

HARDWARE DESIGN



3. CONCLUSION

The future of Variable Frequency Drives is robust, driven by the global push for **energy efficiency**, **automation**, and **sustainability**. As industries digitize and decarbonize, VFDs will be central to enabling smart, efficient, and eco-friendly operations.

ACKNOWLEDGEMENT

The completion of this project was a result of significant effort and dedication from our team. We extend our heartfelt appreciation to all those who supported and motivated us throughout this journey.
We would like to thank Prof. Sitaram Longani, HOD, Department of Electronics and Telecommunication Engineering, Pune, who has been a constant support and encouragement throughout the course of this project.
We consider it a privilege and honour to express my sincere gratitude to our guide Prof. Neha Singh, for her constant guidance, valuable insights, and unwavering support throughout the project. Her expertise and guidance were invaluable in shaping our ideas and bringing them to fruition.
We also extend our thanks to all the faculty of Electronics and Telecommunication who directly or indirectly encouraged us.
Finally, we would like to thank my parents and friends for all the moral support they have given during the completion of this project.

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