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DESIGN AND FABRICATION OF DOL STARTER

[#1] Sravan Kumar Konathala, [#2] Korukonda Kiranmai, [#3] Konathala Yuva Karthik,

[#4]Karri Achhiyya Naidu,[#5] Kondu Disney Sandhya, [#6]Lokavarapu Venkata Srija .

[1,2,3,4,5,6]Department of Electrical and Electronics Engineering,

Vignan's Institute of Information Technology(A) (Affiliated by JNTU-GV),Visakhapatnam, India.

ABSTRACT: This paper is about making a Direct-On-Line (DOL) for 5hp motors. This starter has important parts like a switch, a safety device called overload relay, a small switch for protection called miniature circuit breaker (MCB), and a power source. It gives the motor all the power it needs to start quickly and strongly. We make sure it's safe by adding an overload relay and MCB to stop it if there's too much power. Our goal is to make it easy and good for starting big motors, especially ones that need a lot of power to start, while keeping it very safe and working well.

Key Words:DOL Starter, MCB, OLR, Contactor

1. INTRODUCTION

Within the field of electrical engineering, Direct-On-Line (DOL) starters play a pivotal role in facilitating the operation of induction motors. These starters offer a simple yet effective approach to initiating and regulating the power supply to induction motors, thereby guaranteeing their secure and efficient performance across a wide array of industrial and household settings.

A Direct-On-Line (DOL) starter is an essential electrical device designed to safeguard electric motors from potential damage during startup. Its primary function is to initiate induction motors efficiently by directly linking them to the power supply, delivering full voltage. The DOL starter plays a crucial role in mitigating the risk of overheating and mechanical strain on motor windings caused by the initial high current surge during startup. By momentarily limiting this inrush current and facilitating a controlled startup process, the DOL starter not only prolongs the motor's lifespan but also ensures seamless operation. Widely used across diverse industrial and commercial sectors, it is indispensable for maintaining reliable motor performance where operational consistency is paramount.

2. OBJECTIVES

The objective is to develop, build, and validate a Direct-On-Line (DOL) starter tailored for electric motors. The primary goal is to ensure efficient and dependable motor initiation while reducing inrush current and safeguarding against electrical faults. This project aims to deepen comprehension of motor control fundamentals, elevate safety protocols within electrical setups, and enhance the operational efficiency and durability of induction motors across industrial and commercial settings.

3. BLOCK DIAGRAM

Fig 1: Block Diagram of DOL Starter

A Direct-On-Line (DOL) starter is an essential component for kickstarting powerful motors. Here's a rundown of its functioning [1]:

1. Main Circuit: Comprising a contactor (heavy-duty relay), overload relay, miniature circuit breaker (MCB), and a power supply, the main circuit furnishes the necessary voltage to the motor.

2. Contactor: The linchpin of the DOL starter, the contactor, operates through an electromagnetic coil. Upon pressing the start button, the coil energizes, sealing the contactor's contacts and allowing current to course through the motor windings.

3. Overload Relay: The overload relay acts as a safety measure against motor overload. It monitors the current flowing through the motor's windings. If the current surpasses a predetermined threshold for an extended period, the overload relay trips, severing power to the motor to prevent damage.

4. Miniature Circuit Breaker (MCB): Serving as a protective shield for the DOL starter circuit, the MCB guards against short circuits and overcurrent’s. In the event of a fault like a short circuit or overload, the MCB trips, halting power to the entire circuit and safeguarding the starter components and connected equipment.

5. Start Button: Initiating the starting sequence, the start button dispatches a signal to the contactor's coil, energizing it and closing the contacts.

6. Stop Button: When pressed, the stop button interrupts the power supply to the contactor's coil, causing the contacts to open and halting the motor [1].

7. Wiring: The wiring of a DOL starter is straightforward. The motor connects directly to the power supply via the contactor, bypassing any starting resistors or additional devices. This direct link ensures the motor receives full voltage during startup, generating maximum torque for acceleration.

In essence, a DOL starter offers a simple and efficient solution for initiating induction motors, particularly those with substantial starting torque demands. Nonetheless, it may lead to high inrush currents and mechanical strain on the motor and connected machinery. Integrating an MCB elevates the safety and fortification of the starter circuit.

4. COMPONENTS USED

Thecomponents used in this project are:

1. Enclosure
2. Miniature Circuit Breaker
3. Contactor
4. Over Load Relay
5. Metering Device
6. Connecting Wires
7. Push Buttons and Indicators

1. Enclosure:

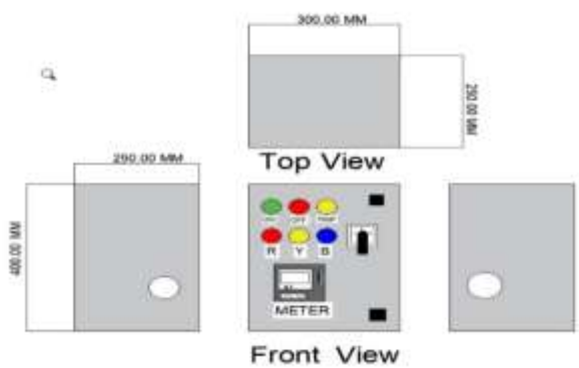

Fig 2: Enclosure

The control panel's most noticeable section, the enclosure, serves the crucial role of housing and safeguarding components from environmental factors and preventing electrical shocks to users. Constructed from CRCA Sheet, with a main frame thickness of 2.0mm and a door thickness of 1.6mm, it ensures robust protection for the enclosed equipment.

2. Miniature Circuit Breaker:

Fig 3: MCB (Miniature Circuit Breaker)

Circuit breakers are essential for safeguarding electrical circuits, devices, and individuals. Among these, Miniature Circuit Breakers (MCBs) are commonly employed in low-voltage applications, prevalent in both residential and industrial environments, typically operating below 1000 V AC-RMS or below 1500 V DC. Despite their small size, MCBs are capable of swiftly interrupting short-circuit currents of up to 10 kA, typically within the frequency range of 50-60 Hz.

An important subset of MCBs includes current-limiting types, which can predict the natural zero crossing of current in AC circuits and mitigate current during switching transients. The effective interruption of current relies on the quick release of stored energy within the circuit. This released energy primarily converts into heat within the electric arc that forms inside the MCB during the separation of electrical contacts [2].

3. Contactor:

Fig 5: Contactor

A contactor functions as a mechanical switch with the ability to establish, conduct, and interrupt currents within a circuit, while also managing currents for a set duration, particularly under overload conditions. Its primary roles include protecting circuits from overload currents, providing isolation, and facilitating control. Contactors are extensively utilized in telecommunication systems and heavy electrical installations, where any malfunction or failure can result in significant operational disruptions [3][4].

4. Over Load Relay (OLR):

Fig 4: Over Load Relay

Many thermal overload relays utilize a bimetal strip as the heat-sensitive component, which bends in response to changes in temperature. For example, in the design of a starter for a single-phase household refrigerator motor, an integrated overload relay is commonly employed. This setup includes both start and run windings in the circuit when the motor is activated by the cold control. A solenoid, featuring a current coil in series with the run winding, controls the starting contacts to disconnect the start winding once the starting current decreases to the typical operating level. The overload relay becomes part of the motor circuit during both startup and operation. When sufficient heat is absorbed, the bimetal strip deflects due to the current passing through it and a nickel heater. This deflection triggers the opening of the overload contacts, isolating the motor from the power source. Upon sufficiently cooling down to reset, the overload contacts automatically return to their closed position [5].

5. Metering Device:

Control panels are outfitted with metering instruments such as hour run meters, ammeters, and voltmeters to gauge the voltage, current, and speed of the equipment. In the proposed system, a dedicated voltage meter is utilized for the precise measurement of voltage.[6]

Fig 6: Voltmeter

6. Connecting Wires:

Wires are chosen based on load requirements. In this project, 1 sqmm and 10 sqmm wires are employed, tailored to specific load capacities. This selection ensures efficient and reliable electrical connections, optimizing performance and safety within the system.[7]

Fig 7: Connecting Wires

7. Indicators and Push Buttons:

Indicators are used to show the status of the DOL Starter.Red Lamp indicates R phase, Yellow Lamp indicates Y phase, Blue Lamp indicatesB phase and the Orange Lamp indicates Trip.

Green color Push Button indicates the ON of the DOL starter and Red color Push Button indicates the OFF position of the DOL Starter.

Fig 8: Indicators

Fig 9: Push Buttons and Trip Indicator

5. CALCULATIONS

Calculation of MCB and OLR:

To accurately establish the ratings for MCB and overload relay, comprehensive specifications for the panel board are essential. This process commences with.

Step-1: The Full Load Current (FLC) based on the power consumption of the load. Usually given in horsepower (HP), the load is transformed into kilowatts (KW) utilizing a defined formula.

$$W=0.746\times HP$$

$$KW=W\times 1000$$

- Converting Load to KW:
  Load = 5HP
  $W = 0.746 \times (HP)$
  $W = 0.746 \times (5)$
  $W = 3.75$
  $KW = 3.75 \times 1000$

Step-2: Specify the voltage rating for the panel to commence the process (eg: 120V, 240V, 480V)

Voltage(V) = 415volts

Step-3: Power Factor

$$COS\emptyset=0.8$$

Step-4: Specify the current rating for the panel board based on the load value to proceed.

$$I=KW/(\sqrt{3}\times V\times COS\emptyset)$$

$$I = (3.75\times1000)/\sqrt{3}\times415\times0.8$$

$$I = 6.52 \text{ Amp}$$

Step-5: In the selection of the appropriate MCB, consideration is given to its type and tripping features. For a C-type MCB, the protection current typically equals 10 times the rated current. Thus, the MCB rating is derived by multiplying the Full Load Current (FLC) by 10.

- Selection of MCB: Based on the MCB type, the protection current is determined. Type C MCBs are utilized, and the initial current is multiplied by 10 [2][8].

$$FLC = 6.5\times10$$

$$= 65.2 \text{ Amp}$$

- Taking into account short circuit protection, typically ranging from 15% to 25% above the Full Load Current (FLC), the MCB rating is adjusted accordingly.

Based on electrical theory, short circuit protection typically ranges from 15% to 25%.

Let the average is 20%

$$\text{MCB Rating} = 65.2\times20\%$$

$$= 13.04 \text{ Amp}$$

The nearest value of MCB Rating is 20 Amp

Step-6: In the process of selecting the Overload Relay (OLR), it is customary to establish the minimum and maximum settings at 80% and 120% of the Full Load Current (FLC) respectively. This practice ensures that the OLR operates within a safe range, protecting the motor from overheating and potential damage [3].

- Selection of OLR (Overload relay):

$$Max = FLC\times120\% \quad Min=FLC\times80\%$$

$$Max = 6.52\times120\% \quad Min=6.52\times80\%$$

$$Max = 7.8 \approx 8 \quad Min=6.52\times80\%$$

The rating OLR is 5.5 – 8 Amp

In conclusion, these calculations ensure that the MCB and OLR protection devices are accurately sized to protect the electrical system and equipment from overloads and short circuits. This guarantees optimal performance and safety in their operation.

HARDWARE COMPONENTS RATINGS:

HardwareComponents	Ratings and Specifications
Miniature Circuit Breaker	6Amps(SP),20Amps(TP), Type C
Over Load Relay	5.5-8 Amps
Contactor	25 Amps
Connecting Wires	10mm and 1sqmm wires
Push Buttons	ON/OFF switching operation
Enclosure	CRCA Sheet, 2.0mm main frame, 1.6mm doors

6. RESULT

DOL starter supplies full voltage to induction motors, producing high starting current and torque, despite potential mechanical strain and voltage fluctuations.

Fig 10: ON Function of DOL Starter

In the above figure Fig 10 shower, illuminated DOL starter signifies it's in the 'on' position. The contactor links the motor directly to the power supply, while the closed overload relay ensures uninterrupted current flow.

Fig 11: OFF Function of DOL Starter

In the above figure Fig 11 shows, the DOL starter is in the 'off' position, with the contactor not engaged. The overload relay is open, halting the current flow to the motor. Additionally, the indicator light is off, signaling that the starter is not activated.

Fig 12: Trip Function of DOL Starter

In the above figure Fig 12 shows, the DOL starter is in a 'tripped' state, activated by excessive current detected by the overload relay. The contactor is disengaged, cutting off the power supply to the motor. The indicator light may either flash or remain off, signaling a fault condition.

7. CONCLUSION

In concluding our DOL Starter project, we have effectively developed and deployed a resilient system specifically designed for high-capacity motors. The assembled starter, incorporating critical elements like the contactor, overload relay, miniature circuit breaker (MCB), and a dependable power supply, has proven its efficiency by consistently delivering full voltage during motor startup, ensuring rapid torque generation for swift acceleration. Through the integration of safety features such as the overload relay and MCB, we have proactively mitigated potential risks linked with overcurrent's and short circuits, underscoring our commitment to prioritizing user safety and safeguarding equipment integrity.

8. FUTURE SCOPE

In the future, there's potential for DOL Starter projects to advance efficiency and safety. This could include integrating smart sensors for monitoring motor conditions in real-time, enabling predictive maintenance and early detection of faults. Exploring the use of renewable energy sources to power the starter could also play a role in promoting sustainability. Moreover, advancements in materials and design could lead to more compact and lightweight starters without compromising durability. Overall, future developments aim to enhance performance, reliability, and environmental friendliness of DOL Starter systems.

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