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Designing an electrical system by using a variable frequency drive to replace a generator in an electrical winch for construction

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A R T I C L E I N F O

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A B S T R A C T

The need for a lack of three-phase energy for the operation of an electric winch that is used to empty infrastructure constructions such as (houses, buildings, among others). The scientific article aims to replace the electric generator used in an electric winch for infrastructure construction, implementing the design of an electrical system through the use of a frequency inverter, this new alternative will reduce costs when using the electric winch. Analytical methods were used and it was checked in the Autodesk Inventor program, obtaining optimal results in the solution, the established methodology is technological-explorative, since the problem was identified, and the possible solutions had to be investigated, when establishing the new solution, it began to be designed and manufactured. Once completed, it was incorporated and assembled into the electric winch, where the respective tests were carried out, being effective at 95%, since the power of the network is unstable where there are ranges where the current is raised and lowered, being an inconvenience for the machine to work at 100%, but it is being used for different activities and needs in construction. The results obtained by adding up all the costs that concern each system of the electric winch for construction: the use of the electrical system is S/ 392.98, the use of the electric generator is S/ 831.60 per day and manually it is S/ 580.00 per day. In summary, by using a frequency inverter in the solution, it allows us to prolong the useful life of the motor, preventing deterioration and unnecessary stoppages that cause downtime, it helps us to reduce energy consumption with a more efficient use, matching the demand of the application, avoiding current peaks and voltage drops, above all, it allows us to regulate the frequency according to the need, configure the acceleration and deceleration to avoid stops and sudden starts of the engine.

1. Introduction

The migration of people to areas where there are new job opportunities. It is seen more and more. Hence the need to increase construction infrastructures or houses. Most people invest in the construction of their houses, so that they can live in them or rent them.

Fig. 1. Gross value added, construction activity, department of Junín.
Source 1: National Institute of Statistics and Informatics (INEI)-2024

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In recent years, infrastructure construction has increased significantly in Peru. This growth is contributing very positively to the economy and to employment, this is because it depends on both public and private investment. Therefore, according to the National Institute of Statistics and Informatics (INEI), from 2007 to 2022 construction activity has been increasing (**Fig. 1**). Likewise, we verify the indicators of the construction sector in the Junín region, and it is corroborated that in recent years the demand is increasing (**Fig. 2**) (Pérez Silva & Trujillo Zurita, 2016; INEI, 2021).

MAIN INDICATORS OF THE CONSTRUCTION SECTOR, 2017 – 2021,					
Indicator	**2017**	**2018**	**2019**	**2020**	**2021**
GDP					
(Annual % Change)	2,5	4	2,2	-11	13,3
VAB Construction					
(Annual % Change)	2,4	5,4	1,5	-14,9	35,5
Cement (tons)	10 686 521	10 799 272	11 327 487	9 821 375	13 668 653

Fig. 2. Main indicators of the Construction Sector.
Source 2: National Institute of Statistics and Informatics (INEI)-2024

It has been choosing to use new technological advances such as in industry, mining, construction, etc. Taking this into account, control measures are being implemented to improve and optimize when the need to implement machinery and tools is observed. Of course, there are a wide variety of electric machines on the market, which differ according to the model and design, in addition to this, they are very useful. In industry, new technological disciplines such as electronics, mechatronics are being used. Therefore, these careers are being focused on automating mostly industrial machinery (Lujan Soto, 2021; Zambrano Loor & Vélez Solórzano, 2020).

A large number of industrial machinery need three-phase power supply so that the motors can operate without any problem. The home electricity network installations are single-phase which becomes an inconvenience, therefore, single-phase frequency inverters are an alternative since they power the three-phase motors with a single-phase network, and also allow their operation to be controlled. Much of the research conducted has shown that the variable frequency drive is one of the solutions in energy saving efficiency. However, given the high environmental impact generated by this type of material, new, more environmentally friendly solutions have emerged. (Gómez Águila, Mayáns Gómez, & Jiménez, 2015) (Ramos Yangali, 2023) (Arbeláez Toro & Rodríguez Ledesma, 2019)

Construction is a sacrificial task, since workers daily transport loads from one place to another, and if infrastructures of more than 2 floors are built, there is a need to use mechanisms that facilitate the transport of construction materials from the first floor to the level they are working on. Likewise, the use of electric winches is currently being used, since it is multifunctional, and can be used in the transport of construction materials or for the emptying of roofs.

The roof pouring process is developed as follows, first the sand, cement and water are mixed for 10 seconds in the mixing machine, so that then the mixture is fed to the buckets of the electric winch, where when the action is activated, the mixed concrete material rises to the level where it is being worked. which is dispersed throughout the roof until it culminates with the slab or surface finish.

Fig. 3. Operation of an electric winch for construction.

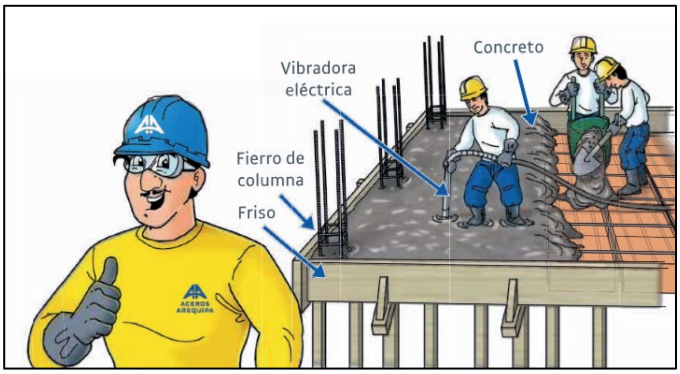


Fig. 4. Pouring of a concrete slab of a house.

According to Aceros Arequipa, in the course of concrete pouring, the beams and joists must first be filled and finally the upper slab until a height of 5 cm is covered. Therefore, for good compaction of concrete, it is advisable to use a mechanical vibrator. In addition, care must be taken not to vibrate excessively, as the components of the concrete can separate (Medina Cruz & Blanco Blasco, 2022).

2. Materials and methods

To guarantee the proper functioning of the electric winch, the use of an electrical system was used by means of a single-phase input frequency inverter and three-phase output since there are no three-phase home installations. This research is of an applied level.

2.1 Mechanical design

In this section, the design of the electric winch for construction was replicated, since it was an operational machine that was working, the problem of its frequent use in any part of the Huancayo Zone was identified, it was designed in the Autodesk Inventor program and its fundamental parts are the following.

Main Structure

It is the main element that will serve as a support for the different structures of the electric winch. It must be able to withstand the movements of the arms with loads in the bucket of up to 350Kg, vibrations from motor stops, and be easy in its assembly and disassembly of the different components that are attached. The dimensions of the square tube 150×150×3mm thick, height 2200mm, width of the support legs: 970mm, support for the transmission mechanism and motor: 775mm in height.

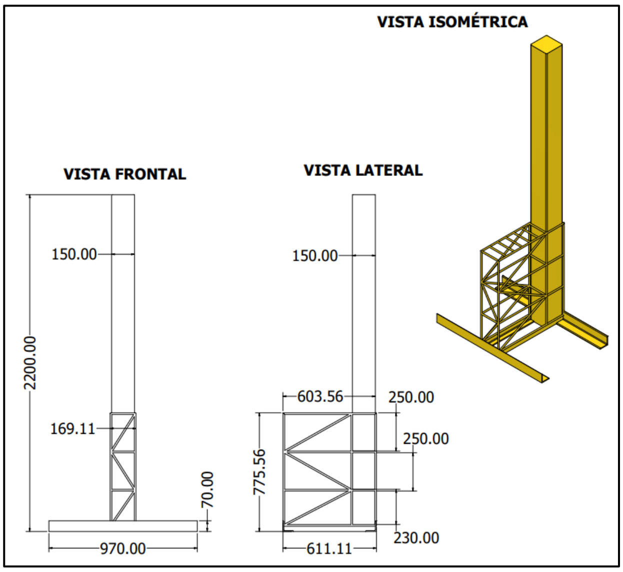


Fig. 5. Detailed view of the main structure of an electric winch for construction.

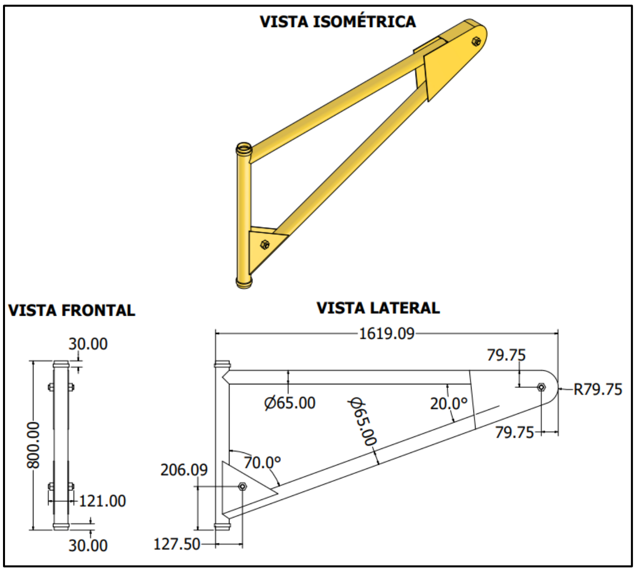


Fig. 6. Detailed view of the arm of an electric winch for construction.

Arms

They are metal structures with 2 pulleys incorporated for the route and dragging of the steel cable, which is hooked to the buckets. They are 65mm diameter tubes 2mm thick, reinforced with 2mm thick plates for the support of the pulleys, the ends of the upper and lower part are anchored in a support with holes to fit and allow 180° rotation.

Buckets

Composed of a square-shaped bucket 856x719mm wide and 600mm high, with 3mm thick plates, designed to support 350 Kg of load for each bucket, reinforced at the top all around. It has a reinforcement in the central part of both sides to be attached to a main support of the bucket that is tied to steel cable.

Body

It is the system that carries out the transmission of power through the sprockets and chains connected to the motor, it has a control lever that fulfills 2 main functions: send the signal to the variator to activate and give movement to the motor, activate and deactivate the brake when it is activated. A pulley is also located where the steel cable runs to transmit the driving force of the buckets up and down.

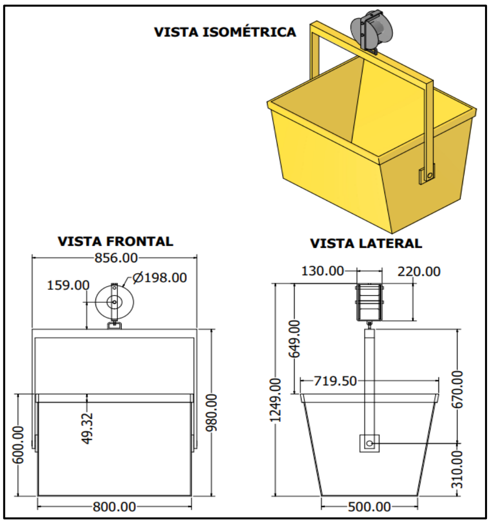


Fig. 7. Detailed view of a bucket of an electric winch for construction.

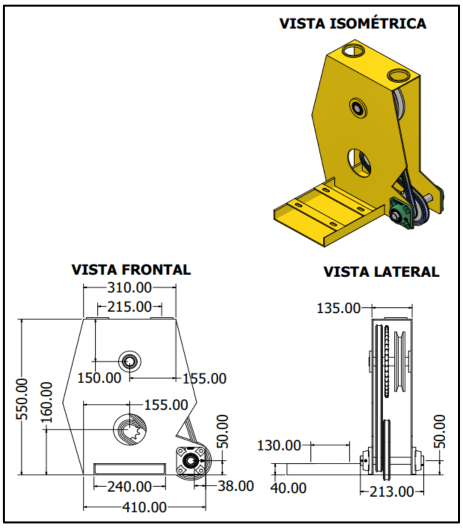


Fig. 8. Detailed view of the body of an electric winch for construction.

2.2 Electrical – Electronic Design

Engine

Electric motors are rotating machines, which convert electrical energy to mechanical rotational energy on an axis. Asynchronous motors are the most widely used in the industry, because of their robustness, simplicity and easy maintenance (Brito Socarrás, Bermello Crespo, Sierra Rodríguez, & Vega Vega, 2005). The motor used for the electric winch is designed to lift a weight of 350Kg, so the power of the motor is 3.7KW (5HP) three-phase of the Siemens brand.

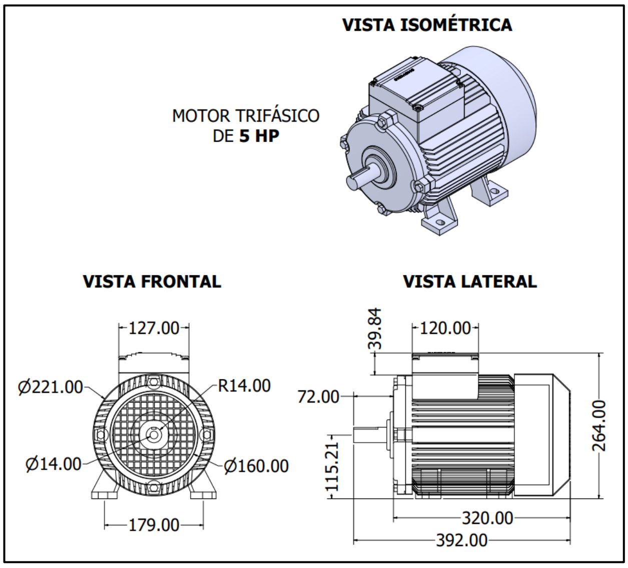


Fig. 9. 5 HP three-phase motor for the electric winch for construction.

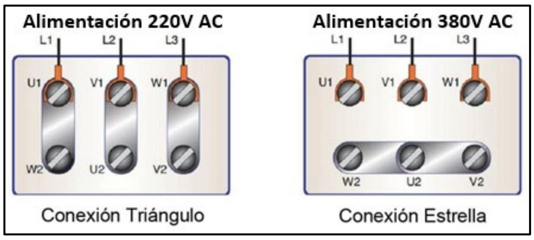


Fig. 10. Star-triangle connection of a motor.

Motor Power

For the energization of the asynchronous motor, a triangle connection is made at the terminals of the coils according to the diagram of the (**Fig. 10**), the three-phase power supply will come from the 220V AC frequency inverter.

Thermomagnetic keys

According to the motor plate and the power of the frequency inverter, the use of independent thermomagnetic keys is used for both the force and control part, respectively according to the catalog of, for the force part 20A capacity is used with code

(A9F74220) see (**Table 1**), since the nominal current of the motor is 15.8A and the output current of the frequency inverter is 17.8A; as for the control part, a 4A thermomagnetic key with code (A9F74204) see (**Table 1**) is used to activate the relay coils and the contactor (Schneider Electric, 2024).

Table 1. IC60N Switch Selection.

	Reference number	
Nominal current	Multi 9	Acti 9
1	24331	A9F74201
2	24332	A9F74202
3	24333	A9F74203
4	**24334**	**A9F74204**
6	24335	A9F74206
10	24336	A9F74210
16	24337	A9F74216
20	**24338**	**A9F74220**
25	24339	A9F74225
32	24340	A9F74232
40	24341	A9F74240
50	24342	A9F74250
63	24343	A9F74263

Reference: Schneider Electric Catalog 2024

Bipolar switch

For the 220V AC voltage step, the general bipolar switch is calculated in Eq. (1).

$$I_{Total} = I_{Fuerza} + I_{Control} \qquad I_{Total} = 20A + 4A \qquad I_{Total} = 24A \tag{1}$$

According to the catalogue of , considering the 25% oversizing, we calculate the actual current in Eq. (2) (Bremas, 2024).

$$I_{real} = I_{total} + I_{total} \times 25\% \qquad I_{real} = 24A + 24 \times 25\%A \qquad I_{real} = 30A \tag{2}$$

The actual current gives us 30A, so we choose the nearest upper current, which is 32A with code (CA0320002PL2), according to (**Fig. 11**).

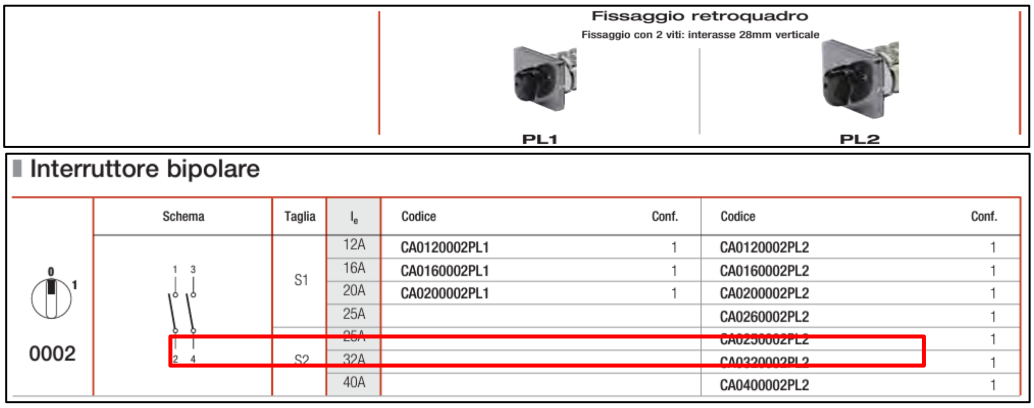


Fig. 11. Bipolar switch selection (11-pin relay with base) Bremen Catalogue.

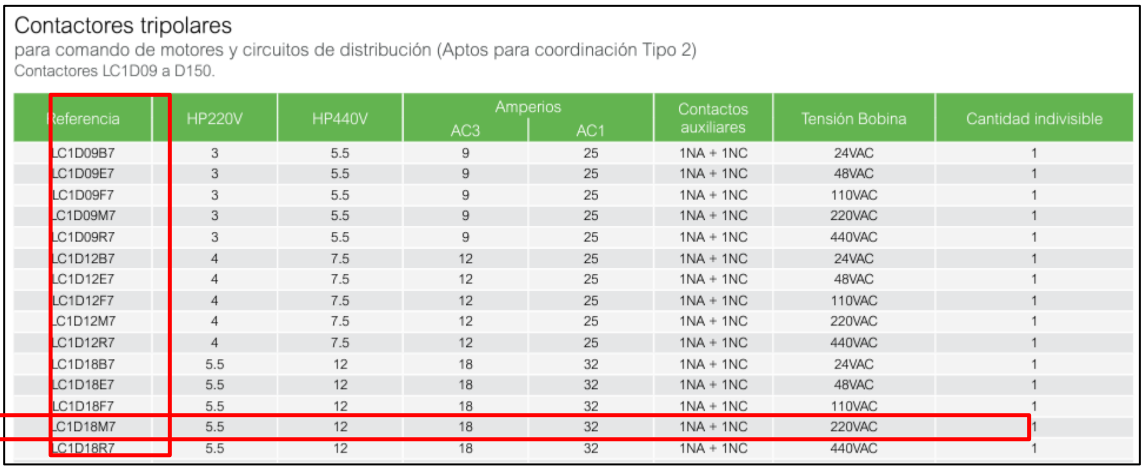
To activate the contact in Forward and Reverse mode of the frequency inverter, relays are used for both rotations, with 220V AC coils with 3 open and closed contacts, according to (**Fig. 12**).

Zelio Relay RUM - Tipo Universal

Referencia	Voltaje de Control	Contactos	Corriente térmica (A)	Indicador	IP	Cantidad indivisible	Pines
RUMC21BD	24 VDC	2 C/A	10	-	40	10	5
RUMC31BD	24 VDC	3 C/A	10	-	40	10	5
RUMC32BD	24 VDC	3 C/A	10	luz piloto	40	10	5
RUMC21B7	24 VAC	2 C/A	10	-	40	10	5
RUMC31B7	24 VAC	3 C/A	10	-	40	10	5
RUMC21F7	120 VAC	2 C/A	10	-	40	10	5
RUMC31F7	120 VAC	3 C/A	10	-	40	10	5
RUMC21P7	220 VAC	2 C/A	10	-	40	10	5
RUMC31P7	220 VAC	3 C/A	10	-	40	10	5
RUMC32P7	220 VAC	3 C/A	10	luz piloto	40	10	5

Fig. 12. Relay Selection - Universal Type.

To protect the frequency inverter towards the output, a contactor is used for possible power generation from the motor to the inverter. The motor consumes 15.8A in triangle connection, it is chosen from the ranges 18A to 32A according to the power of the 5HP motor, according to (**Fig. 13**).


Contactores tripolares
para comando de motores y circuitos de distribución (Aptos para coordinación Tipo 2)
Contactores LC1D09 a D150.

Referencia	HP220V	HP440V	Amperios AC3	Amperios AC1	Contactos auxiliares	Tensión Bobina	Cantidad indivisible
LC1D09B7	3	5.5	9	25	1NA + 1NC	24VAC	1
LC1D09E7	3	5.5	9	25	1NA + 1NC	48VAC	1
LC1D09F7	3	5.5	9	25	1NA + 1NC	110VAC	1
LC1D09M7	3	5.5	9	25	1NA + 1NC	220VAC	1
LC1D09R7	3	5.5	9	25	1NA + 1NC	440VAC	1
LC1D12B7	4	7.5	12	25	1NA + 1NC	24VAC	1
LC1D12E7	4	7.5	12	25	1NA + 1NC	48VAC	1
LC1D12F7	4	7.5	12	25	1NA + 1NC	110VAC	1
LC1D12M7	4	7.5	12	25	1NA + 1NC	220VAC	1
LC1D12R7	4	7.5	12	25	1NA + 1NC	440VAC	1
LC1D18B7	5.5	12	18	32	1NA + 1NC	24VAC	1
LC1D18E7	5.5	12	18	32	1NA + 1NC	48VAC	1
LC1D18F7	5.5	12	18	32	1NA + 1NC	110VAC	1
LC1D18M7	5.5	12	18	32	1NA + 1NC	220VAC	1
LC1D18R7	5.5	12	18	32	1NA + 1NC	440VAC	1

Fig. 13. Selection of three-pole contactors.
Source: Schneider Electric Catalog

A variable speed drive is a power supply with variable voltage and frequency, which modifies the speed of a motor while maintaining a useful torque in a certain regulation range. The drive must be able to keep the engine torque within limits useful for the application. The use of variable frequency drives increases the time between maintenance of the mechanisms, due to the smoothness of the starting force and the change in speed with which the motors work (SAT, 2020; Delgado Santana, Monteagudo Yanes, & Consuegra Urquiza, 2015).

Criteria for choosing the optimal frequency inverter

Engine Features

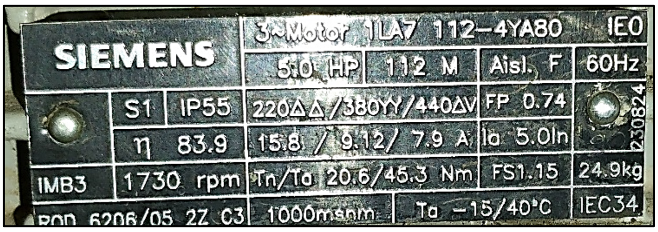


Fig. 14. Siemens 5 HP three-phase motor plate.

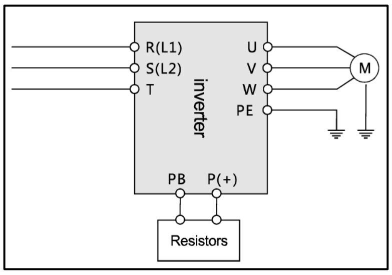


Fig. 15. Regenerative resistance wiring scheme.

Load Type

Motor used to lift concrete buckets, construction materials; This requires constant torque.

By de arranque

The frequency inverter is sized according to the criteria of use, according to the single-phase supply network, the motor is 3.7KW (5HP), so the choice of a 3.7KW (5HP) power inverter is made to supply the motor.

Regenerative braking

As they are loads of great inertia, vertical movements exposed to free fall, a regenerative resistance is used to protect the frequency inverter according to (**Table 2**).

Table 2. Regenerative resistance values according to Rievtech manual

Model	Applicable motor (KW)	Resistance (Ω) 220V single phase	Resistance power	Brake unit
R13000-2S0004G	0.4KW	200Ω	100W	Built-in
R13000-2S0007G	0.75KW	150Ω	200W	Built-in
R13000-2S0015G	1.5KW	100Ω	400W	Built-in
R13000-2S0022G	2.2KW	75Ω	500W	Built-in
R13000-2S0030G	3.0KW	50Ω	700W	Built-in
R13000-2S0037G	**3.7KW**	**30Ω**	**800W**	**Built-in**

Reference: Manual Rievtech.

According to the manual, a 30Ω resistor with a power of 800W is used for the frequency inverter of that power for regenerative braking (Rievtech, 2019).

Environmental conditions

Ambient temperature 17°C – 22°C, humidity 80% - 85%, altitude 3259 meters above sea level, installed in a control panel with sufficient ventilation to avoid overheating in each component.

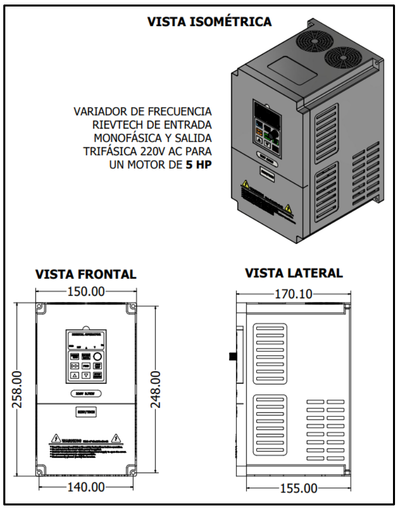


Fig. 1. Single-phase frequency inverter for 5 HP motor.
Source: Authors.

Conductor Gauge Calculation:

$P = 3730\text{ W},\ V = 220V\ AC$ and $FP = 0.74$

where *P, V* and *FP* represent the engine plate data: and they power (W), voltage (V) and power factor, respectively.

Conductor Gauge Calculation by Current:

$$I_{3\emptyset} = \frac{P}{\sqrt{3} \times V \times FP} = \frac{3730}{\sqrt{3} \times 220 \times 0.74} = 13.228\ A \tag{3}$$

Adding 25% reliability yields,

$$I_{3\emptyset} = I_{3\emptyset} + I_{3\emptyset} \times 25\% = 13.228 + 13.228 \times 25\% = 16{,}535\ A \tag{4}$$

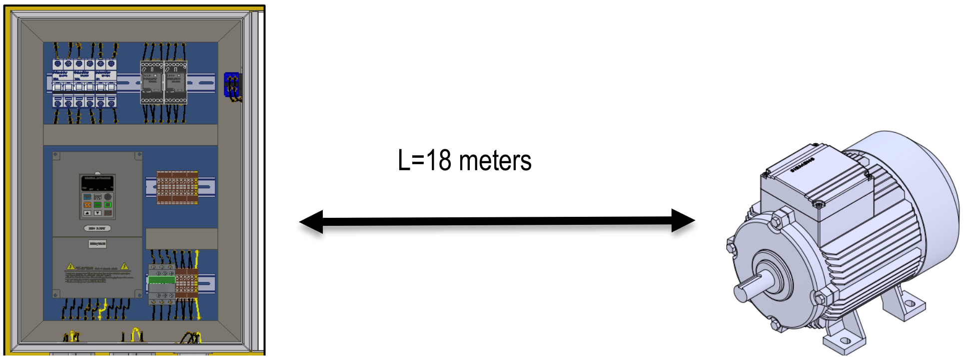
where *I* represents current. According to the table of we make the choice of the conductor caliber 12 AWG, according to the consumption current of the motor (INDECO, 2022).

Table 3. Technical data of the drivers' calibers

AWG-MCM Conductor Gauge	Cross Section mm^2	Minimum number of wires	Insulation Thickness mm	External diameter mm	Nominal Weight Kg/Km	Amperage	
						Duct	Air
14	2.08	7	0.8	3.6	29	25	35
12	**3.31**	**7**	**0.8**	**4.1**	**40**	**30**	**40**
1	5.26	7	0.8	4.7	60	40	55
8	8.37	7	1.1	6.5	110	55	80
6	13.3	7	1.5	8.0	170	75	105
4	21.2	7	1.5	9.5	250	95	140
2	33.6	7	1.5	11	380	130	190
1	42.4	19	2.0	13	490	150	220
1/0	53.5	19	2.0	14	600	170	260
2/0	67.4	19	2.0	16	740	195	300
3/0	85.0	19	2.0	17	910	225	350
4/0	107.2	19	2.4	19	1130	260	405

Source: INDECO Catalog.

Calculation of conductor gauge by voltage drop:



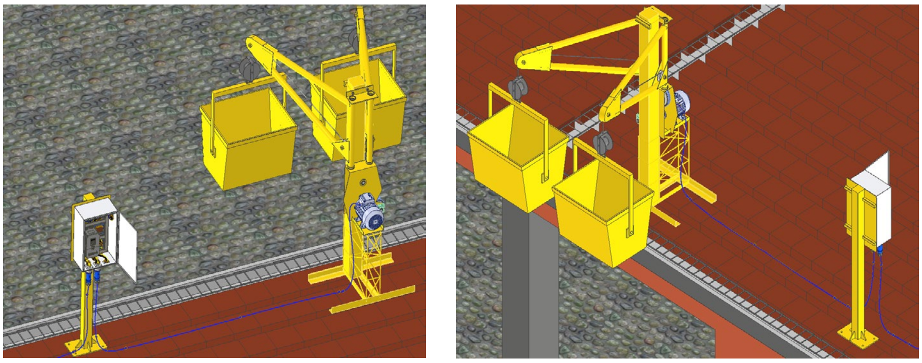
$$\Delta V = \frac{L \times P}{K \times S \times V} = \frac{18 \times 3730}{59 \times 4 \times 220} = 1.293\ V \quad (5)$$

where L, K, ΔV and S represent distance between the board and the engine (m), copper conductivity, voltage drop (V) and cable section (mm^2), respectively. So 1.293 V is 0.59% of 220 V, according to a 12AWG gauge cable has a range of variation in voltage of ±2%, according to the calculations obtained by voltage drop meets the gauge selected in (Table 3) (INDECO, 2022)

3. Implementation

3.1 Mechanical Implementation

The design of the electric winch for construction was carried out according to the existing measurements of the machine, see (**Fig. 17**).



(a) **(b)**

Fig. 2. Design of the electric winch for construction.

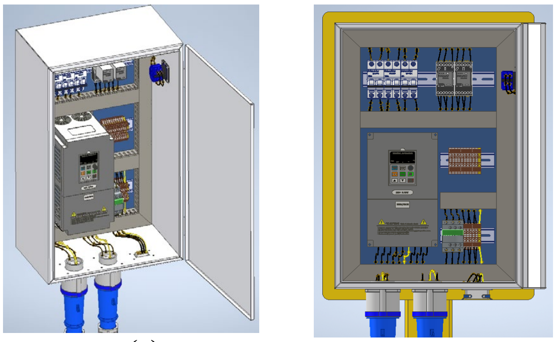
The electric winch for construction was assembled as seen in (**Fig. 18**) (a) in a house on the second level in the District of Palian – Province of Huancayo, to lift materials such as: pre-mixed concrete, coarse sand, concrete, bricks and cement. The necessary connections were made to the engine, control lever and emergency stop box as shown in (**Fig. 18**) (b).

(a) **(b)**

Fig. 3. Construction of the electric winch for construction.

3.2 Electrical – Electronic Implementation

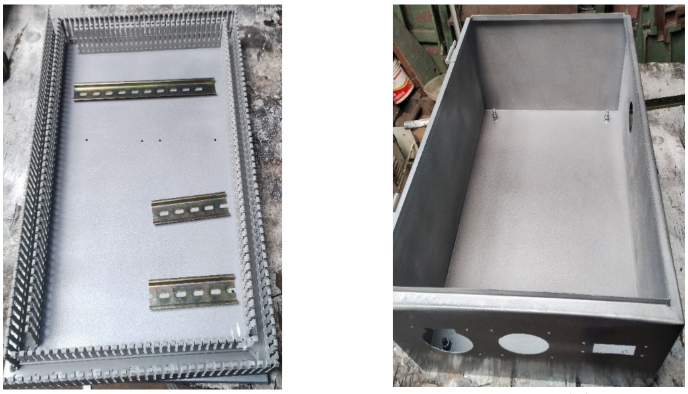
The design of the electrical control panel for the electric winch was carried out according to the calculations made previously, see (**Fig. 19**).



(a) (b)

Fig. 4. Manufacture of fake board/Electrical panel.

The electrical panel with dimensions 600mm, width 400, depth 260mm see in (**Fig. 20**) (b) and the false board with dimensions length 565mm, width 365mm, depth 12mm see in figure (**Fig. 20**) (a) was manufactured, where the assembly of the grooved gutters, DIN rails, holes for the female mennekes for the inlet of the 220V AC power supply was carried out, for the output of the motor, fix the bipolar switch, and fix all the electrical-electronic components.



(a) (b)

Fig. 20. Manufacture of fake board/Electrical panel.

The electrical connections were made, see in **Fig. 21**, to the general bipolar switch, the thermomagnetic keys, the force circuit, to the inverter, the contactor and the output to the motor in the female menneke embedded in the panel, the control circuit to operate the relays, passing through the control lever and the emergency stop button that gives the signal for the drive to be operated clockwise or Anti-clockwise depending on the position of the bucket of the electric winch for construction. The input and output of the signal uses a 10-pin female and male connector, these types of connectors were implemented in order to facilitate the connection and disconnection at the time of assembly for use by the machine.

(a) (b)

Fig. 21. Implementation of electrical - electronic wiring.

4. Results

After the electrical system of the electrical winch for construction had been assembled and connected, the following data was obtained regarding the current consumption. Making a comparison with respect to the implementation of the electrical system, the use of a generator and manual work, we made comparison tables, to see the costs of man-hours, machine rental, consumables per day.

- Cost of the number of personnel employed by the use of each type of system per day, the electric winch for construction.

Table 4. Cost of number of personnel and machine rental per day.

	Use of the electrical system	Using the Electric Generator	Manually
Number of staff	4	5	6
Cost per staff per day (Soles)	S/ 90.00	S/ 90.00	S/ 90.00
Machine rental (Soles)	-	S/ 250.00	-
Total, Spend Per Day	**S/ 360.00**	**S/ 700.00**	**S/540.00**

- Cost of consumables for each system you use per day, the electric winch for construction.

Table 5. Cost of consumables for each system.

	Use of the electrical system	Using the Electric Generator	Manually
Number of liters of gasoline per hour	-	4	-
Working Hours (Hours)	-	6	-
Cost per Liter (Soles)	-	S/ 4.65	-
Hydration (Soles)	S/ 20.00	S/ 20.00	S/ 40.00
Total, Spend Per Day	**S/ 20.00**	**S/ 131.60**	**S/ 40.00**

- Cost of energy consumption per Kw/h per day, taking into consideration that the motor is of one power (3.73 Kw), and approximately 6 hours of work of the electric winch for construction is considered.

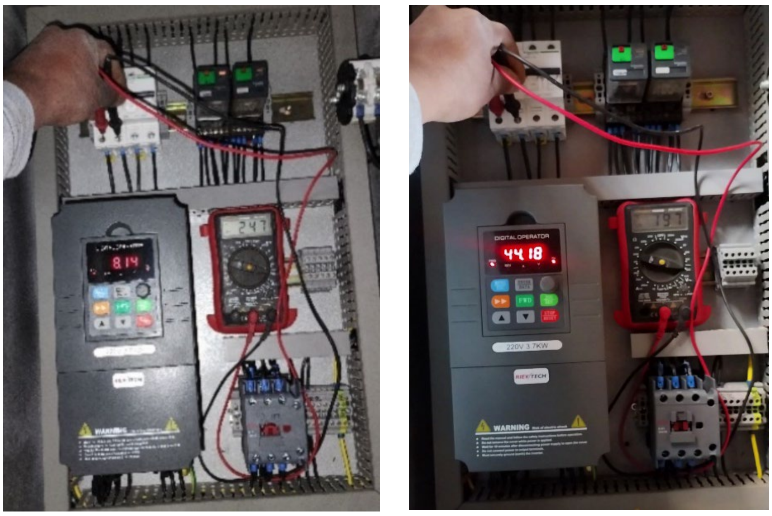
Table 6. Cost of energy consumption per (Kw/h) per day.

	Use of the electrical system	Using the Electric Generator	Manually
Energy consumption (Kw/h)	22.38	-	-
Cost per Kw/h (Soles)	S/ 0.58	-	-
Total, Spend Per Day	**S/ 12.98**	**S/ -**	**S/ -**

- Adding up all the costs that concern each system, we compare the amounts that are spent per day for the electric winch for construction.

Table 7. Total cost per system per day.

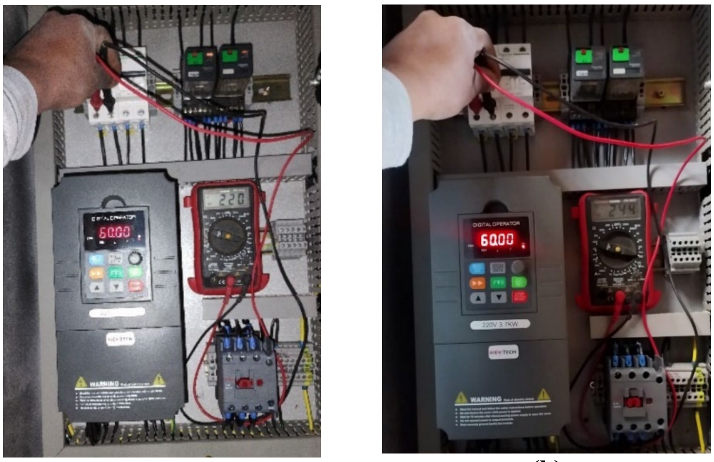
	Use of the electrical system	Using the Electric Generator	Manually
Number of personnel and machine rental (Soles)	S/ 360.00	S/ 700.00	S/ 540.00
Cost of consumables per system per day (Soles)	S/ 20.00	S/ 131.60	S/ 40.00
Cost of electricity consumption	S/ 12.98	-	-
Total, Spend Per Day	**S/ 392.98**	**S/ 831.60**	**S/ 580.00**



(a) **(b)**

Fig. 22. Drops and voltage rise at the time of engine ignition.

The prices calculated in each table are with current prices, both the payment of workers and machine rental, and the prices of electricity consumption (Kw/h). As we go up the floor, both for the emptying of the roof and lifting construction materials, the prices will increase in the use of the electric generator since they consume more fuel and lifting the materials manually requires more personnel since the physical wear and tear is much greater, but the price of the electrical system used in the electric winch increases slightly with respect to energy consumption. Measurements are made with the multimeter with respect to the input voltage to the frequency inverter, where it can be observed in (**Fig. 22**) (a), at the time of ignition there is an increase in input voltage of 27V, when the frequency increases, a voltage drop of 23V is observed in (**Fig. 22**) (b), This is due to the initial effort the engine makes to beat the starting torque. When the motor is running at 60Hz, the input voltage is 220V, see (**Fig. 23**) (a), and when the motor stops there is a voltage increase of 24V, as seen in (**Fig. 23**) (b), this is due to the effort that the motor makes when it stops, because it has to slow down the inertial force of the bucket with load.



(a) **(b)**

Fig. 23. Implementation of electrical - electronic wiring.

For these drawbacks of voltage drop and increase, a 10 KVA single-phase servomotor state stabilizer is used, as long as the input is in the range of 160V to 260V AC, the output of the stabilizer is always 220V AC, see (**Fig. 24**).

Fig. 24. Status stabilizer 10 KVA single-phase servomotor.

Implementation of the 10 KVA single-phase servomotor status stabilizer in the machine, the improvements can be evidenced at the time of starting and stopping the electric winch machine, having a margin of error of ± 2% of voltage at the output, see (**Fig. 25**).

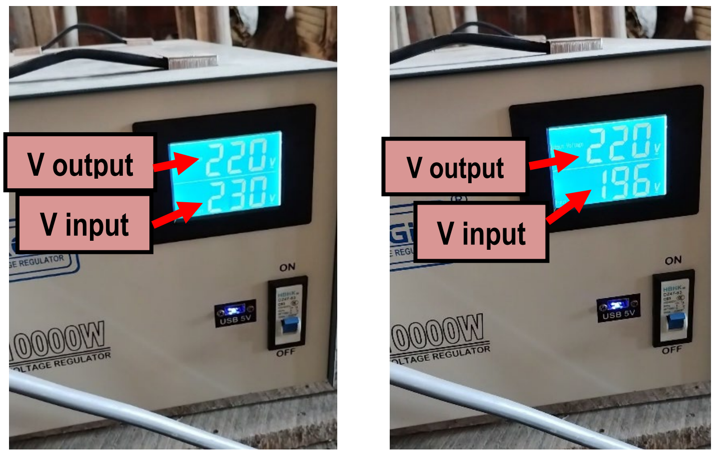


Fig. 5. Implementation of the 10 KVA single-phase servo motor in the machine.

It is evident in (**Fig. 26**), at the time of turning the machine on and off it is observed that there is a slight increase in voltage of 2V, which fulfills its function in stabilizing the output voltage.

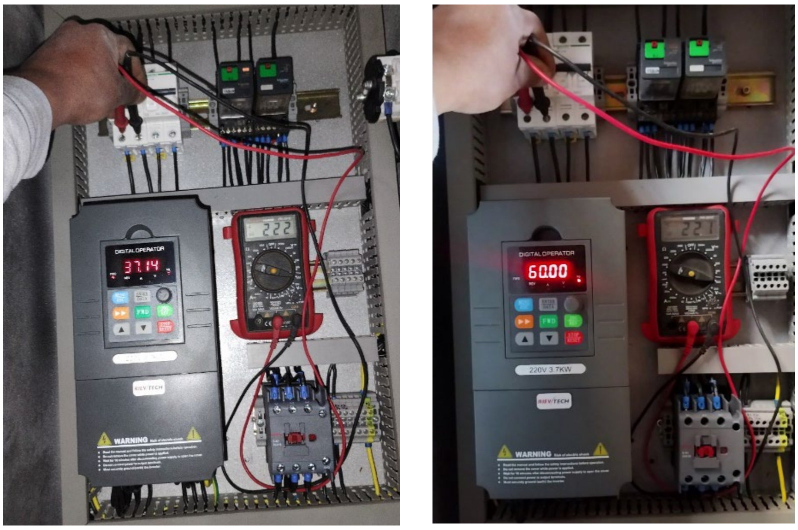


Fig. 6. Status stabilizer 10 KVA single-phase servomotor.

5. Conclusions

- The present research project with the implementation of the electrical system through the use of a single-phase input frequency variator and three-phase output of 220V AC, the expense that is made is S/ 392.98 soles per day, while with the rental of an electric generator the expense is S/ 831.60 soles per day. this allows us to save S/ 438.62 soles per day, which is significant money for the master mason who uses this type of machine for the construction process.
- With the implementation of this solution we significantly save downtime when lifting construction materials, since lifting materials manually takes approximately 2 to 3 minutes for each trip with pauses of 1 to 2 minutes depending on the floor that lifts the material, with the implementation of the electrical system the materials are lifted every 20 to 25 seconds for each bucket with pauses of 15 to 25 seconds until the bucket stops and stabilizes for the start of the ascent.
- This solution implies a compact and cost-effective design over time, with an initial implementation cost of approximately S/ 3700.00 soles, since in 9 to 10 times that they use it they would be recovering their investment and as the construction floor rises it is much cheaper, which would be impossible to do manually. and prices would rise to rent an electric generator because they consume more gasoline.
- Using a frequency inverter in the solution allows us to prolong the useful life of the motor, preventing deterioration and unnecessary stoppages that cause downtime, it helps us to reduce energy consumption with a more efficient use, matching the demand of the application, avoiding current peaks and voltage drops, above all it allows us to regulate the frequency according to the need, Configure acceleration and deceleration to avoid stalls and abrupt engine starts.
- The use of a 10KVA single-phase input and output servomotor state stabilizer, with a power of twice the motor, allows us to suppress the drop and overvoltage since the equipment gives us a stable voltage with a range of ±2% variation towards the power input to the proposed electrical system.
- The electrical system proposed through the use of a single-phase input frequency inverter and three-phase output of 220V AC, allows us to use the machine anywhere where there is a single-phase network and thus be able to operate a three-phase motor without the need for capacitors or transformers, maintaining the force, torque.

6. Recommendations

- It is recommended to make the respective calculations of the conductors according to the power of the motor and also the control panel must be at a close distance from the actuator, to avoid unnecessary trips in the conductor and thus avoid voltage drops.
- It is advisable to use a servomotor status stabilizer for these applications since it allows us to stabilize the input voltage to the frequency inverter, which guarantees the correct operation and possible failures or errors that can affect the inverter.
- It is recommended to increase the contracted power in the house where the machine is going to be used with the proposed system, since in general the power is 3.5KW, for the machine a minimum power of 4KW is required so that it can work without any problem.

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