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Explore Electrical Insights: Evaluation of the Tektronix THS3024 Handheld Oscilloscope for Engine Analysis

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Abstract— The Tektronix THS3024 handheld oscilloscope is explored in this study by examining its efficiency in electrical measurements. In this study, the potential of the instrument is used to evaluate its performance in both unloaded and loaded engines. The THS3024 is equipped with 8 channels and allows the measurement of current and voltage. For this work, 6 channels were enabled due to the delta configuration of the engine, providing 3 voltage channels and 3 current channels. Using a 60 volt supply, the channels were configured to measure voltage and current parameters with appropriate attenuations. Through analysis, this study examines the behavior of the engine at startup and steady state, both with and without load. The plots showing the current waveforms during startup and steady state with and without load highlight the ability of the device to automatically adjust its scale to capture even subtle variations. The study acknowledges that while intrinsic factors have hindered the analysis of harmonics, the THS3024 still provides the ability to display harmonic spectra. By examining the voltage and current response during engine startup, this study demonstrates the value of the THS3024 in capturing essential transient characteristics and precise parameter changes. The negligible differences between loaded and unloaded engines underscore the reliability of the instrument in evaluating electrical behavior. This study thus demonstrates the potential of the THS3024 for precise electrical measurements and promotes its applicability in electrical engineering research.

Keywords— Tektronix THS3024, Oscilloscope, Electrical Measurement, Electrical Analysis, Handheld Device, Performance Evaluation

I. INTRODUCTION

The purpose of this study is to investigate and examine devices used to measure magnitudes associated with electrical energy in three-phase engines [1]. This focus is directed to Tektronix THS3024 [2] device notable for its ability to store information, enabling customized analyzes according to the user's demands. The results obtained evidence of the consistency of the stored values, both during the engine at no load and under load. This highlights the ability of this device to enable a detailed statistical analysis of the collected data. These functions are fundamental when deepening the understanding of the correlation between the characteristics of the engine and the captured electrical quantities. In addition to this aspect, the customization of the Tektronix THS3024 device's input parameters by the user, expands its applicability in scientific investigations aimed at measuring and analyzing issues concerning electrical energy. The results obtained establish a solid foundation for the development of advanced measurement and analysis methodologies in three-phase engines, thus contributing to the continuous progress in this evolving field of research.

The relevance of research aimed at quantifying electrical energy in three-phase engines is widely recognized within the scientific community, as electrical energy is one of the most important products consumed by homes and industries [3]. Previous studies have contributed significantly with valuable information in this field of study, allowing a solid base for the continuous evolution of research and development in this domain [4, 5]. The prior investigative approach is crucial to understanding the complexities inherent in three-phase engines and their interactions with electrical properties, thus facilitating the advancement of technical solutions and effective measurement methodologies [6].

Due to the complex characteristics of three-phase engines and the subtle interactions between their performance attributes and electrical properties [7], choosing a reliable measurement approach is extremely significant. To address this critical need for reliable measurement methodologies, it is imperative to consider the use of specialized equipment. In this context, the Tektronix THS3024 portable oscilloscope [2] emerges as a potentially valuable tool for the precise and detailed analysis of three-phase engines. With its ability to capture and visualize complex three-phase waveforms, the THS3024 offers deep insights into the electrical behavior

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of these engines, enabling the detection of anomalies and the assessment of interactions between performance attributes and electrical properties [2].Thus making it suitable equipment for this study, as explained in Section II

II. Methodology and Tools

The primary objective of this project resides in carrying out a thorough analysis of the Tektronix THS3024 device operation manual [2], to investigate and analyze information associated with three-phase engines [1]. This analysis will cover both the operating conditions of the engine at no load and with a small load.

In this section of the work, a theoretical study is carried out through the use of a careful bibliographic survey. Additionally, other theoretical resources were consulted within the scope of the bibliographical survey, aiming to clarify the complexities that could arise during the outlined theoretical course. Finally, as shown in Section III, the measurements of the magnitudes were : Starting Voltage (in Voltage - V), Post-start Voltage (in Voltage - V), Starting Current (in Amps - A) and Post-start Current (in Amps - A). Next, the tools used in this work are explained: Tektronix THS3024 and engines

a. Instrumentation: Tektronix THS3024

The Tektronix THS3024 is an oscilloscope with significant technological potential suitable for use as a power quality analyzer. This instrument can be used for data acquisition in the laboratory and for characterization of household appliances. Its manual [2] highlights that the THS3024 oscilloscope is equipped with 4 isolated channels and a battery life of up to 7 hours, so you can safely perform various types of measurements on your workbench or in the field.

This instrument offers distinctive features that set it apart from other handheld oscilloscopes. The Tektronix THS3024 has excellent bandwidth and a remarkable sampling rate with a significant number of data points in the recording length per channel [2], as shown in Fig. 1.

Fig. 1: The Tektronix THS3024 [2].

With a bandwidth of 200 MHz and a maximum sample rate of 5 GS/s, no other handheld oscilloscope offers this much bandwidth and sample rate in a portable format. The THS3024 has a recording length of 10,000 points per channel, so you can capture more signal information at high sampling rates to clearly see signal details. For applications where it is important to measure slowly changing signals over long periods of time, the THS3024 offers Roll mode, which extends the length to 30,000 data points [8].

Figure 1 shows the Tektronix THS3024 navigation panel, which serves as the primary means of accessing the tools in this device [4]. The navigation panel consists of buttons, each of which is associated with a command of the THS3024 device, such as the bottom left button responsible for turning the device on and off. Once the device is activated, certain functions can be changed using these buttons. Tektronix [2] clarifies that when any button on the front of the device is pressed, the associated menu appears on the screen. To navigate the menus, Tektronix [2] recommends using the up, down, right, and left arrow keys to move through the submenus. To select a submenu item, press the "Enter" key.

The screen of the Tektronix THS3024 is responsible for displaying data acquired from measurements on a specific circuit, as illustrated in the following section's (III) figures. It allows users to interact with this data and manipulate it using the navigation panel [4]. Signal input into the THS3024 involves enabling channels Ch1, Ch2, Ch3, and Ch4. The top section of this equipment features four inputs where measurement probes can be connected. These probes can be replaced with current clamps for alternative measurements [2].

b. Engine Specifications

This subsection presents the collected data from a WEG asynchronous engine [1], as shown in Fig. 2, running both unloaded and with a small load generated by an idle direct current generator, utilizing Tektronix THS3024 equipment [2].

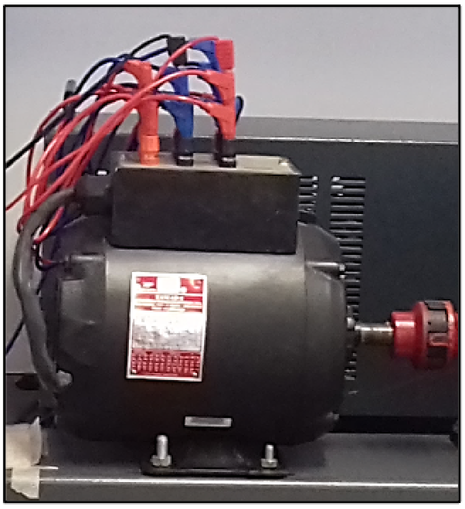

Fig. 2: WEG asynchronous engine [1].

A 1 HP engine was employed, which represents a relatively low power rating. Nevertheless, this power level permits a direct start of the engine, implying that the rated power of an electric machine can influence the starting moment. Moreover, initiating the engine with no load or with a minor load also allows for the experiment to function as a direct start. In this regard, Mamede [7] asserts that:

- Engine can only undergo a direct start if the following conditions are met: the nominal current of the power supply is so high that the engine's starting current is insignificant;

- The engine's starting current is low due to its small power;
- The engine starts with no load, reducing the impact of the starting current and consequently mitigating its effects on the power supply system.

The principal characteristics of the electric engine are typically contained within the nameplate data, thus ensuring that operations with the electric machine are executed as safely as possible. Consequently, the key information within the nameplate data for this engine is summarized in Table 1 [1].

TABLE 1: PLATE DATA OF THE WEG ENGINE USED.

Characteristics	Values
Frequency	60Hz
Voltage	220V (phase-neutral) 380 V (phase-phase)
Power	1Hp
SF	1.5
Insulation	F

The coil configuration employed for this engine was the delta configuration, which eliminates the need for a neutral connection within the circuit. Subsequently, a automatic voltage regulators (Variac®) [9] was connected to the input of the three-phase power supply, and from its output, the engine was linked to the idle DC generator. Fig. 3 illustrates the configuration with the engine connected to the unloaded DC generator.

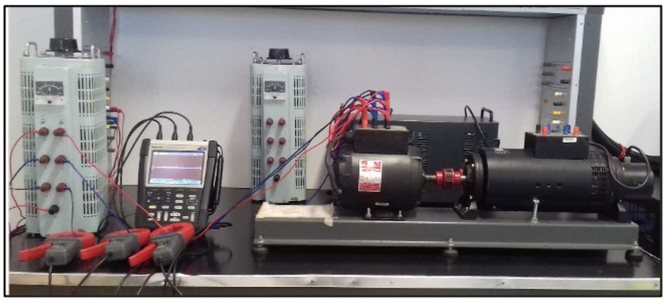

Fig. 3: Configuration for engine connected to DC generator.

III. RECORDED RESULTS

a. Initial considerations

The Tektronix THS3024 equipment [2], has a total of eight channels, four of which are dedicated to measuring electric current, and the other four are for measuring voltage. However, due to the specific configuration of the engine coils[1], it was selected only six channels. It should be noted that the engine under consideration adopts a delta configuration due to the lack of a neutral point current. At the same time, it should be noted that the operating system is three-phase, thus requiring three channels for voltage measurement. In this experimental context, a voltage of 60 Volts was adopted.

In this sense, it is worth noting that channels 1, 2, and 3 are associated, respectively, with the R, S, and T phases of the system, while channels 5, 6, and 7 were designated to measure the currents of the same phases. To proceed properly, the selected configuration incorporates a current attenuation of 100 mV/A and a voltage attenuation of 1:1, as detailed in Figs. 4 and 5.

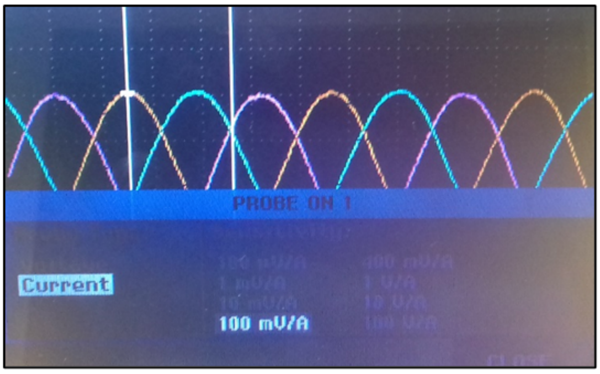

Fig. 4: Current attenuation THS3024.

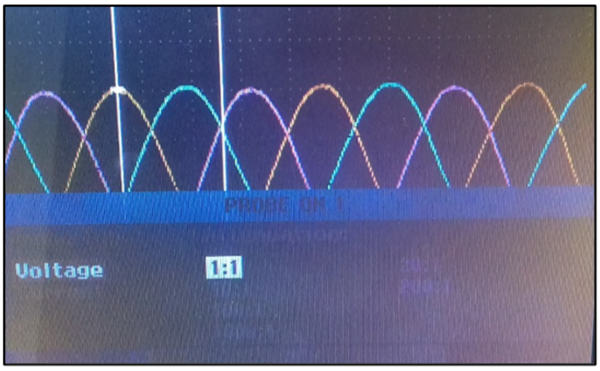

Fig. 5: Voltage attenuation THS3024.

b. Comparison of the engine at no load and with load

When starting up a given engine, the current demanded by it exceeds the current requested during its operation by that device. This discrepancy is reflected in the electric current graph, which shows a significant variation between the starting moment and the moment when the engine operation stabilizes. These aspects are shown in Figs. 6, 7, 8 and 9, representing the graphs corresponding to the engine start and the subsequent period of operational stability, both in the absence and in the presence of load.

It is important to note that the equipment automatically adapts the representation scale due to considerable differences between the recorded current values. While the graph shown in Figs. 6 and 7 shows a scale of 100 amps per division, the graph depicted in Figs. 8 and 9 is characterized by the use of a scale of 500 amps per division.

Although the quantification of harmonics using this equipment has been unfeasible due to intrinsic factors such as calibration and the device's precision, it is capable of measuring and graphically representing the harmonic spectra, as shown in Fig. 10, which illustrates the harmonic

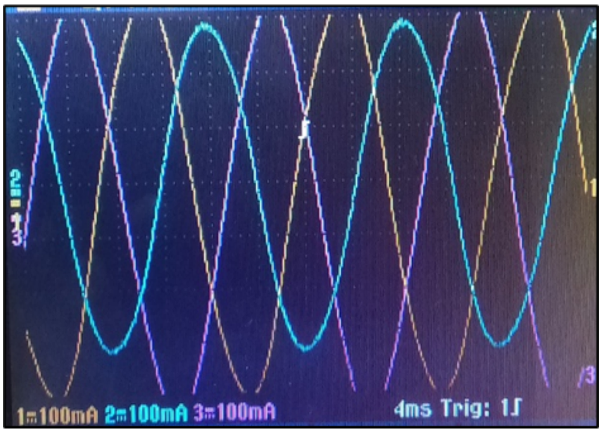

Fig. 6: Engine at no load starting current waveform.

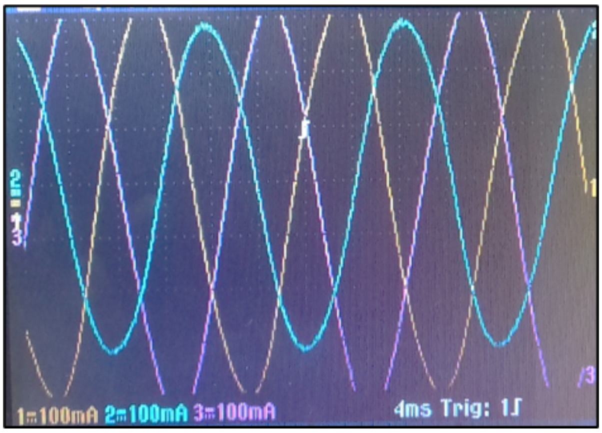

Fig. 7: Engine starting current waveform with load.

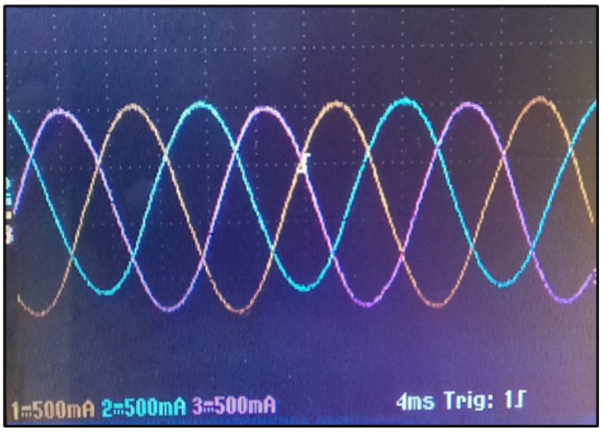

Fig. 8: Peak-peak current waveform in phases R, S and T, engine at no load.

spectrum up to the 15th order and the quantification of each individual harmonic order can be registered with the moving cursor on the device itself. Information such as total harmonic distortion can also be recorded.

IV. FINAL CONSIDERATIONS

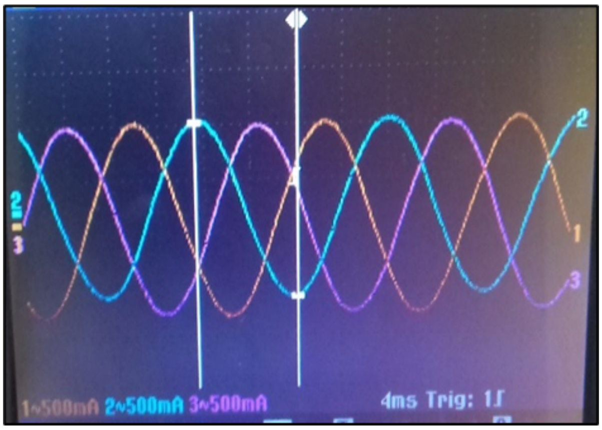

Fig. 9: Peak-peak current waveform in phases R, S and T, engine with load.

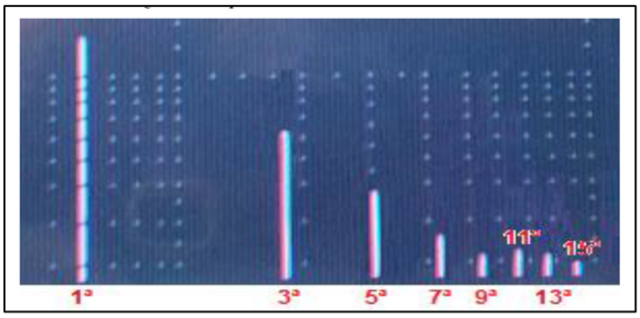

Fig. 10: Harmonic spectra obtained with the THS3024.

When analyzing the obtained results, the slight variation of the voltage during the engine start is noticeable, as highlighted in Table 2. It is important to emphasize that the values presented in this table are affected by the damping assumed in this study. Table 2 provides a overview of the quantities measured during the experiment, for both the unloaded and loaded engine. The quantities include Starting Voltage (in V), Post-start Voltage (in V), Starting Current (in A) and Post-start Current (in A).

TABLE 2: COMPARATIVE ANALYSIS OF MEASURED PARAMETERS.

Measured Parameters	Engine Empty	Engine With Load
Starting Voltage (V)	1.586	3.421
Post-start Voltage (V)	1.863	3.874
Starting Current (A)	14.452	34.869
Post-start Current (A)	11.641	32.158

On the other hand, Fig. 11 visually summarizes the data presented in Table 2 and provides a more accessible statistical analysis. Figure 11 clearly shows that the deviations between the values obtained for the loaded and unloaded engines are minimal. This graphical representation highlights the consistency of the results and shows that the small differences in the measured quantities do not affect the effectiveness of the Tektronix THS3024 in evaluating the electrical performance of the engines under various conditions.

Thus, looking at both the details in Table 2 and the visual representation in Fig. 11, it is clear that the Tektronix THS3024 has a remarkable ability to provide accurate and consistent analysis of electrical quantities in engines, regardless of the applied load. These robust findings support the utility of this handheld oscilloscope in the context of electrical system analysis and promote a more refined and informed approach to engine performance evaluation.

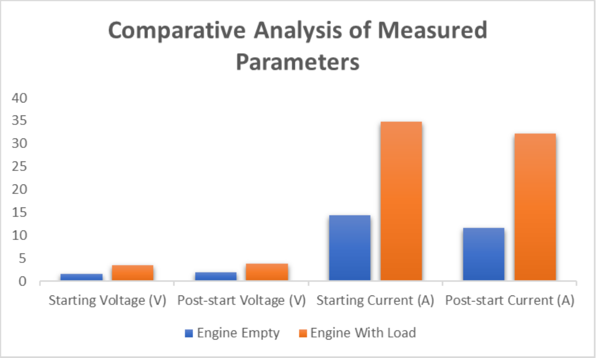

Fig. 11: Comparison of measurements.

V. ACKNOWLEDGMENT

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