Development of an Electrotherapy Output Sound Indicator Device (EOSID) as an Objective Alternative to Traditional Sensory Output Testing

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Abstract

Background: Routine output testing of electrotherapy equipment such as Transcutaneous Electrical Nerve Stimulation (TENS), Interferential Therapy (IFT), and Electrical Muscle Stimulation (EMS) is traditionally performed using examiner sensory perception. This approach lacks objectivity, repeatability, and examiner safety.

Objective: To develop a low-cost Electrotherapy Output Sound Indicator Device (EOSID) and evaluate its application as an objective alternative to traditional sensory output testing of electrotherapy equipment.

Methodology: EOSID was developed using a piezoelectric electronic buzzer connected via standard electrotherapy electrode cables. The device converts electrical output from electrotherapy machines into audible sound. Output testing was performed by connecting EOSID to the output terminals of TENS, EMS, and IFT units and gradually increasing intensity. Auditory patterns were observed and interpreted based on frequency characteristics. Cable fault detection was also assessed.

Results: EOSID successfully detected output from all functioning electrotherapy devices. Distinct auditory patterns corresponded to low-frequency, high-frequency, and interferential currents. The device enabled differentiation between machine output failure and electrode cable faults. Examiner sensory exposure was eliminated.

Conclusion: The Electrotherapy Output Sound Indicator Device provides a simple, safe, and objective alternative to traditional sensory output testing methods and may be adopted as a routine clinic-level screening tool.

Keywords: Electrotherapy, Output Testing, TENS, Interferential Therapy, Physiotherapy Equipment, Quality Assurance

Introduction

Electrotherapy modalities such as Transcutaneous Electrical Nerve Stimulation (TENS), Interferential Therapy (IFT), and Electrical Muscle Stimulation (EMS) are widely used in physiotherapy practice. Prior to clinical application, verification of machine output is essential to ensure functionality and patient safety.

Traditionally, output testing of electrotherapy devices has been performed by applying electrodes to the examiner's skin and increasing intensity until sensations such as tingling, pricking, or muscle contraction are perceived. While this method confirms the presence of output, it is inherently subjective and examiner dependent.

Repeated sensory testing exposes the examiner to unnecessary electrical stimulation and fails to differentiate between machine output failure and electrode or cable malfunction. Hence, an objective and reproducible method is required for routine electrotherapy output testing.

The present study describes the development of an Electrotherapy Output Sound Indicator Device (EOSID) designed to replace traditional sensory testing with an objective auditory-based output verification method.

Aim and Objectives

Aim:

To develop an objective auditory-based device for routine output testing of electrotherapy equipment used in physiotherapy practice.

Objectives:

1. To design a low-cost Electrotherapy Output Sound Indicator Device (EOSID).
2. To evaluate the ability of EOSID to detect output from TENS, EMS, and IFT devices.
3. To assess qualitative differentiation of frequency characteristics using auditory signals.
4. To determine the utility of EOSID in identifying electrode cable faults.
5. To eliminate examiner sensory exposure during output testing.

Materials and Methods

Study Design:

Instrument development and observational evaluation study.

Ethical Consideration:

No human subjects were involved in this study. Ethical approval was not required.

Materials Used:

- TENS unit
- EMS unit
- Interferential Therapy unit
- Standard electrotherapy electrode cables
- Piezoelectric electronic buzzer (Input voltage: 3.5–12 V, current <25 mA)
- Electrotherapy Output Sound Indicator Device (EOSID)

Development of EOSID:

The Electrotherapy Output Sound Indicator Device was developed by connecting a piezoelectric electronic buzzer to standard electrotherapy electrode cables. The cables were cut and soldered to the buzzer terminals, allowing direct connection to the output ports of electrotherapy machines. The device converts electrical pulses into audible sound, thereby eliminating the need for human skin involvement during output testing.

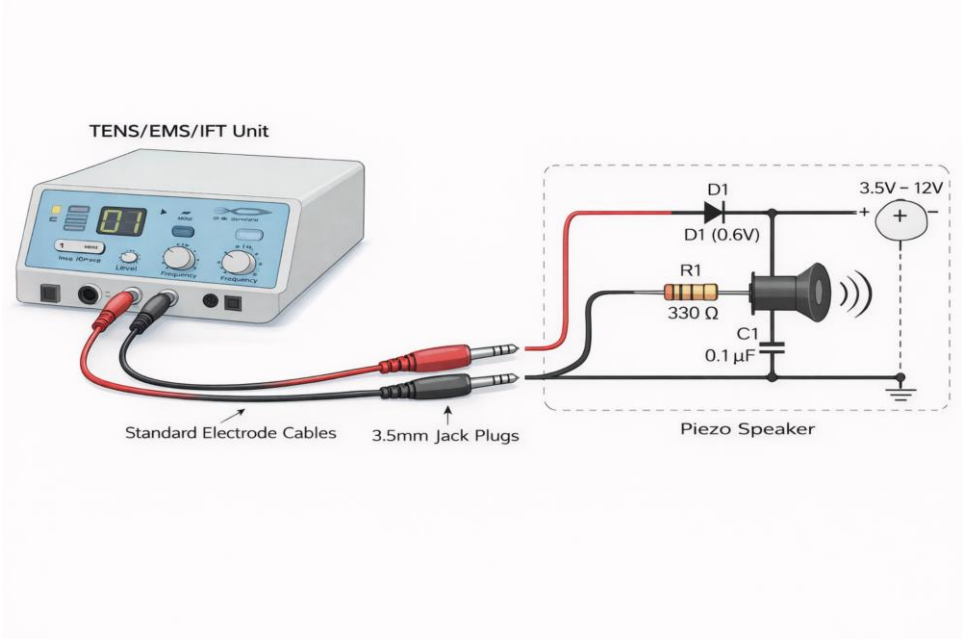
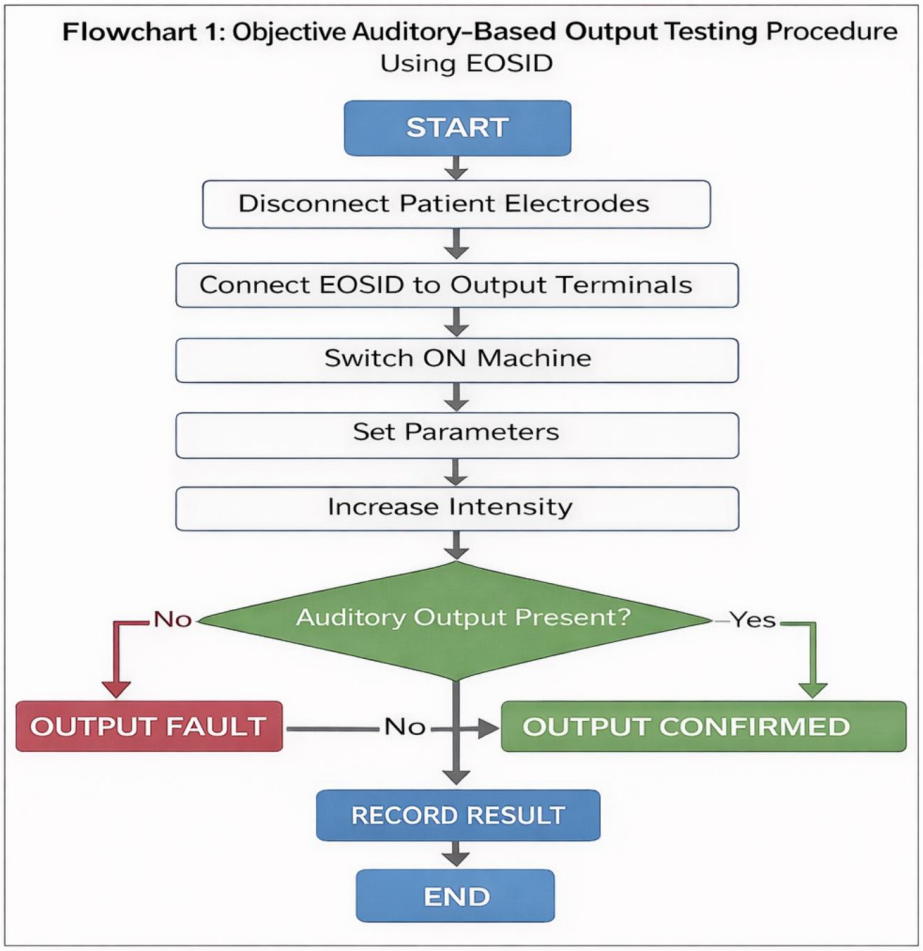


Figure 1: Electrical circuit representation of the Electrotherapy Output Sound Indicator Device (EOSID)

Testing Procedure:

1. Patient electrodes were disconnected from the electrotherapy unit.
2. EOSID was connected to the output terminals using standard electrode cables.
3. The electrotherapy unit was switched ON and treatment parameters were set.
4. Intensity was gradually increased.
5. Auditory output from EOSID was observed and recorded.



Flowchart 1: *Objective Auditory-Based Output Testing Procedure Using EOSID*

Flowchart 1: Objective auditory-based electrotherapy output testing procedure using EOSID

Interpretation of Auditory Output:
No sound – No output or machine fault
Intermittent 'tik-tik' sound – Low-frequency pulsed current
Continuous buzzing sound – High-frequency current
Very rapid continuous sound – Interferential current present
Sound present but no patient sensation – Cable or electrode fault

Results

EOSID successfully produced audible output in all functioning electrotherapy machines tested. Low-frequency currents generated intermittent sounds, while high-frequency currents produced continuous buzzing. Interferential therapy output resulted in rapid continuous sound. The device reliably differentiated between machine output failure and electrode cable damage. Examiner sensory testing was completely avoided.

Discussion

Traditional sensory output testing relies on subjective examiner perception and lacks reproducibility. EOSID replaces this subjective approach with an objective auditory indicator, improving consistency and safety.

Although EOSID does not quantify electrical parameters, it provides qualitative verification of output presence and frequency nature, similar to traditional sensory testing but without examiner exposure. Additionally, the device allows identification of cable faults, which is not possible with conventional sensory testing. EOSID is intended as a routine screening and functional verification tool and does not replace formal biomedical calibration procedures.

Limitations

- EOSID does not provide numerical measurement of output parameters.
- Electrical impedance does not simulate human tissue resistance.
- Frequency differentiation is qualitative rather than quantitative.

Conclusion

The Electrotherapy Output Sound Indicator Device is a simple, safe, and objective alternative to traditional sensory output testing of electrotherapy equipment. EOSID eliminates examiner exposure, improves reliability, and enhances routine quality assurance in physiotherapy clinics.

Future Scope

Future development of EOSID may include integration of visual indicators, protective circuitry, standardized enclosure design, and quantitative measurement features in advanced versions.

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