

Article

Low-Power Long-Term Ambulatory Electrocardiography Monitor of Three Leads with Beat-to-Beat Heart Rate Measurement in Real Time

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Abstract: A low-power long-term ambulatory ECG monitor was developed for the acquisition, storage and processing of three simultaneous leads DL, aVF and V2 with a beat-to-beat heart rate measurement in real time. It provides long-term continuous ECG recordings until 84 h. The monitor uses a QRS complex detection algorithm based on the continuous wavelet transform with splines, which automatically selects the scale for the analysis of ECG records with different sampling frequencies. It includes a lead-off detection to continuously monitor the electrode connections and a real-time system of visual and acoustic alarms to alert users of abnormal conditions in its operation. The monitor presented is based in an ADS1294 analogue front-end with four channels, 24-bit analog-to-digital converters and programmable gain amplifiers, a low-power dual-core ESP32 microcontroller, a microSD memory for data storage in a range of 4 GB to 32 GB and a 1.4 in thin-film transistor liquid crystal display (LCD) variant with a resolution of 128 × 128 pixels. It has programmable sampling rates of 250, 500 and 1000 Hz; a bandwidth of 0 Hz to 50% of the selected sampling rate; a CMRR of −105 dB; an input margin of ±2.4 V; a resolution of 286 nV; and a current consumption of 50 mA for an average battery life of 84 h. The ambulatory ECG monitor was evaluated with the commercial data-acquisition system BIO-PAC MP36 and its module for ECG LABEL SS2LB, simultaneously comparing the morphologies of two ECG records and obtaining a correlation of 91.78%. For the QRS detection in real time, the implemented algorithm had an error less than 5%. The developed ambulatory ECG monitor can be used for the analysis of the dynamics of the heart rate variability in long-term ECG records and for the development of one's own databases of ECG recordings of normal subjects and patients with cardiovascular and noncardiovascular diseases.

Keywords: ambulatory ECG monitor; heart rate; real-time QRS detection; ESP32; ADS1294; long-term ECG recordings



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1. Introduction

Cardiovascular diseases are the leading cause of death worldwide [1]. Therefore, there is a need for ambulatory (Holter) electrocardiography (ECG) monitors that can supplement traditional medical and clinical care, allowing for the noninvasive evaluation of electrocardiographic abnormalities over long periods of time and permitting the patients to conduct their normal daily activities. In contrast to the standard 12-lead ECG recordings of brief duration used in clinical examinations, where these intermittent cardiac abnormalities during the day may be undetected, the Holter ECG monitor allows one to continuously examine a patient over an extended time of 24 to 48 h, providing a long-term continuous recording [2].

Longterm Ambulatory Electrocardiography

A Loxley



Longterm Ambulatory Electrocardiography:

Unveiling the Magic of Words: A Report on "**Longterm Ambulatory Electrocardiography**"

In a global defined by information and interconnectivity, the enchanting power of words has acquired unparalleled significance. Their power to kindle emotions, provoke contemplation, and ignite transformative change is truly awe-inspiring. Enter the realm of "**Longterm Ambulatory Electrocardiography**," a mesmerizing literary masterpiece penned by way of a distinguished author, guiding readers on a profound journey to unravel the secrets and potential hidden within every word. In this critique, we shall delve into the book's central themes, examine its distinctive writing style, and assess its profound affect on the souls of its readers.

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THE GLASS MENAGERIE". He stretches out his hand.] Oh, be careful - if ... The Glass Menagerie book script of the play. [SCREEN LEGEND: 'OÙ SONT LES NEIGES."] There was young Champ Laughlin who later became vice-president of the Delta Planters. Bank. The Glass Menagerie - Tennessee Williams (AMANDA exits through living-room curtains. TOM is left with LAURA. He stares at her stupidly for a moment. Then he crosses to shelf holding glass menagerie. The Glass Menagerie Amanda Wingfield is a faded, tragic remnant of Southern gentility who lives in poverty in a dingy St. Louis apartment with her son, Tom, and her daughter, ... The Glass Menagerie When Amanda convinces Tom to bring home from his workplace a "gentleman caller" for Laura, the illusions that Tom, Amanda, and Laura have each created in order ... The Glass Menagerie Text Scene 1: The Wingfield apartment is in the rear of the building, one of those vast hive-like conglomerations of cellular living-units that flower as. Tennessee Williams - The Glass Menagerie (Scene 3) LEGEND ON SCREEN: 'AFTER THE FIASCO' [TOM speaks from the fire-escape landing.] TOM: After the fiasco at Rubicam's Business College, the idea of getting a ... "The Glass Menagerie," Scene One and Scene Two, by ... 41 Scene 1. 352 The Wingfield apartment is in the rear of the building, one of those vast hive-like conglomerations of cellular living-units that flower as ... Tennessee Williams - The Glass Menagerie (Scene 7) A moment after the curtain rises, the lights in both rooms flicker and go out.] JIM: Hey, there, Mr Light Bulb ! [AMANDA laughs nervously. LEGEND: 'SUSPENSION ... The Glass Menagerie: Acting Edition: Tennessee Williams A new introduction by the editor of The Tennessee Williams Annual Review, Robert Bray, reappraises the play more than half a century after it won the New York ...