Cosmic Motion

A clip-on sport performance tracker with Lead II equivalent ECG

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Executive Summary

Cosmic Motion is the name of a lightweight compact clip-on performance tracker designed to provide athletes with electrocardiography (ECG)-grade heart monitoring and advance training feedback without the discomfort of chest straps, adhesive electrodes, or inaccurate wrist devices.

Unlike mainstream smartwatches, which lose reliability in heart rate (HR) tracking at high intensities, this product uses a three electrode Lead II equivalent ECG configuration combined with low power inertial measurement units (IMU) to provide accurate heart rate, heart rate variance (HRV), cadence, and motion analysis during intense or prolonged training sessions. Data is logged locally and synched with a phone app over Bluetooth. Haptic feedback provides real-time coaching alerting the user when to speed up, slow down, or rest.

This product targets athletes and recreational runners seeking accurate bio-sensing based performance tools rather than consumer grade cosmetic health metrics.

Version History

9/29/2025 -- V1.0 proposal released.

Background

Modern devices such as the apple watch and Fitbit can provide reliable HR metrics at rest but struggle at high BPM and with heavy motion. Chest strap ECGs on the other hand are bulky and uncomfortable; however, they provide gold standard diagnostics.

Cosmic motion bridges this gap: It delivers the accuracy of a chest strap in a flexible clip-on form factor. The device shifts the cost and complications of designing a custom strap by providing non disposable dry electrode clips with respective IMUs that connect to a central information processing device. The user is able to provide their own belt, waistband, or simply attach the clips to their clothing. The end result is a comfortable, light, durable, accurate tool to help athletes train smarter and reach their goals faster.

Approach

To achieve the small form factor, the device is split into a string of three clips each with their own electrode facing the skin. The electrodes are stainless steel (316L) with a possible upgrade to Ti or Ag/AgCl plated stainless if cost allows to lower impedance. The central electrode acts a bias to improve signal to noise ratio (SNR) for the Lead II equivalent ECG. A low power IMU on each side can provide accurate left-right distinction in movement data and detect any asymmetry or imbalances. Data will be stored onboard in flash when away from a connection to the app and synched over BLE once connection is established so a constant phone connection is not needed. A coin vibrator will be used to provide interval coaching and alerts, this could be expanded upon later in the app itself. The enclosure will be 3D printed initially but will eventually move to a full injection molded waterproof case.

Research

Market Research

Apple watch, Garmin, and Fitbit are all significant contenders in this market; however, they put convenience before accuracy. The wearables market is also quite saturated however people are always looking for products that are simple, cheap, and effective products and this product is able to provide high quality performance metrics without extra bells and whistles thereby it has potential to earn a share of the more serious section of the market.

Patent Research

The combination of clip-on ECG and IMU technology is well established, and current patents do not appear to restrict development of this product. While the twin-IMU signal-processing approach could theoretically support a novel claim, its main value here lies in mitigating performance issues common to dry stainless-steel electrodes during high-motion activity. For use as a fitness performance tracker, there is freedom to operate, but the product itself is not sufficiently unique to warrant patent protection.

Regulations

The device is positioned strictly as a sports performance aid and will not make any medical claims. An IP67 waterproof rating is a suitable target to ensure protection against sweat and rain. Wireless compliance is covered by the pre-certified radio module, eliminating the need for additional certification at the system level. The integrated Li-ion battery must meet Japanese regulatory requirements and pass UN38.3 testing, with an on-cell NTC included for safety monitoring.

Hardware

MCU

The MDBT50Q, a low power Bluetooth only system on module (SoM) with built in antenna was chosen. This module is cheap and includes an nRF52840 MCU and is pre certified so there will be less paperwork to get a shipped product. The product has a 2.4GHz IEEE 802.15.4 BLE transceiver with -103dBm sensitivity in 236Kbps at over 500 meters. It has an ARM M4 32-bit 64MHz processor with 1MB flash, 256 KB RAM, USB 2.0, 32MHz SPI, on-chip DC/DC, fast-wake and low idle current. An external 32.768MHz crystal will be used for accurate sleep timing.

Sensors

The ECG will be a single lead ambulatory ECG with 3 .5x26mm 316L stainless steel electrodes in a Lead II equivalent configuration with the central electrode as a common mode rejection (CMR) bias. Non disposable Ag/AgCl plated stainless electrodes would be preferrable for their lower impedance and polarization if they could be sourced cheaply. Each side clip will have a low power LIS2DW12 IMU and its own differential electrode. Wires will leave each clip and connect to the main MCU via a 20cm max length lead in twisted pair configuration with a silicone jacket. The ECG will use an ADS1291 serial peripheral interface (SPI) analog front end (AFE) as it is SPI and able to read the uV ECG signals. If needed to save costs, an alternative single IMU on the main chip will be chosen. The Bosch smart fusion is a more expensive higher power IMU with more features and a built in MCU serves as a future upgrade option.

Power

The device will be powered by a EEMB 402030 200 mAh Li Ion pouch, connected by a 3 pin JST-PH connector to the main board. The cell will be monitored by the BQ24075 charger IC and charged by a board mounted USB C receptacle with ESD protection. The power will be regulated to the MCU by a TPS7A0230 LDO with another TPS7A0230 for a quiet analog power source. Should the device use excessive power, a buck converter will take the place of the digital LDO. Battery cell voltage will be read periodically and combined in the radio packets. The device will not be usable while charging and will shut down during overheating.

Memory

The device will be able to store data on long treks without constant access to a phone Bluetooth connection by storing recent data in a W25Q32JVZPIQ 4MB SPI NOR flash IC which will store information even during power loss and can be uploaded to the app or the cloud for larger data storage and analytics. To save on read/write wear the device will store data in RAM and send data preferentially over BLE when a phone is nearby and connected.

Haptics

A JYC1020 ERM coin vibrator will be used to provide the user haptics with different vibration profiles indicating different training strategies. This can be programmed or disabled in the app.

Enclosure

Two designs for enclosures will be made, one for the center clip and the other for the side clips. Each clip will aim to be IP67 tested for sweat and rain resistance. The designs will start out as 3D printed enclosures and switch to either anodized aluminum (costly and heavy), or injection molding (expensive tooling requires large orders to be reasonable. The device will have a transparent window for an LED and a button pad to control power and mode. O-rings and gaskets will be used if to provide better sealing along with epoxy coatings.

Software

ECG

The two side electrodes will have their voltage levels over time compared using the central bias electrode to provide an accurate Lead II ECG reading. The AFE will compare the analog voltages and send its data over SPI to the MCU where it will be filtered, processed, and stored for later upload. The data will be used to determine HR, HRV, and arrhythmias.

IMU

The two IMUs will communicate directly to the MCU via I2C and have their data compared, filtered, processed, and stored for later upload. The data will be used to calculate pace, cadence, motion irregularities and filter out motion artifacts from the ECG.

Data Management

Data will be stored on the external flash chip as needed when no Bluetooth connection is recognized so that performance data is not lost. This data will be logged along with a timestamp and sent over Bluetooth in a series asynchronous bulk packets when connection is reestablished.

Power Management

The system will be designed for low power with an idle current of 10uA and an average active current of 1.5mA aiming for a battery life in excess of 5 hours of constant use. The device will turn off after ten minutes of not detecting a heart rate and/or motion to save power.

Phone App

The phone app will have a free and a performance subscription tier. The free tier will provide access to all metrics and controls and the performance tier will supply coaching, long term analytics, and other features TBD. App will be designed to be gamified to keep users checking in and be usable even without the device.

Budgeting

BOM

TODO

Cost of Prototype

TODO

Funding

TODO

ROI

TODO

Design

Prototype Design Guide

The pcb will be fabricated at JLCPCB and assembled in house with a small test run of 5-10 units. The firmware will be uploaded, debugged, and optimized. This initial prototype will be fault tested, stress tested, and EMI/SNR tested for future revisions. A 3D enclosure will be printed to test out the form factor and will be tested by a group of athletes to optimize and refine algorithms. A final injection molded design with water ingress validation will be implemented before the product is ready for the initial release.

Schematics

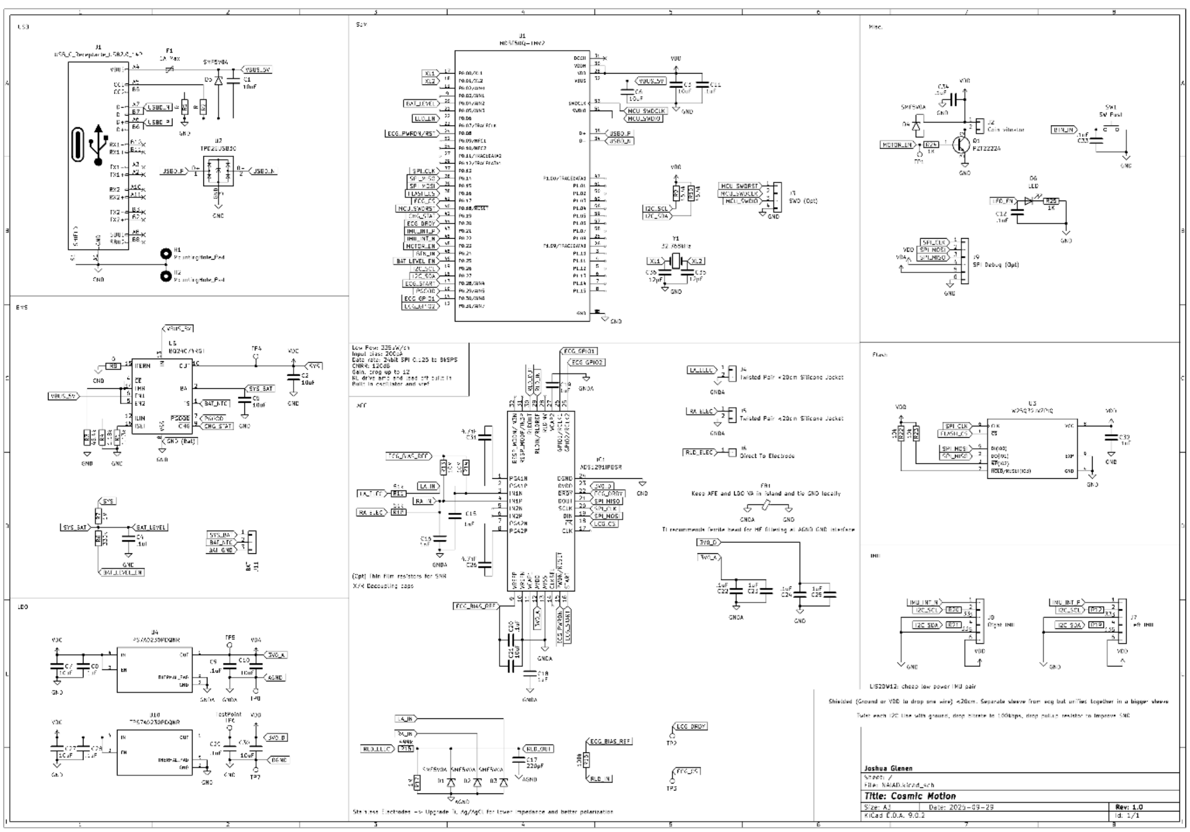

Figure 1: Central Clip Schematic

Conclusion

This product is designed to deliver chest-strap-level ECG accuracy in a compact, lightweight clip-on form factor. By combining reliable ECG data with parallel motion tracking and real-time coaching, it can establish a niche within a crowded but evolving performance market. The development plan is realistic, the components are widely available with low technical risk, and the application is both practical and valuable. With careful control of the bill of materials, a phased rollout strategy, and a well-designed companion app, this product has the potential to be a contender.

References

TODO