User Guide – Bluetooth Low Energy Digital Instrument Cluster for Two / Three Wheelers

1 Solution Features

- Reference Solution based on RealTek's Single BLE 5.3 compliant MCU RTL8772 along with 7" TFT LCD display connected with throttle assembly, combination switch in a two-wheeler handlebar mock setup.
- Digital Gauges for Speed, RPM, ODO meter, Trip Meter, Gear Position, Battery status, Tell tales etc.
- BLE communication & control with the Mobile phone through Android app. with the foll. features
  - Connection Status
  - Phone Call Notification / Call Accept or Reject
  - SMS Notification (Normal / ALERT)
  - Turn-by-Turn Navigation
  - Location Notification
  - TPMS Notification (currently simulated)
- Test setup for the Throttle and switch assembly
  - Throttle with Speed mode switch configured as Gear Position
  - Combination switch containing Left / Right Indicator, Lights On/Off, High Beam On/Off, Beam flasher switch positions
  - Potentiometer to simulate the Battery charging / discharging

2 Description

Parry Technology's ***Bluetooth Low Energy 5.3 Digital Instrument Cluster Solution*** is a reference solution based on **Single BLE MCU** operating at **maximum 125MHz** for BLE connectivity, Graphic display, Navigation and other core Digital Instrument cluster functions.

This MCU has Single Real-M300V core (compatible with Cortex-M55) could run at 40MHz with lower supply voltage for low power consumption purpose, and at maximum clock 125MHz in high performance mode. It supports Trustzone, AES 128/256, SHA, ECC, RSA, TRNG and consists of flexible memory controller (FMC), AUXADC and high-resolution ADC, high TX power RF transceiver, audio codec, display controller supporting QSPI/8080/RGB interfaces, Ethernet RMII, CAN, LCD segment/common terminal controller, 2.4GHz proprietary, USB 2.0 controller, etc. The MCU has ITCM 192KB, DTCM 128KB, internal 4MB MCM PSRAM, GPIOs, SPI, I2C, I2S and UART. The MCU comes with 88-pin QFN in 10x10mm^2 0.4mm pitch package. The operating temperature range is -40° C to +85° C.

5 Simplified Block Diagram

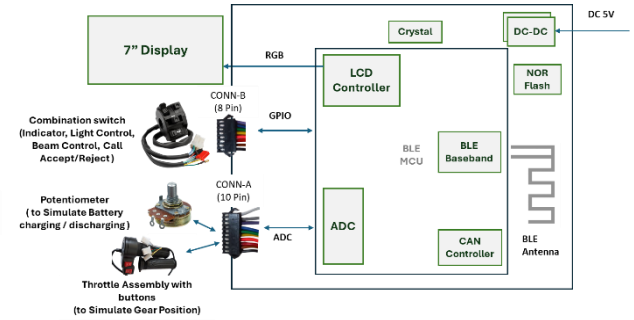

Figure 1 Block Diagram

CONNECTOR A: 8-Pin (for Combination switch Assembly)

Pin #	Color	Function
1	Black	GND
2	Brown	PASS / Flash
3	RED	NC
4	Orange	Low Beam
5	Yellow	Right Indicator
6	Green	Left Indicator
7	Blue	Call Accept
8	Violet	Call Reject

Table 1: Connector A – 8 Pin

CONNECTOR B: 10-Pin (for Throttle Assembly)

Pin #	Color	Function
1	Black	GND
2	Brown	Throttle Out
3	RED	Throttle PWR (5V)
4	Orange	Gear 1st
5	Yellow	FWD / Neutral
6	Green	Gear 3rd
7	Blue	GND
8	Violet	NC
9	Grey	NC
10	White	NC

Table 2: Connector B – 10 Pin

3 Cluster Application Features

The cluster application has the following features

- Graphical Display of RPM, Speed, Gear Position, Speed Mode (STANDARD, ECO, SPORTS), Indicator, Light status, Battery Status, ODO, Trip meters, Call / SMS Notification, Call Accept/Reject and OFF, TPMS display
- Map showing the movement once the device location is enabled and Turn-by-Turn Navigation is ON

4 Android Application Features

The reference Android application has the following features

- Available / Paired BLE devices listing
- Buttons for
  - Connect / Disconnect
  - Notification: ON / OFF
  - Start / Stop Turn-by-Turn Navigation
  - Send TPMS (simulated value pushed to the Cluster to display Tire-pressure)
  - Start GPS / Stop GPS
- Map showing the movement once the device location is enabled and Turn-by-Turn Navigation is ON

Revision History

Sl. No	Version	Date	Remarks
1	V1.00	29 Sep 2024	First revision for release

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6 Detailed overview

ParryTech's ***Bluetooth Low Energy 5.3 Digital Instrument Cluster Solution*** is a reference solution based on **Single BLE MCU** operating at **maximum 125MHz** delivering Real-time simulation of core digital cluster functions (Speed, RPM, Indicator ON/OFF, Lights ON/OFF etc.) combined with the Bluetooth communication features and control with your paired mobile phone. The Solution is driven by RTL8772GWP MCU (ARM Cortex-M33 equivalent) operating maximum at 125MHz with internal PSRAM of 4MB and the external SPI flash.

The solution comprises of the BLE MCU Board along with 7" LCD enclosed in acrylic enclosure (1) with the two-wheeler handle-bar assembly connected along Combination switch (2) assembly and Throttle assembly (3) for the real-time simulation of Speed, RPM, Tell-tale features. The Acrylic enclosure has potentiometer (4) to simulate the battery charging / discharging function. The cable harness coming out with 8-Pin Connector-A (5) and 10-Pin Connector- (6) B to connect as shown in the figure 4. The buttons (7) panel below the LCD has Reset, Theme change and TPMS simulation.

Figure 2 Parry's Digital BLE Cluster Reference Solution

The solution operates on 5V DC supply and can be powered by external 5V AC-DC power adapter.

The combination switch assembly has been tweaked to include two tactile switches each for call Accept and call Reject (or) call End functionality as shown below

Figure 3 Combination Switch with Call Answer / Reject buttons

7 Connection Diagram

The Acrylic enclosure (MCU main board with 7" LCD) has Power supply Connector (DC-5V/2A max), CON A 8-pin male connector and CON B 10-pin male connector. The board is powered on using an external 5V (2A Max) AC-DC adapter.

The CON A, CON B have to be connected with Connector-A (8-pin female) and Connector-B (10-pin female) from the two-wheeler handlebar assembly cable harness as shown in the following figure

Figure 4 BLE Cluster – Connection with Cluster enclosure and handle-bar assembly

7.1 Connector-A (8-pin)

This connector is mainly for the Indicator, Lights control, Call control to be connected from the "Combination switch assembly" to the BLE MCU Board.

The indicator controls (Right indicator, Left indicator) are notified through the 3-position switch control (MCU GPIOs). The middle position notifies the "Indicator OFF" position, which is in floating state and not connected to any MCU GPIO. The Left position notifies the "Left Indicator" position, which is connected to MCU GPIO and the right position notifies the "Right Indicator" position, which is connected to another MCU GPIO

The Light control (default in Low Beam) is managed by Lock switch. The lock position notifies the "High Beam" position, which is connected to MCU GPIO (GND). The Unlock position notifies the "Low Beam" position, which is connected to MCU GPIO (5V). In addition to this the assembly has "PASS" switch for the "Beam Flashing" functionality and it notifies the MCU through GPIO when it is Low-level state.

Pin #	Color	Function
1	Black	GND
2	Brown	Flash Beam (PASS beam)
3	RED	NC
4	Orange	Low Beam / High Beam
5	Yellow	Right Indicator
6	Green	Left Indicator
7	Blue	Call Accept
8	Violet	Call Reject

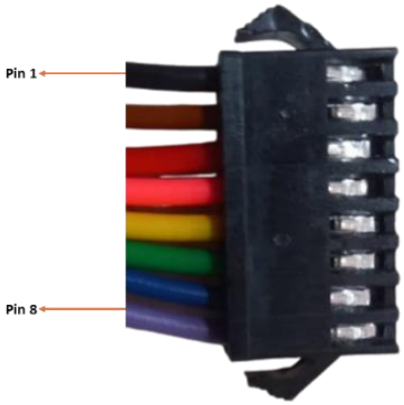

Figure 5 BLE Cluster: Connector A Pin-out

There are two 'TACTILE switches' for the Call Accept and Call Reject functionality. The first one is for "CALL Accept" functionality and second one is for "CALL REJECT" then the call notification is displayed or for "CALL END" when call is in ACTIVE state. These signals are sent over GPIO to MCU.

7.2 Connector-B (10-pin)

This connector is mainly for the throttle inputs to be connected from the "Throttle assembly" to the BLE MCU Board.

The board supplies 5V power to the throttle assembly (Conn A: Pin #3) and the throttle ADC voltage output (Conn A: Pin #2) goes to MCU ADC pin. The ADC voltage output varies from 0V to 5V.

The Gear position is notified through the 3-position switch control (MCU GPIOs). The middle position notifies the "Gear 2" position, which is in floating state and not connected to any MCU GPIO. The Left position notifies the "Gear 1" position, which is connected to MCU GPIO and the right position notifies the "Gear 3" position, which is connected to another MCU GPIO.

Pin #	Color	Function
1	Black	GND
2	Brown	Throttle Out (ADC voltage from 0V to 5V)
3	RED	Throttle PWR (5V goes as input from Board)
4	Orange	Gear 1st (GPIO)
5	Yellow	FWD / Neutral
6	Green	Gear 3rd (GPIO)
7	Blue	GND
8	Violet	NC
9	Grey	NC
10	White	NC

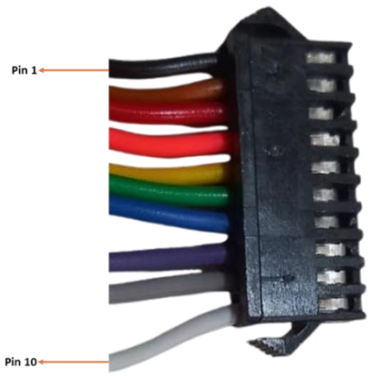

Figure 6 BLE Cluster: Connector B Pin-out

The cluster has few button controls which are used for board reset, UI theme change and TPMS simulation.

The details are given below.

Figure 7 BLE Cluster: Button controls

8 Cluster Application: Overview

The entire cluster application runs on Single Core BLE MCU by showing the real-time inputs from the handle-bar assembly (throttle inputs, combination switch inputs) and also connectivity features with ParryTech Bluetooth Mobile application. The mobile application passes the Call/SMS Alerts/Notifications, and location, navigation information to the cluster when it is paired and connected.

The Single core BLE MCU also runs the customized Open GL library to display the UI controls for these data concurrently on real-time.

The Cluster HMI is shown in Single window with multiple controls / elements placed in the window, overlaying certain information depending upon the user / mobile application inputs.

The following figure shows the different controls and notification areas in the Cluster HMI window.

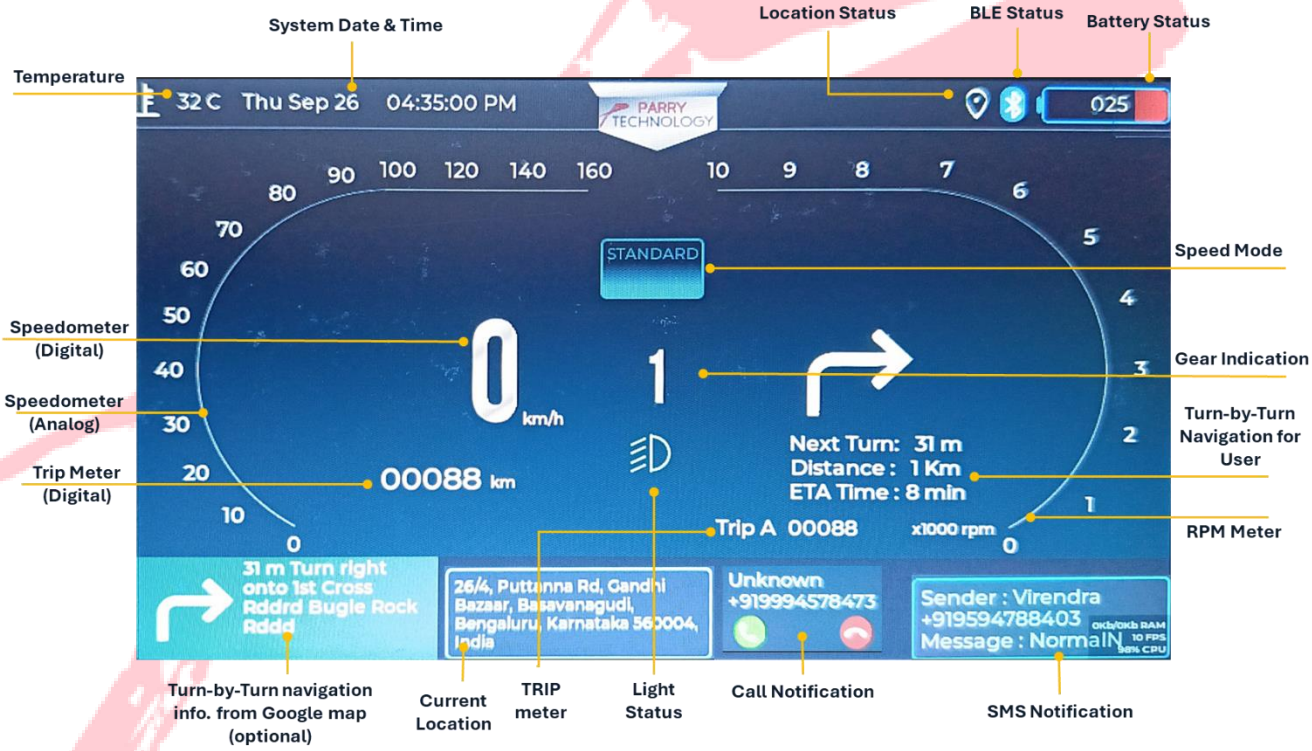

Figure 8 Cluster HMI: UI Elements, Position and description

9 Cluster Application: Detailed

9.1 Initial Screen

On Powerup the following initial screen is displayed and the application waits for the real-time inputs to come from the Handlebar assembly / BLE application.

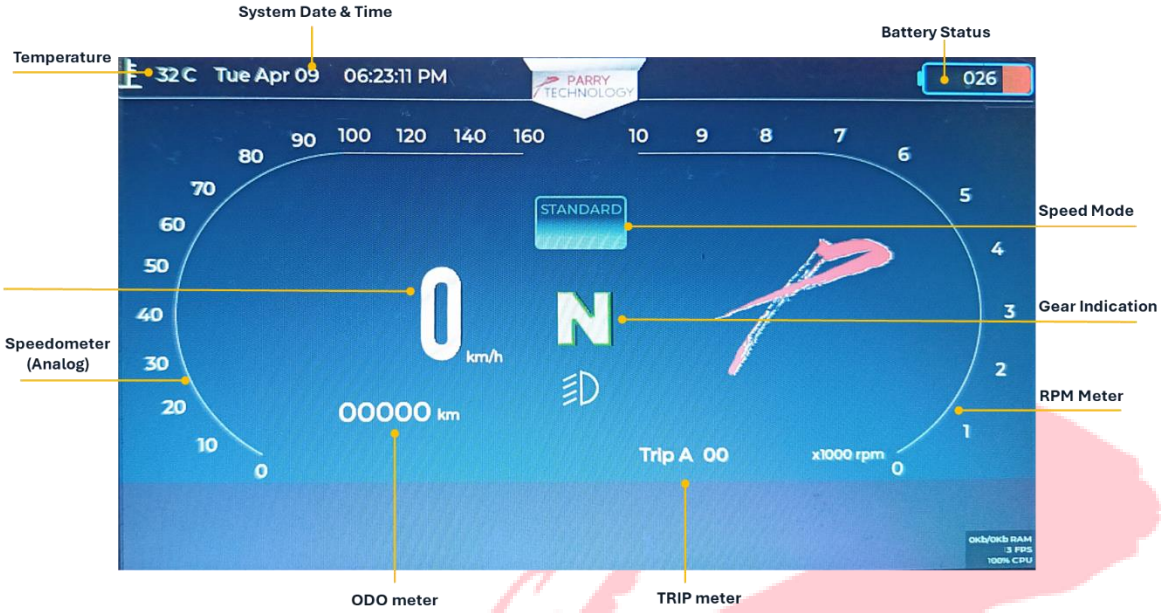

Figure 9 Cluster HMI: Application Main Screen

9.2 Throttle Functions & Screens

Figure 10 BLE Cluster:

Gear, Neutral / Forward buttons

To start seeing the real-time throttle inputs, the user should first change the drive mode to "F" (Forward or Drive mode) from "N" (Neutral) by toggling the "F-N" switch.

The user also can toggle the gear by using the "1-2-3" switch and start giving the throttle. When the throttle is given, both RPM and Speed analog controls are displayed on the screen with the "Speed Mode" displayed depending on the RPM and Speed values.

Figure 11 Cluster HMI: Gear position, Speed, RPM Analog meter

The following logic were used to display the Speed Mode, RPM meter color and Speedometer color.

Gear Position	Speed Range
1st Gear	0 to 56 km/h
2nd Gear	0 to 90 km/h
3rd Gear	0 to 160 km/h

RPM Value	Speed Mode	RPM COLOR
0 to 5000	STANDARD	BLUE
5001 to 8000	ECO	YELLOW
>8001	SPORTS	RED

Speed Value	Speed Color
0 to 120 km/h	BLUE
121 to 160 km/h	RED

Note: In this reference solution, The Speed and RPM values displayed are directly proportional to the throttle input given by the user and not the based on the real Vehicle Speed.

For e.g. If the user has given throttle and the speedometer value has gone to 56Kmph (based on Gear and RPM), and the user suddenly stops the throttle input, the speedometer value displayed comes down to ZERO from 56kmph suddenly.

However in real-time scenarios, though in real scenario, the vehicle would still be having some momentum and it doesn't suddenly drops to ZERO.

To summarize, we are not using the realistic vehicle speedometer data to show the application SPEED data. This is due to the unavailability of the vehicle's wheel circumference and the input from the OEM to simulate the speedometer. However this demo gives the real-time feel to the user of showing the throttle movement by displaying the SPEED and RPM purely based on the throttle input (acquired through ADC).

The following images show the representation of the SPEED, RPM data along with the Gear position.

Figure 12 Cluster HMI: Speed / RPM, Gear Position, Speed Mode snapshots

9.3 Combination Switch Functions & Screens

The combination switch assembly has the indicator control through 3-position switch (***Right, Left, OFF***) and Light Control through lock switch (***High Beam / Low Beam***) and ***PASSING*** switch for the high-beam flashing

The UI elements for the High and Low Beam, Right and Left indicators, Call notification are given in the figure below.

Figure 13 Cluster HMI: High Beam / Low Beam, Indicator elements snapshots

The tactile switches "ANS" and "REJ" are for call accept and call reject functionality. Call notification on the mobile phone, is sent over BLE with the Caller name, Caller ID to the cluster and displayed till the call notification is OFF in the mobile phone.

9.4 Mobile Application installation

ParryTech's mobile application (ParryTech_V2.apk) can be installed by downloading it locally in the mobile storage. Clicking on the APK file will initiate the application installation.

During the installation, the Android system (on some of the Android version) may throw the following Warning Message indicating Unsafe installation, as we have not launched the application in the Google Play Store.

The user should allow (Click Open) the installation to continue.

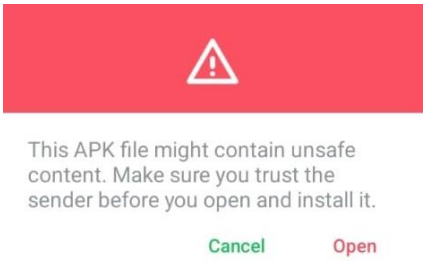

Figure 14 Android App: Installation Warning

9.5 Mobile application Connectivity to Cluster HMI

ParryTech's reference solution has Android mobile application (ParryTech_V2) to pair with the cluster and provide the Location information, Call / SMS Notification etc.

Pre-requisites:

This mobile application (ParryTech_V2) will run on Android Version 9 and above and the following settings in the phone are mandatory.

1. Precise Location feature should be available under Location settings

For the mobile application to work properly, we need the following settings / permissions to be done / allowed in 'Android App Settings' for 'ParryTech_V2' app.

a. Under Apps settings Select 'ParryTech_V2 app'

b. 'Settings→Apps→ParryTech V2→Remove permissions if app is unused' should be disabled.

For Navigation / Turn-by-Turn navigation features

c. Location 'Always ON'. 'Settings→Apps→ParryTech V2→Permissions→Location', enable 'Allow all the time' (or) 'Allow only while using the app'

d. Precise Location must be enabled in the 'Settings→Apps→ParryTech V2→Permissions→Location', 'Use precise location' to be enabled

e. Nearby devices permission 'Settings→Apps→ParryTech V2→Permissions→Nearby devices' should be always 'Allow' ed.

For Call / SMS notification features

f. For call notifications, phone permission should be 'Allow' ed in Settings→Apps→ParryTech V2→Permissions→Phone'

g. For message notifications, SMS permission should be 'Allow' ed in Settings→Apps→ParryTech V2→Permissions→SMS'

h. For Caller Id display, Contacts permission should be 'Allow' ed in Settings→Apps→ParryTech V2→Permissions→Contacts'

i. For Caller Id display, Call logs permission should be 'Allow' ed in Settings→Apps→ParryTech V2→Permissions→Call logs'

Start-up

On Startup the following screen is displayed. When the application is launched first-time, it will not have any devices paired.

1. Pressing 'Connect' button will enable the 'Bluetooth' and connect to the Android Bluetooth hardware.

2. Pressing 'Scan' button will list the 'Available Devices' and paired devices.

3. First time pairing is accomplished, by pressing the 'ParryTech_v2' in the 'Available Devices'.

Note: The BLE Cluster device has been named as 'ParryTech_V2', which is displayed in the available devices. This can be customized to any name / string.

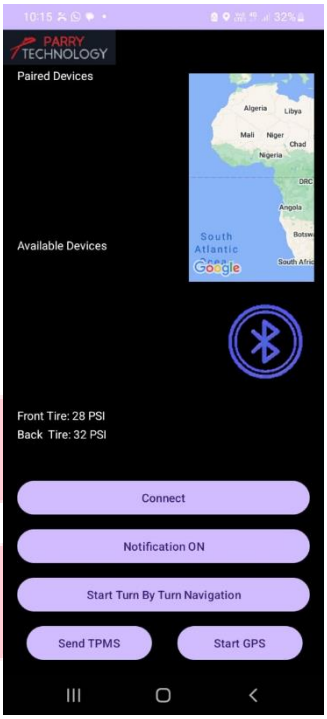

Figure 15 Mobile App: Startup Screen

The above steps ensure the successful BLE connectivity between the Mobile device and cluster. This can be confirmed with the "Bluetooth" logo on the top right side corner of the cluster HMI.

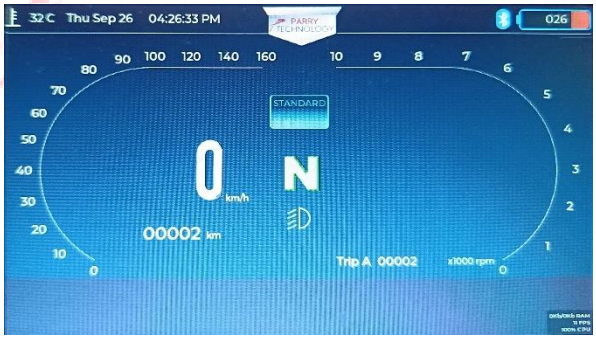

Figure 16 Cluster HMI: BLE connected Status

Successful BLE connection also ensures the real-time clock input (Time and date) from mobile phone is synchronized with the cluster display.

Call Notification

1. Pressing 'NOTIFY ON' button in the Mobile application will enable the Phone call and SMS notifications to be sent from the Mobile phone to the Cluster device.

2. Any call coming to the phone and if the caller Id is present in the contacts, then this 'Caller name along with the number and the call 'Accept' and 'Reject' icons shall be displayed (or) 'Unknown' string with the number and the call 'Accept' and 'Reject' icons shall be displayed in the cluster till the call notification is active in the mobile phone.

3. Pressing 'ANS' button displays 'On Call' Notification and pressing 'REJ' cancels the call notification at the cluster end and also at the mobile phone side.

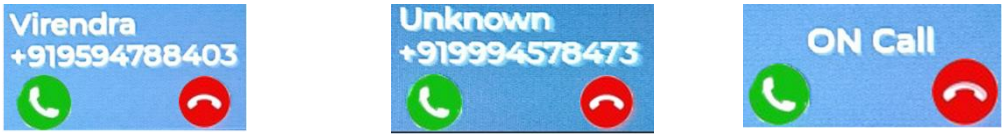

Figure 17 Cluster HMI: Incoming Call Notification and Active Call notification

SMS Notification

1. Any SMS that is delivered to the mobile phone shall also be displayed in the cluster. However, the cluster shall display only the Sender name with number and the SMS type (Normal or ALERT SMS). The contents shall not be displayed. For the ALERT SMS, additional warning symbol and message "Please Park the Vehicle to view SMS" shall be displayed below the Light status area in the HMI.

Figure 18 Cluster HMI: SMS Notification (Normal / ALERT)

GPS

The location is enabled in the Mobile device and the current location is continuously sent to the Cluster device when the user presses "Start GPS" and continues till "Stop GPS" is pressed in the mobile application.

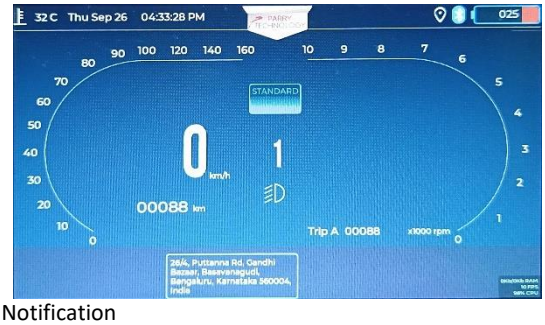

Figure 19 Cluster HMI: GPS Location Notification

Turn-by-Turn Navigation

The turn-by-turn navigation is supported through the Google maps API.

1. When "Start Turn-by-turn Navigation" is pressed, the Location is enabled, and the mobile application starts showing the driving directions from the current location to the destination. Current version of this application takes the Hardcoded Source and destination to simulate the driving directions. The application can be customized according to the customer requirement to handle the real-time source and destination inputs.

2. In the Cluster HMI, both "Turn-by-turn navigation by google map" and "Turn-by-turn navigation for user" are displayed in the respective regions as mentioned in *Section 8. Cluster Application: Overview*

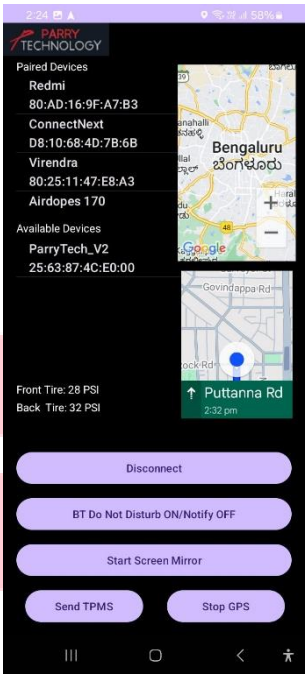

Figure 20 Android app: Enabling Turn-by-Turn navigation

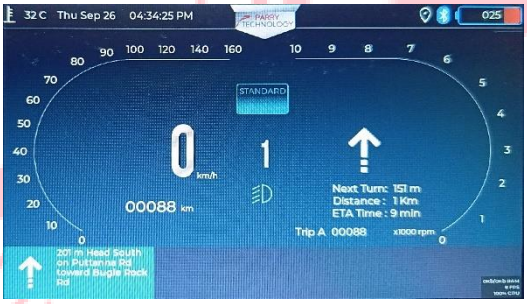

Figure 21 Cluster HMI: Turn-by-Turn Notification

Note: Google maps API is not a free version and for any commercial deployment, proper license version to be taken and integrated. Parry Technology shall help in the development and integration aspects.

When the BLE application sends the TPMS data, the "Turn-by-Turn Navigation for User" data is replaced with the TPMS data for 5 seconds in the same region. The "Turn-by-Turn Navigation for user" is displayed again after 5 seconds of displaying the TPMS data.

Figure 22 Cluster HMI: TPMS Notification

ParryTech can customize the screens, controls and UI as per the customer requirements.

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