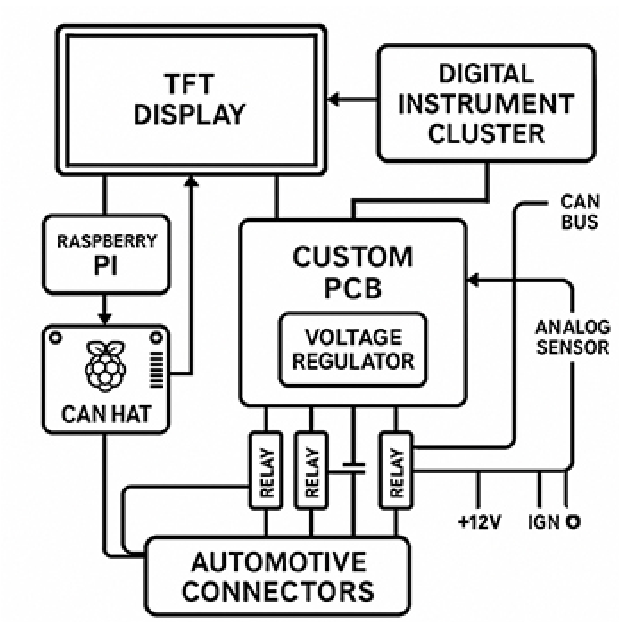
ENGINEERING SPECIFICATION DOCUMENT

Digital Instrument Cluster Development Program

Universal TFT-Based Cluster Platform



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1 Digital Instrument Cluster Development Program

This engineering specification outlines the design, prototyping, software development, electrical integration, validation, and production planning of a universal digital instrument cluster. Originally engineered for the BMW E90 335i, the system is now being adapted for the Honda Civic EF track build and is intentionally designed to be **universal** for all vehicles with minimal configuration changes.

2 System Overview

The cluster replaces OEM analog gauges with a high-brightness TFT display driven by a Raspberry Pi and a custom PCB capable of interpreting CAN-BUS frames, analog sensors, and warning signals.

2.1 Subsystem Breakdown

- **Hardware Electronics:** Raspberry Pi, CAN HAT, TFT display, relays, ADC, custom PCB.
- **Software:** Python-based UI (PyGame), CAN decoding library, OBD-II communication.
- **UI/UX:** Photoshop-designed assets, gauge layouts, animations, warning messages.
- **Mechanical:** CAD-modeled enclosure printed to OEM dimensions and ergonomics.
- **Electrical Integration:** Harness decoding, protection circuits, fusing, grounding strategy.

3 Hardware Subsystem

3.1 Core Components

- Raspberry Pi 4 or 5 compute module.
- PiCAN2 or PiCAN3 CAN-BUS HAT.
- 7"–10.1" IPS TFT display.
- Custom PCB integrating ADC, power conditioning, and CAN transceivers.
- Buck converters, relays, MOSFETs, diodes, and fuses.
- Automotive-grade wiring, connectors, and breadboarding hardware.

3.2 Hardware Cost Summary

Component	DIY Cost (CAD)	Labour Cost (CAD)
Raspberry Pi 4/5	\$85–\$140	–
PiCAN2 / PiCAN3 HAT	\$60–\$120	–
TFT Display (7”–10.1”)	\$70–\$150	–
Voltage Regulators	\$15–\$35	–
Custom PCB Manufacture	\$25–\$80	–
PCB Components	\$20–\$40	–
Relays / MOSFETs / Diodes	\$10–\$40	–
Breadboard Materials	\$15–\$25	–
Automotive Connectors	\$10–\$30	–
Wiring & Fuses	\$10–\$40	–
Electronics Assembly Labour	–	\$150–\$300
Section subtotal	**\$300–\$650**	**\$150–\$300**

4 Software Architecture

4.1 Software Modules

- CAN Input Manager.
- Analog Sensor Manager.
- UI Renderer (60 FPS PyGame engine).
- Warning Logic Engine.
- Future OBD-II (code reading/clearing).
- Data Logging Module for track use.

4.2 Software Development Costs

Item	DIY Cost (CAD)	Labour Cost (CAD)
Python Libraries	Free	–
Development Tools	\$0–\$40	–
Programming Labour	–	\$300–\$900
Section subtotal	**\$0–\$40**	**\$300–\$900**

5 Universal Vehicle Compatibility

5.1 Compatibility Notes

- JSON-configured CAN definitions.
- ADC-compatible analog input support.
- Per-car CAD-designed enclosures.
- Universal power/ground/accessory wiring.

5.2 Customer Guide Pipeline

- Car-specific wiring diagrams.
- Car-specific CAD mounting brackets.
- Pre-configured software profile.

6 Electrical Engineering

6.1 Harness Integration

- Decode OEM cluster connector.
- Map CAN high/low, switched power, ignition, and analog lines.
- Protect circuits with fusing and TVS diodes.

6.2 Electrical Cost Summary

Component	DIY Cost (CAD)	Labour Cost (CAD)
Wiring Loom Materials	\$20–\$40	–
Automotive Connectors	\$10–\$30	–
Protection Components	\$10–\$25	–
Harness Fabrication Labour	–	\$100–\$250
Section subtotal	**\$40–\$95**	**\$100–\$250**

7 Mechanical Engineering and CAD Prototyping

7.1 CAD Development

- Enclosure modeled in Fusion 360 or SolidWorks.
- OEM-fitment geometry, tabs, standoffs, cooling channels.

7.2 3D Printing

- PLA prototypes, ABS/PETG production parts.
- Optional Nylon/SLS for final shells.

7.3 Prototyping Cost Summary

Item	DIY Cost (CAD)	Labour Cost (CAD)
PLA Prototype Prints	\$10–\$20	–
ABS/PETG Final Prints	\$20–\$40	–
Nylon/SLS Prints	\$40–\$120	–
CAD Modelling Labour	–	\$150–\$300
Section subtotal	**\$30–\$180**	**\$150–\$300**

8 PCB Engineering and Manufacturing

8.1 PCB Capabilities

- CAN transceiver.
- ADC inputs.
- 5 V and 3.3 V rails.
- Automotive surge protection.

8.2 PCB Cost Summary

Item	DIY Cost (CAD)	Labour Cost (CAD)
PCB Manufacturing	\$25–\$80	–
Component Kit	\$20–\$40	–
Assembly (optional)	\$30–\$90	–
Professional Assembly	–	\$100–\$250
Section subtotal	**\$45–\$210**	**\$100–\$250**

9 UI/UX Development

9.1 Interface Design

- Tachometer arc and sweep animation.
- Speedometer.
- Temperature bars.
- Shift lights.
- Pop-up warnings.
- Menu navigation.

9.2 UI Cost Summary

Component	DIY Cost (CAD)	Labour Cost (CAD)
Photoshop Assets	Free–\$20	–
UI Coding (PyGame)	Free	–
Professional UI Labour	–	\$200–\$600
Section subtotal	**\$0–\$20**	**\$200–\$600**

10 Testing and Validation

10.1 Bench Testing

- Simulated CAN frames.

- Power cycling tests.
- Heat and vibration.

10.2 In-Vehicle Testing

- Real CAN bus capture.
- ECU integration.

10.3 Testing Cost Summary

Item	DIY Cost (CAD)	Labour Cost (CAD)
Bench Power Supply	\$30–\$60	–
Multimeter	\$20–\$50	–
CAN Simulator Tools	\$0–\$80	–
Testing Labour	–	\$150–\$400
Section subtotal	**\$50–\$190**	**\$150–\$400**

11 Business and Sales Notes

11.1 Scalability Factors

- Modular CAN decoding.
- Reprintable housings.
- Minimal per-car configuration.

11.2 Estimated Customer Pricing

- Hardware: \$300–\$500.
- Labour: \$150–\$300.
- Retail Range: \$600–\$900.

12 Total DIY Cost Estimate

Category	Cost Range (CAD)
Display + Pi	\$150–\$250
CAN HAT	\$60–\$120
PCB + Components	\$45–\$120
Wiring / Relays	\$20–\$50
3D Printing	\$10–\$40
Development Tools	\$30–\$80
OBD/CAN Tools	\$20–\$40
Total Estimated DIY Cost	**\$335–\$700**

13 Summary

The instrument cluster is a fully engineered, modular, universal platform capable of replacing OEM analog clusters across multiple vehicles, including the Honda Civic EF track build.

14 Conclusion

The digital instrument cluster development program integrates mechanical engineering, PCB design, UI/UX, software development, and CAN-BUS decoding into a single universal platform. While originally created for the BMW E90 335i, the architecture was intentionally designed to be adapted to any vehicle with minimal wiring and code adjustments. Future expansions include OBD-II diagnostics, predictive shift lights, GPS lap timing, and wireless updates.

The system elevates cockpit functionality, modernizes vintage vehicles, and provides an aftermarket product that is scalable, reliable, and fully customizable.