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Performance Analysis & Data Acquisition Report Motorcycle Dynamics (ACHA5004)

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Table 1 Abbreviations Table

Abbreviations	Meaning
GPS	Global Positioning System
RPM	Revs Per Minute
TMPS	Tyre Pressure Monitoring System
TPS	Throttle Position Sensor

1 Introduction

This report presents a data acquisition and analysis study of rider performance on a motorcycle track. Using 2D data logging systems and multiple sensors, it examines how different riders apply throttle, brakes and manage vehicle dynamics. The focus is on the objective sensor data to reveal actual motorcycle behavior during lap times, including suspension movement, brake pressure, wheel speeds and other parameters discussed below which are derived from team collaboration on deciding the required sensors. By correlating these channels, the analysis identifies strengths, weaknesses and specific areas for sense and rider improvement.

2 Comparison of 3 Riders

2.1 John

2.1.1 Traces and Analysis

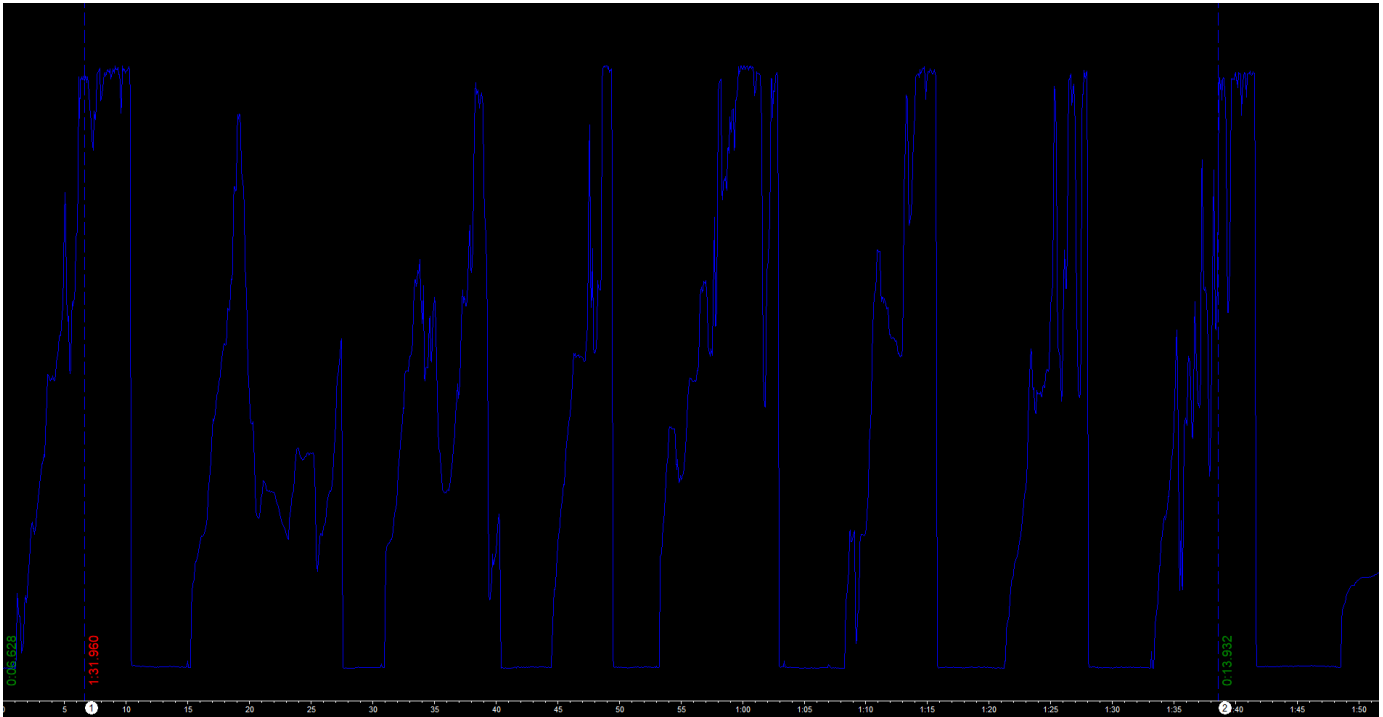


Figure 1 John Mayer's Throttle Trace obtained from team's data supplied by Owen Williams (F. Flye, 2026)

John's Throttle trace shows an aggressive and inconsistent style, characterized by frequent on-off movements rather than smooth, progressive application. The jagged trace features abrupt jumps from low to zero throttle to near 100%, followed by sharp drops, particularly in technical sections. This suggests hesitation, over-correction and late throttle application on corner exits, resulting in slower exits and reduced drive out of turns.

For improvement John should focus on confidence and smoothness of his application to the throttle, by practicing rolling on the throttle with three fingers and aim to open up the throttle earlier while the bike is still leant over. A useful drill would be to be on the throttle at 20% once past the apex round the track.

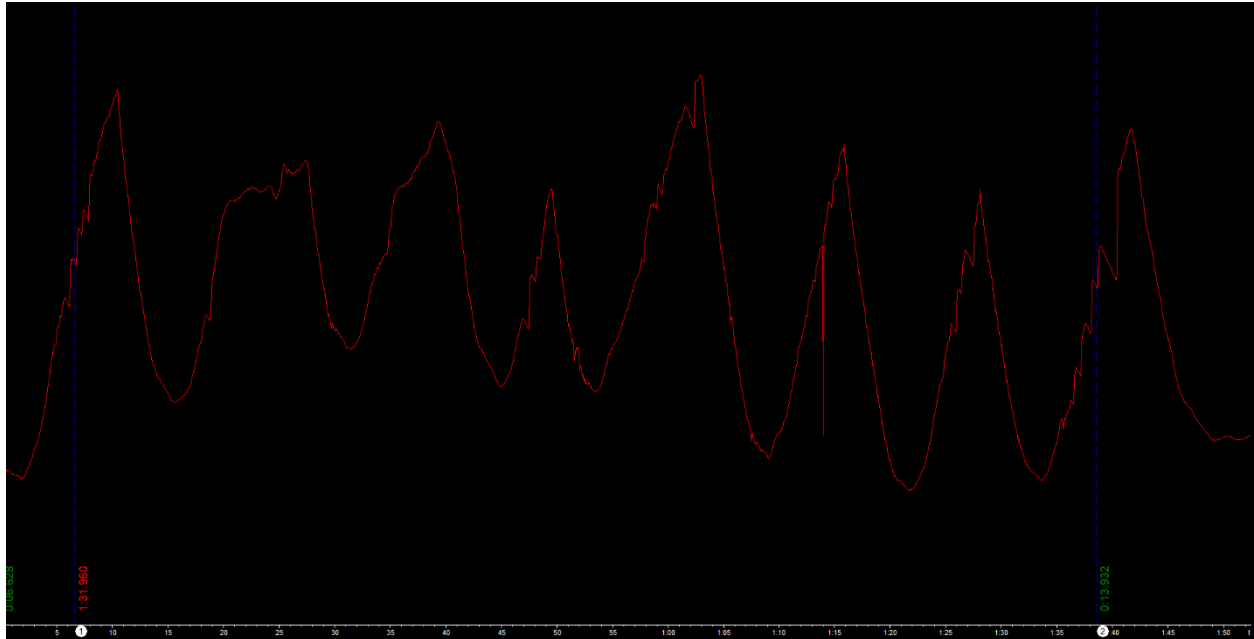


Figure 2 John Mayer's V Front Trace obtained from team's data supplied by Owen Williams (F. Flye, 2026)

Figure 2 illustrates John's speed trace which reveals a more committed riding style with linear acceleration; however, it shows the clear signs of inconsistency and lost time due to his jerky throttle inputs. In several places it can be seen where the speed increases sharply only to flatten off mid acceleration. These plateaus further prove the rider isn't applying power smoothly.

Overall, John's traces reveal his lack of smoothness in riding and applying power to the throttle, where he has slow corner exits, interrupted accelerations and unnecessary time loss between corners. However, he has a solid foundation as there is minimal coasting and reaching adequate top speeds, with better throttle control and confidence in himself the traces will output smoother.

2.2 Garry

2.2.1 Traces and Comparison

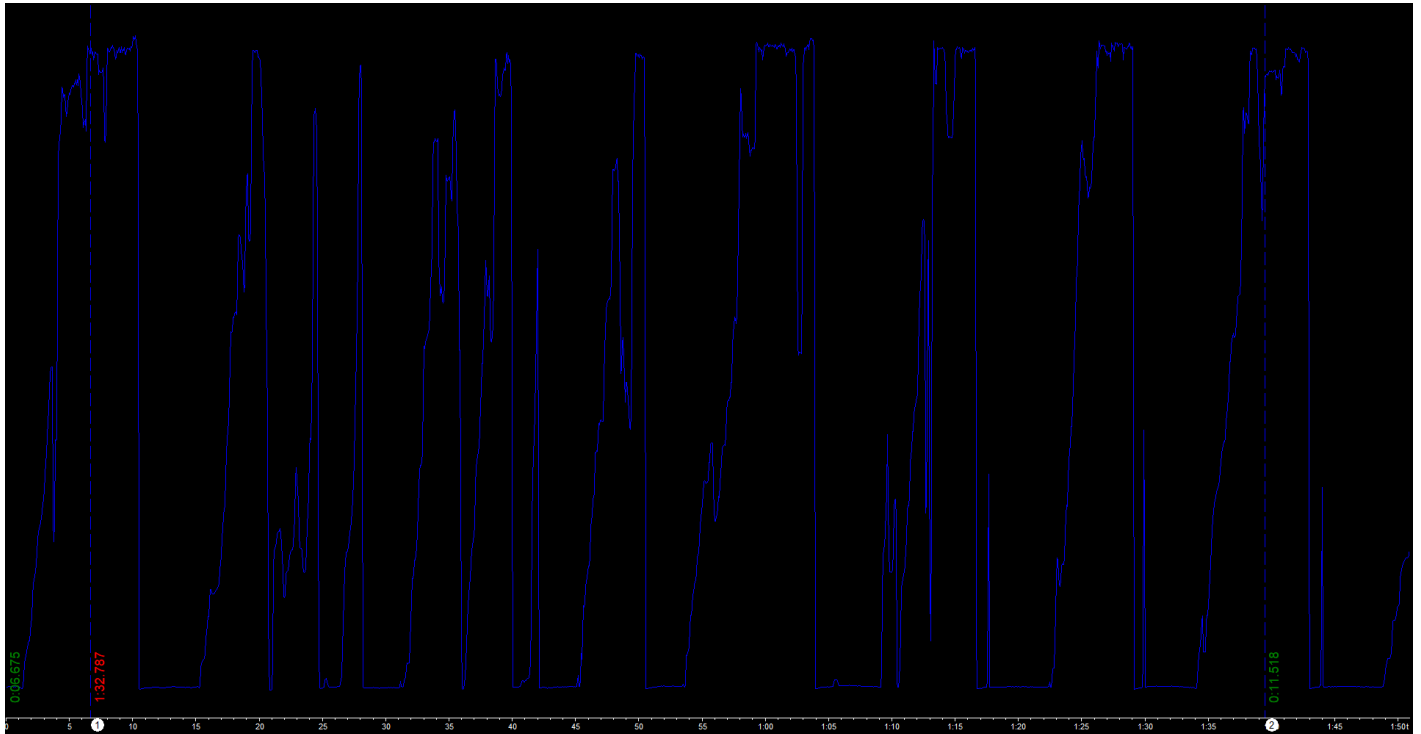


Figure 3 Garry's Throttle Trace obtained from team's data supplied by Owen Williams (F. Flye, 2026)

Figure 3 presents Garry's throttle trace, which demonstrates a much smoother and more controlled riding style compared to John's aggressive on-off approach. The trace features gradual rising slopes rather than sharp spikes and sudden drops, indicating progressive throttle application, especially on corner exits. Full-throttle segments on straights are longer and more sustained, while technical sections display cleaner transitions from closed to full throttle. Garry applies power earlier while the bike is still leant over, stabilizing the chassis and building speed faster of the corners.

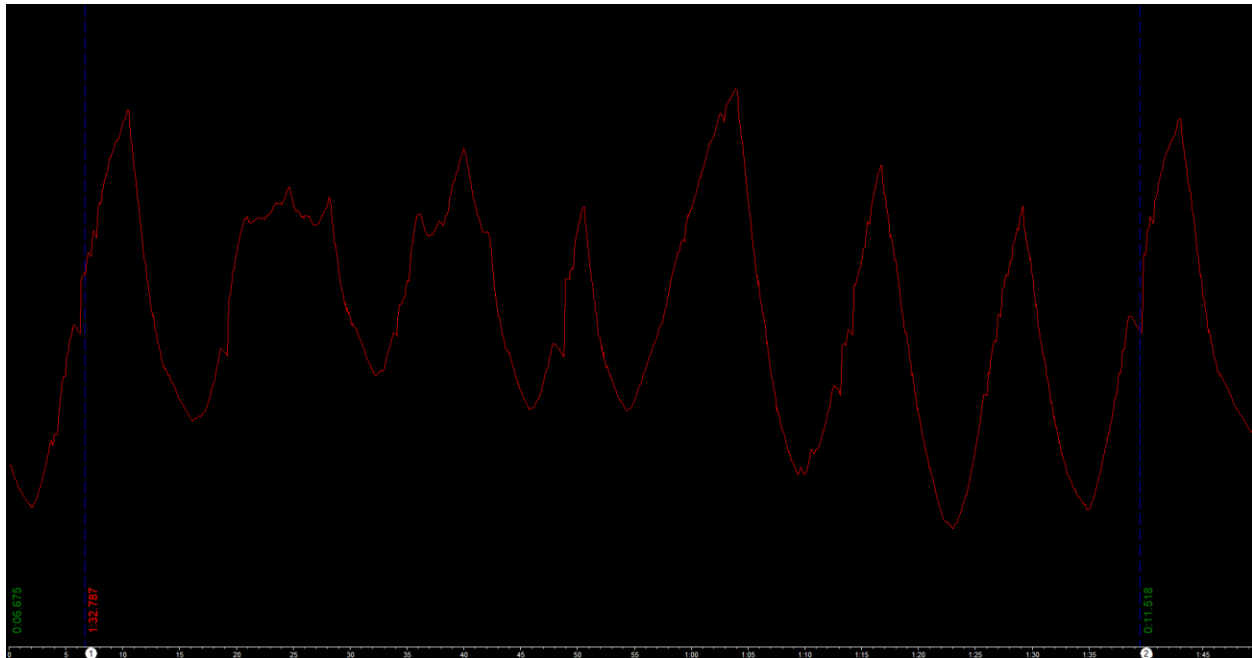


Figure 4 Garry's V Front Trace obtained from team's data supplied by Owen Williams (F. Flye, 2026)

The figure displays Garry's smoother and more efficient riding style. Acceleration phases after each corner show cleaner, more consistent riding lines with fewer interruptions. The overall shape aligns with the throttle trace, showing power applied earlier and more progressively on corner exits. Braking zones feature gentle "V" or "U" shapes rather than John's jagged lines, indicating consistent pressure and better speeds carried into the apex. The speed trace has noticeably less noise and fewer sudden changes, reflecting greater rider confidence.

To improve, Garry should focus on "earlier and smoother" inputs, these consist of applying throttle and drive sooner while slightly raising minimum corner speeds. Reducing minor hesitations could yield faster lap times.

2.3 Simon

2.3.1 Traces and Comparison

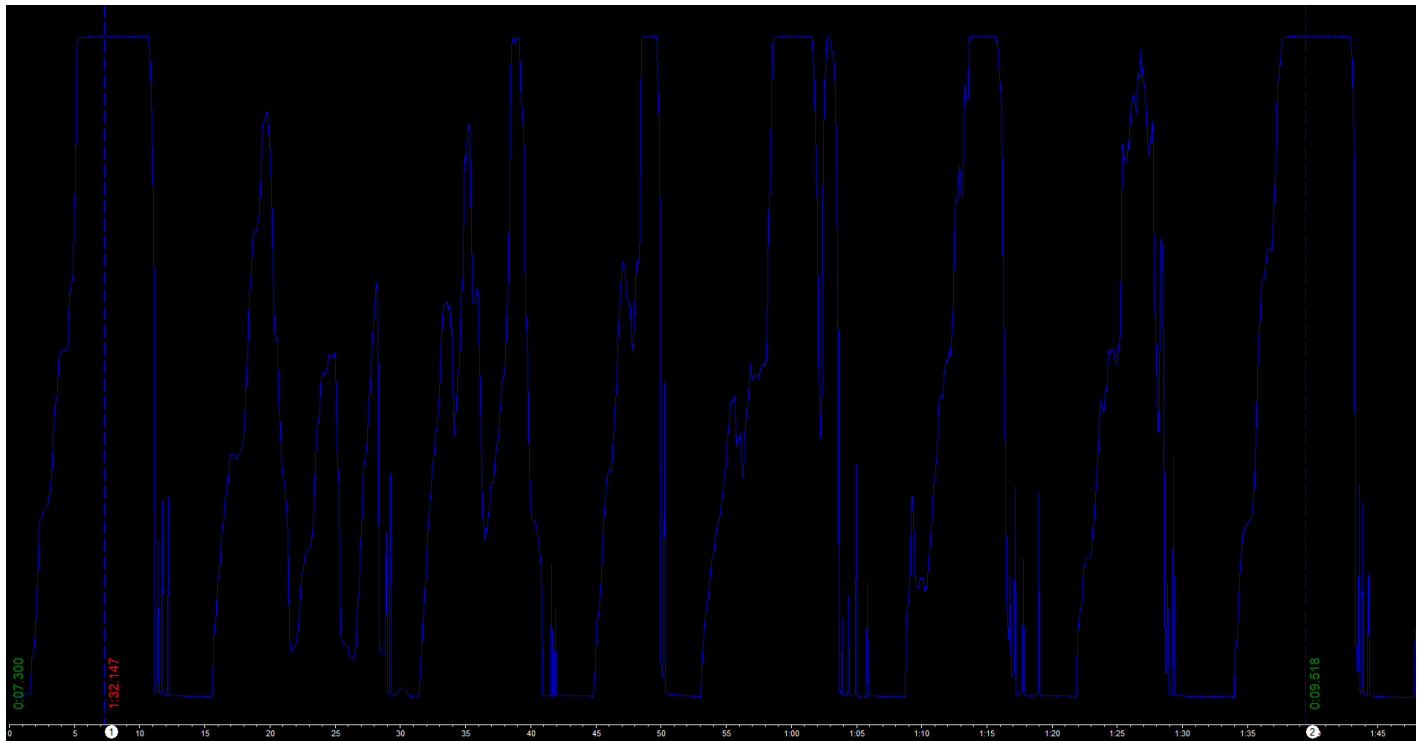


Figure 5 Simon's Throttle Trace obtained from team's data supplied by Owen Williams (F. Flye, 2026)

Simon's throttle trace reveals a highly aggressive and inconsistent riding style dominated by extreme on-off behavior. Long flat periods at 100% throttle are interrupted by sharp vertical drops to zero and abrupt returns of full power, creating a square wave pattern. This suggests hesitation, potential fear of lean angle, or mid corner line corrections rather than gradual roll on. The sudden bursts unsettle the chassis and make rear tyre traction difficult to manage.

Compared to John and Garry, Simon is noticeably rougher. Although he commits strongly on straights, his constant chopping prevents momentum through corners, resulting in interrupted acceleration, late apexes and lost drive. This style increases the risk of wheelspin and limits lap time.

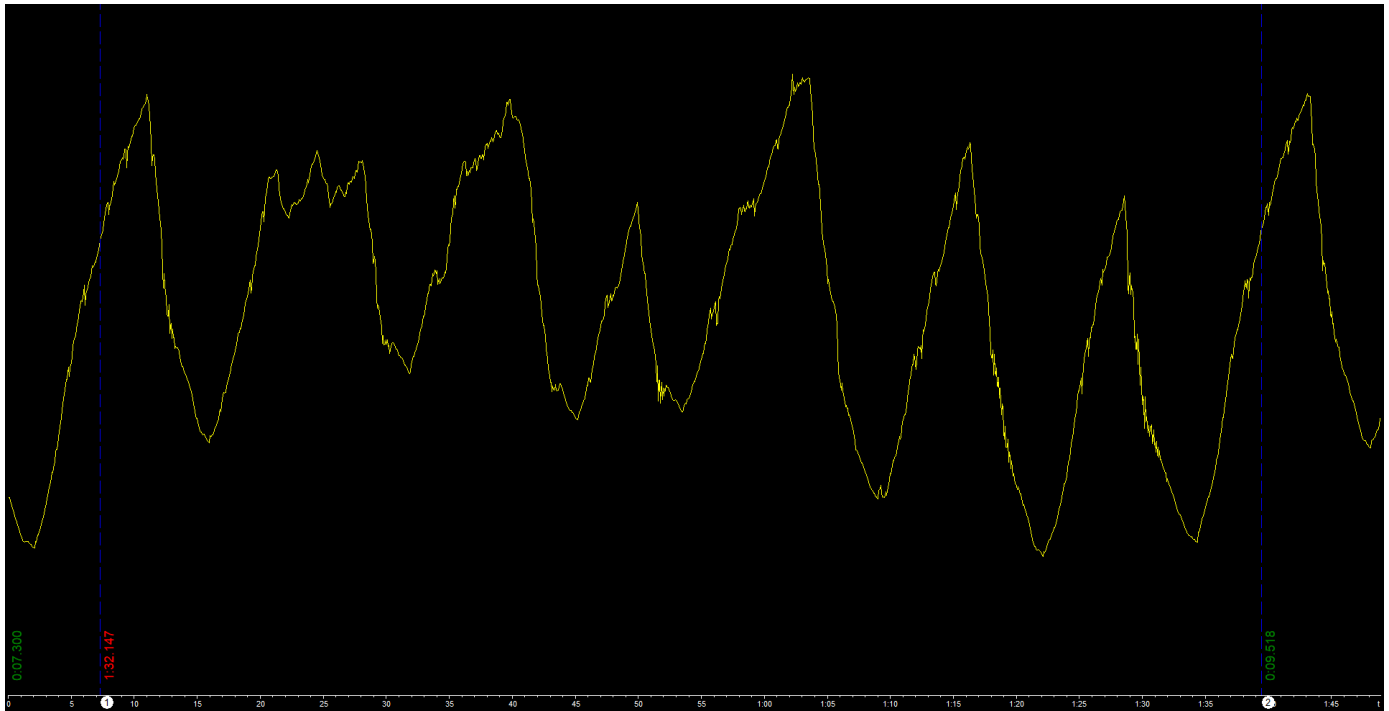


Figure 6 Simon's V Rear Trace obtained from team's data supplied by Owen Williams (F. Flye, 2026)

Simon's rear wheel speed trace reveals significant traction issues caused by his extremely jerky throttle inputs. The trace shows frequent spikes and erratic jumps during acceleration, particularly after sudden large throttle openings, indicating rear wheel spin. Acceleration is often interrupted as the rear tyre loses drive and scrambles to regain grip, creating a noisy, unstable trace compared to Garry's and John's. The combination of violent throttle application and wheelspin explains Simon's inconsistent and nervous riding style, resulting in lost time on corner exits.

To improve, Simon should apply throttle more progressively and smoothly rather than snapping it open, which will reduce wheelspin and significantly enhance corner exit speeds.

2.4 Final Comparison

To conclude this comparison in terms of rider quality and confidence Garry is the best rider from the concluded data having the smoothest transitions between corner and excellent throttle control. However, John had the fastest last time buy a few milliseconds which conveying from the data suggests that it was due to raw aggressiveness trough the straights that gave him an edge over Garry.

3 Data System for ZXR750

This section presents the data system that will be implemented into the Kawasaki ZXR750, this data system consists of pressures in the airbox, tyres and the brakes, Throttle position, Lambda values, Wheel speeds, Coolant temperatures, Engine RPM, GPS and Front and Rear suspension. With this figure 7 was developed to present an overview of the desired wiring system setup.

3.1 Wire Diagram

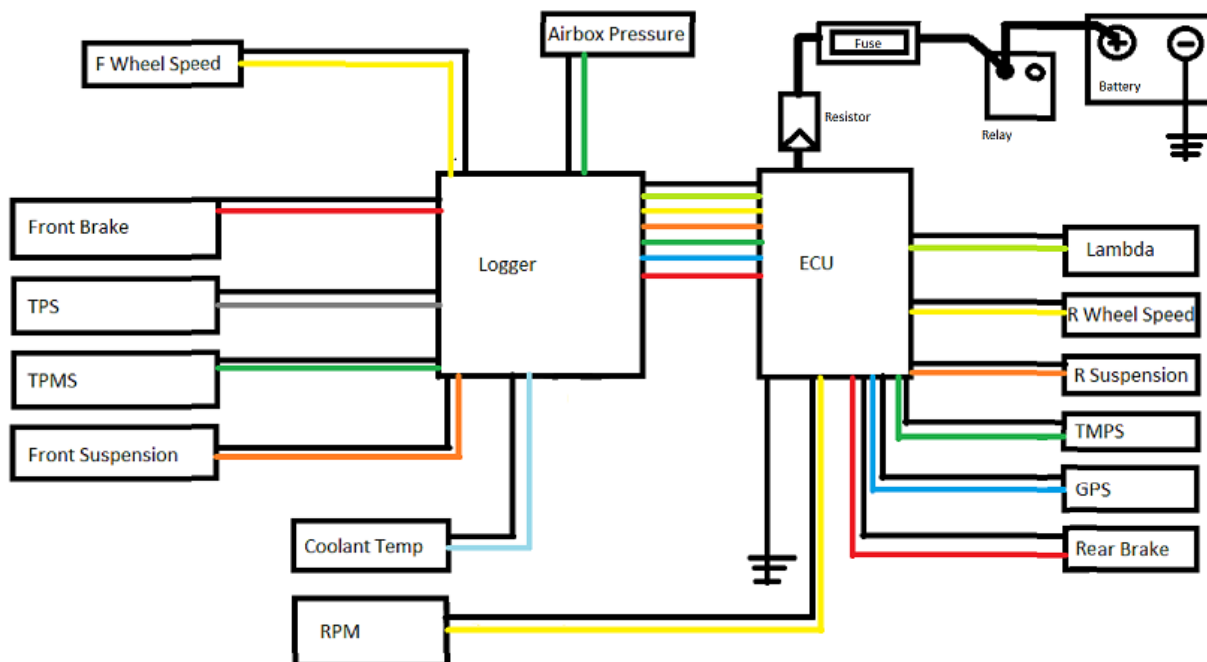


Figure 7 Wire Diagram of the Data System (F. Flye, 2026)

3.2 Sensors

3.2.1 Tire Pressure Monitoring Systems (TPMS)



Figure 8 TPMS from 2D (MRTTECH, 2026)

For the tyre pressure monitoring system, the official 2D monitoring system will be used. This provides the highest level of synchronization with the 2D acquisition software, ensuring seamless integration and data outputs at maximum reliability. These sensors will be sourced from (MRTTECH, 2026) at a price of £155.79.

3.2.2 Wheel Speed Sensors



Figure 9 Wheel speed sensor (ZeusProducts, 2026)

For the instance of wheel speed sensors thorough analysis was able to lead to these wheel speed sensors produced by (Zeus Products, 2026) which quotes £110, these offer excellent value while delivering performance and data output quality similar to that of 2D's version.

3.2.3 Braking Pressure Sensors



Figure 10 Front Brake Pressure sensor from 2D (MRTTECH, 2026)



Figure 11 Rear Brake Pressure sensor from 2D (MRTTECH, 2026)

These sensors from 2D will be sourced from (MRTTECH, 2026) at a price of £383.41 each. These 2D potentiometers feature a compact, slim body design that integrate well into the motorcycles structure which can be easily rotated or angled differently to supply some protection to them through the frame.

3.2.4 Lambda Sensors



Figure 12 Lambda sensor (K-Data, 2026)

The lambda sensor will be sourced from (K-data, 2026) at a price of £72.49 this option offers excellent value providing a cost reduction compared to 2D's sensor of £890.48, while maintaining similar accuracy and reliability for real time air fuel ratio measurement within the exhaust.

3.2.5 Airbox Pressure



Figure 13 Bosch Airbox Pressure sensor (XTRAMotorsport, 2026)

For the instance of the airbox pressure gauge this will be sourced from (XTRAMotorsport, 2026) at £37.18. This Bosch MAP Sensor offers the best price from a trusted and reliable brand while retaining excellent accuracy.

3.2.6 Throttle Position Sensor



Figure 14 Throttle Position sensor (mmgracingstore, 2026)

This compact throttle position sensor will be perfect for the ZXR as there was an issue with finding a compatible sensor to fit so there would be no collision with the fairing, affecting the steering inputs. This sensor will be sourced from (mmgracingstore, 2026) as they had the best price at £54.69.

3.2.7 Coolant Temperature



Figure 15 Coolant Temperature sensor (Autodoc, 2026)

For monitoring the coolant temperature in the motorcycle, an RMS NTC sensor will be sourced from (Autodoc, 2026) for £11.99. Designed specifically for motorsport and high-performance applications, this sensor will provide accurate temperature readings from any riding situation. This design ensures excellent resistance to temperature, vibration, while ensuring maximum quality data outputs.

3.2.8 RPM/Logger



Figure 17 2D Logger (Tenkateracingproducts, 2026)



Figure 16 2D Dashboard (Tenkateracingproducts, 2026)

In terms of the RPM this will be done through the traditional method that RPM is displayed on a dash however feeding this data into the logger which will then output the rpm on the 2D Dash. The 2D logger and parts itself cost £1941.54 and the dash itself prices at £186.33, these being sourced from (tenkateracingproducts, 2026).

3.2.9 Suspension



Figure 18 2D Front suspension sensor (Alpharacing, 2026)



Figure 19 2D Rear suspension sensor (Alpharacing, 2026)

These figures represent the front and rear suspension travel sensors that consist of high precision measurements of linear movement of the suspension that will feed the information back into the logger. These will be sourced from 2D from (Alpharacing, 2026) for £373.65 each reaching a total of £747.30.

3.2.10 GPS



Figure 20 2D GPS (MRTTECH, 2026)

The GPS and antenna will be sourced directly from 2D coming to the price of £194.75 where the GPS itself costs £146.06 and the antenna costs £48.69. These are a key sensor as this will produce the layout of the track that the data acquisition can process to form the map.

3.3 Total Pricing

The addition of wiring components for the 2D logging system requires connectors, pins, analog cables, CAN bus cables and the main sensor harness have been priced based on the current 2D quotations.

These quotations lead to the price of the harness to be £402.84 which means that the total pricing of the entire wiring harness comes to £4704.26 with all the sensors and logger combined. Illustrated in Table 2 below where all the estimated prices of the wiring components for the harness were calculated.

Table 2 Table Showing estimated values of the wiring costs (F. Flye, 2026)

Wiring Parts	Price (£)
34 pin Harness	210
8 extension cables	55.99
CAN cables/ GPS and TPMS	94.55
Miscellaneous (heat shrink, crimp pins, conduit)	42.3
Total	402.84

4 Calibration, Setup and Testing

To review the section and completion of calibration, setup and testing, due to time and track access constraints the full live dynamic testing was not possible. However, significant preparatory work was carried out through close team collaboration to ensure a robust and practical installation.

To further this the sensor selection was conducted collaboratively as a team. After collectively reviewing the motorcycles layout and data requirements, we collectively identified the most suitable sensors for capturing the required data. To visualize and communicate these decisions effectively and efficiently, a bird's eye view drawing of the motorcycle was created as shown in figure 23 below illustrating where the general local of the sensors would be positioned.

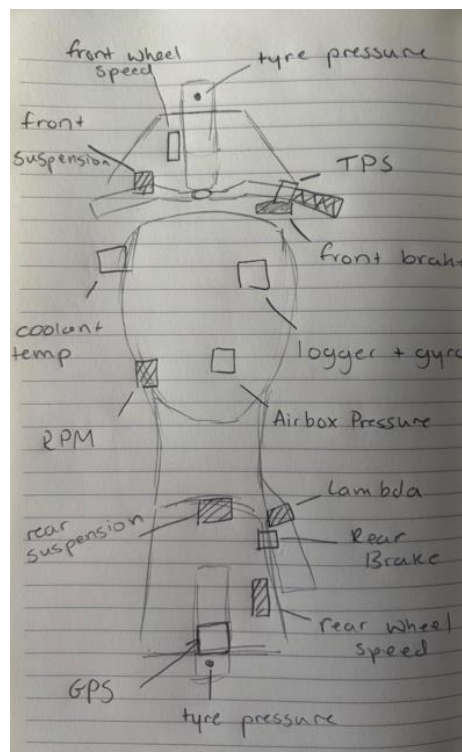


Figure 21 Bird's eye view of Motorcycle showing the general locale of the sensors (F. Flye, 2026)

In addition to this, for the sensors that couldn't be mounted directly to the motorcycle CAD Models were made as shown in figure 22 and 23 as these will help achieve optimal positioning for the sensors to gather precise data. In terms of challenges that occurred were the limitation of mounting options, cable routing constraints and ensuring sensor alignment without compromising the motorcycle's functionality, these were addressed through iterative design through team discussions. Where possible non-invasive method was taken using Velcro for light sensors to limit the number of modifications made to the motorcycle.

Although live testing couldn't be conducted, bench level calibration and static verification of the sensors could be performed. Signal quality was reviewed on the data logger to confirm connections and basic functions. These preemptive steps, combined with team collaboration enabled a solid foundation to be laid in preparation for track testing.

4.1 Cad Models

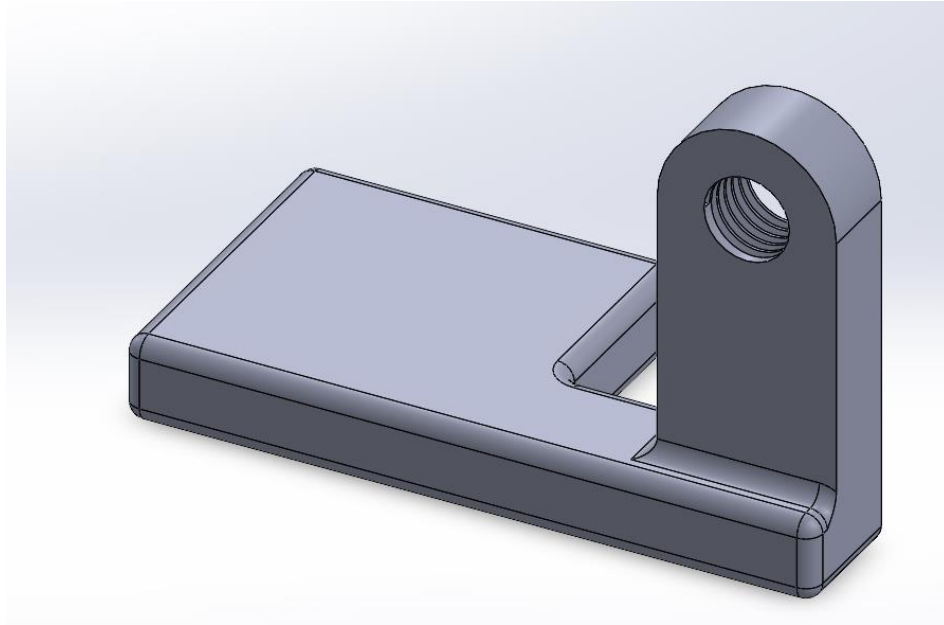


Figure 22 CAD Model of the mounting bracket used for the rear wheel speed (F. Flye, 2026)

Figure 22 presents the CAD Model developed to attach the rear wheel speed sensor. The design secures the sensor by fastening the bracket to the pre-existing feature on the swingarm while being held down with Velcro to ensure no movement occurs. This offers a convenient yet simplistic solution while maintaining excellent structural integrity. The approach ensures the expensive sensor remains securely protected during track use.

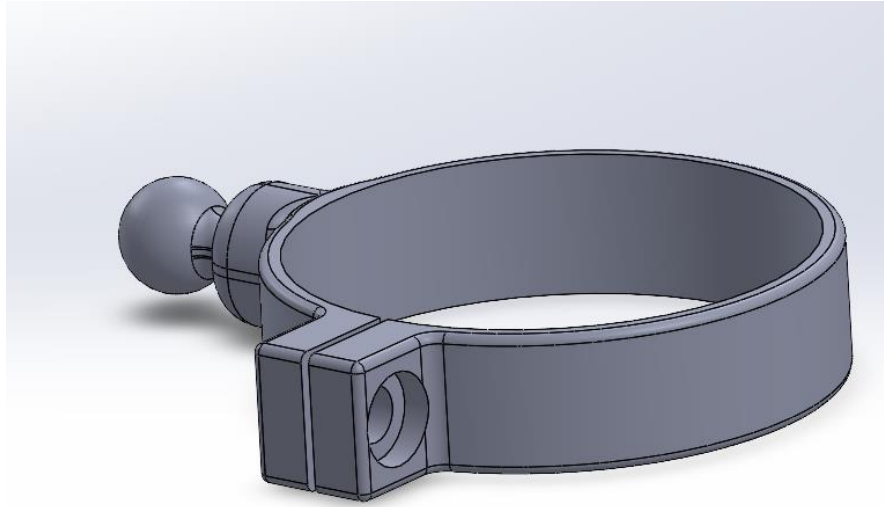


Figure 23 CAD Model of top and bottom bracket for front suspension sensor (F. Flye, 2026)

Figure 23 illustrates the CAD Model developed for the top and bottom mounting brackets for the front suspension potentiometer. This design will be positioned on the left fork as this area provides the most clearance and allows for optimal sensor alignment. The assembly will be fastened and secured at the top and bottom using Allen-heads as this provides easy disassembly and relocation of the system to ensure adequate and precise data recordings.

5 Analysis of Pembrey Race

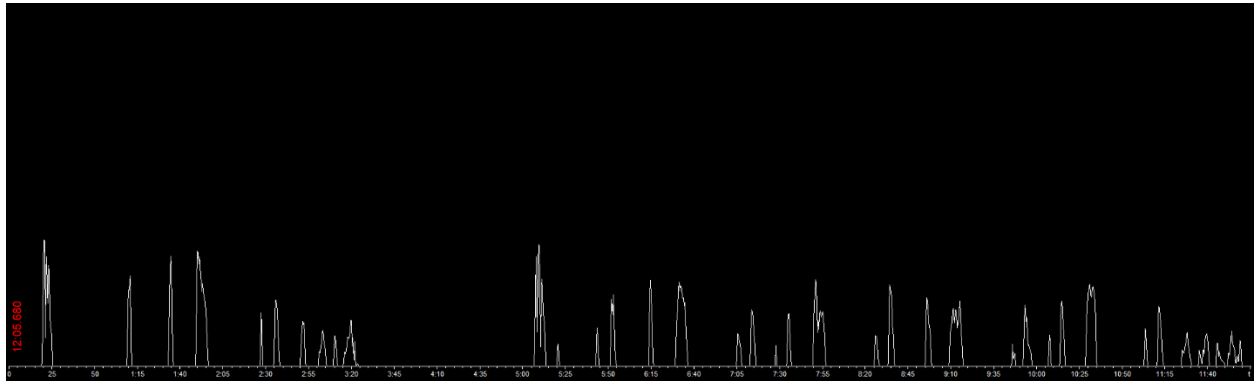


Figure 24 Front Brake pressure trace collected from Pembrey Track Day (F. Flye, 2026)

The Front Brake pressure trace presented by the 2D data logging system shows good technical performance during the race. The sensor successfully captured every braking event, with clear pressure rises, stable holding phases and clean returns to zero upon release. However, the signal contains noticeable chatter or noise on the rising and falling edges of the pressure spikes. This noise slightly reduces the precision of the data making analysis of brake modulation more challenging.

In Addition to this, from a physical perspective the sensor performed well, with the constant rises and releases in pressure behavior indicates there was no brake fade, air in the brake lines or any master cylinder problems.

The captured data provides substantially important values for analysis as it enables clear visualization of brake. This allows for math channels to be created to uncover brake bias and rate of change calculations.

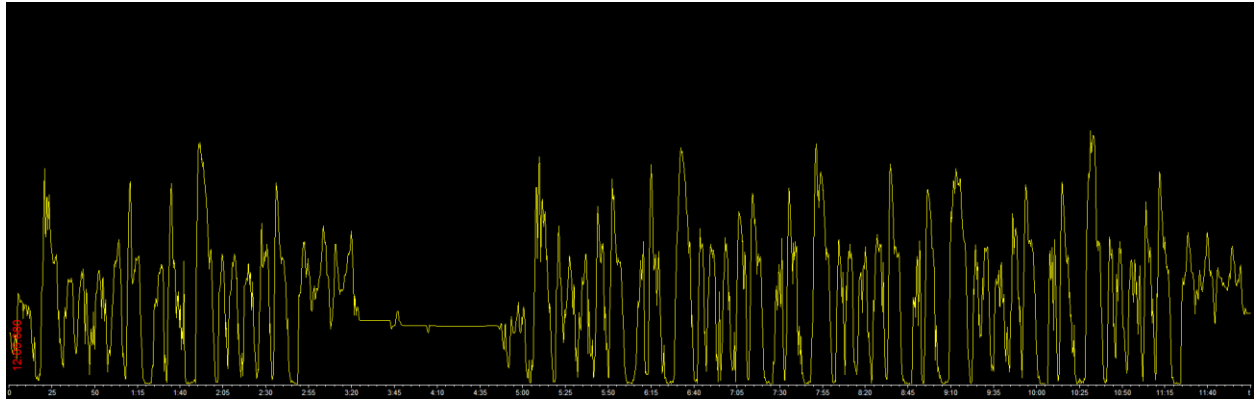


Figure 25 Front Suspension trace collected from Pembrey Track Day (F. Flye, 2026)

The front suspension displacement trace shows acceptable technical performance. The sensor captured overall suspension movement, with clear periods of high activity during braking, acceleration, and cornering. However, like the brake pressure sensor, it suffers from significant noise, which obscures finer details and makes genuine suspension behaviour harder to analyse. Resolution remains adequate for large movements.

Physically, the sensor performed as expected, recording consistent compression and rebound cycles in response to track surface and rider inputs. Despite the noise limiting precise ride-height analysis, the data is still useful for understanding overall motorcycle dynamics when correlated with braking events.

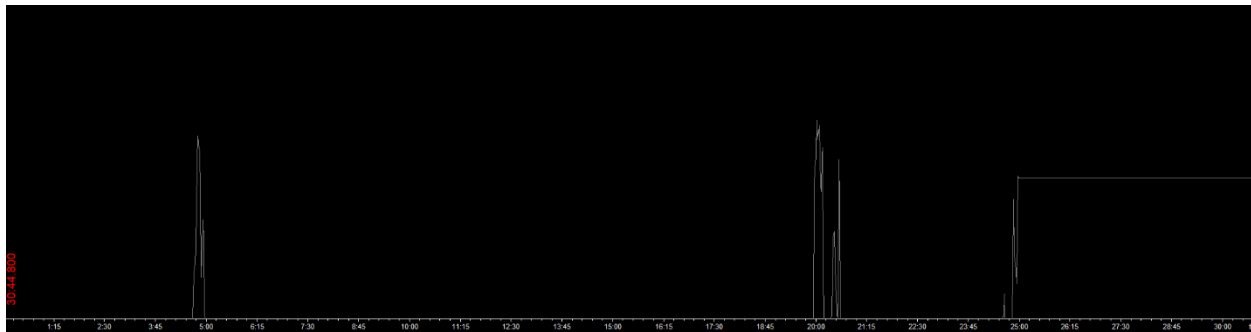


Figure 26 Rear Brake Pressure trace collected from Pembrey Track Day (F. Flye, 2026)

The rear brake pressure trace demonstrates excellent technical performance, with clear pressure spikes that correspond well to rider inputs. Peak pressures are visible, and the trace returns cleanly to zero after each braking event. Unlike other channels, it shows significantly less noise, providing higher-quality data for analysis.

Physically, the sensor performed well under track conditions. Brake applications produce lower and narrower spikes than the front brake trace, confirming a front-biased braking system with the rear providing supplementary force.

The data is particularly valuable when correlated with the front brake trace, enabling accurate calculation of brake bias percentages and analysis of the rider's braking distribution across the track.

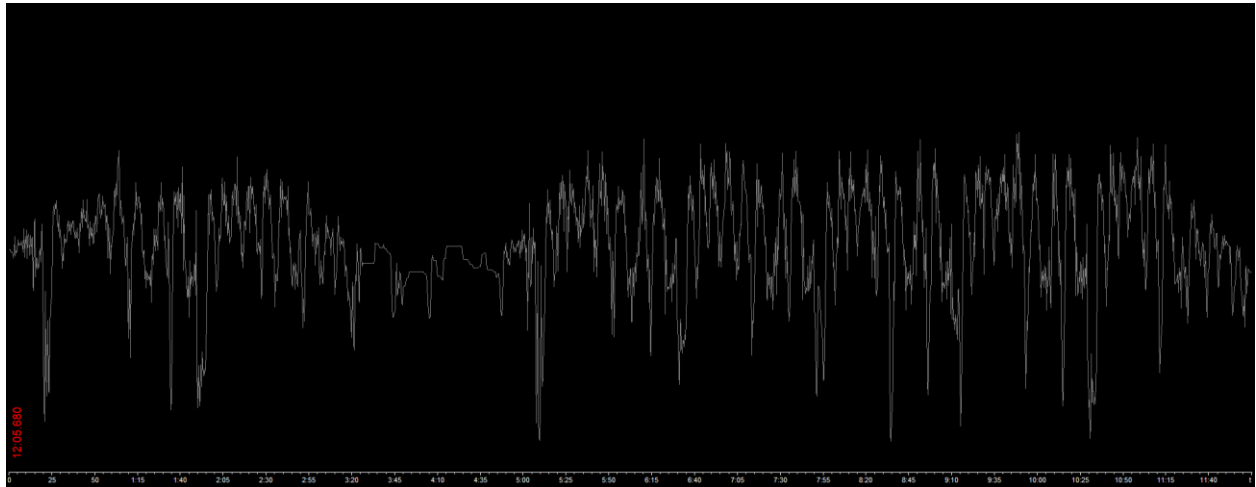


Figure 27 Rear Suspension trace collected from Pembrey Track Day (F. Flye, 2026)

Figure 27 shows the rear suspension trace overall with moderate technical performance, highlighting visible oscillations corresponding to acceleration, cornering and braking events. The trace reveals periods of activity in high load sections of the lap and smoother sections of straights.

Physically, the sensor and system appear to be performing moderately, with direct correlation to the front suspension showing the compression and rebound cycles with no signs of bottoming out or loss of suspension travel.

Finally, to use the data for calculations it can be correlated to braking and acceleration when overlaid with, wheels speeds, tyre pressures and brake pressure traces.

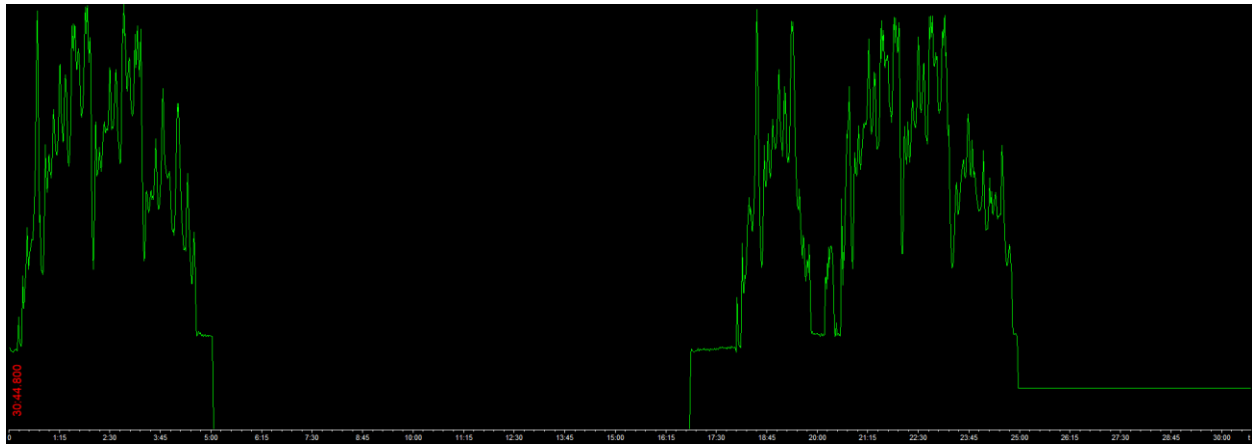


Figure 28 Engine RPM trace collected from Pembrey Tack Day (F. Flye, 2026)

The Engine RPM trace demonstrates excellent technical performance, with a clearer and smoother signal than other channels. It precisely captures transitions between low-RPM and high-revving sections under acceleration, with sharp rising and falling edges indicating gear shifts and throttle inputs. The flat sections suggest coasting.

Physically, the system performed well, clearly showing repeated acceleration phases, smooth RPM build-up, gear changes, and deceleration. As a key reference channel, it synchronises well with other data, particularly when overlaid with brake traces to evaluate braking points and gear selection strategy.

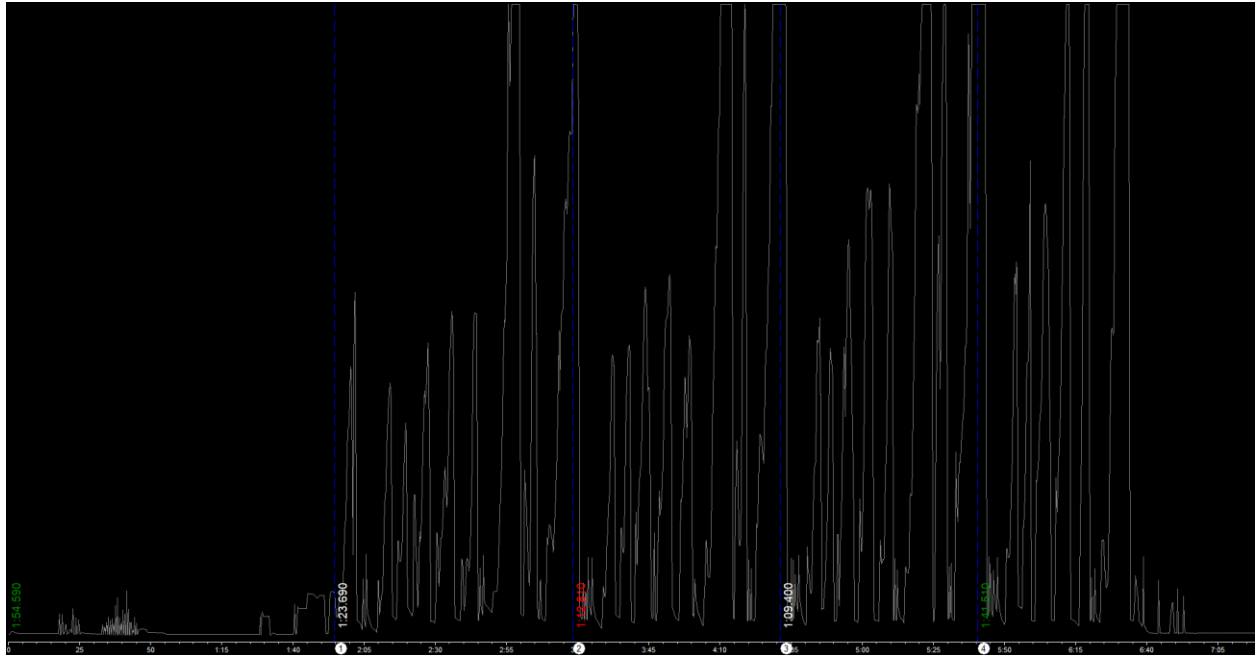


Figure 29 Throttle Position trace collected from Pembrey Track Day (F. Flye, 2026)

The Throttle position Trace acquired from sensor A shows good technical performance as the signal captures the data clearly and precisely conveying the throttle application events with sharp rises corresponding to corner exits and smooth deceleration during braking or gear transitioning.

Physically, the system performed consistently over the laps, the data shows repeatable throttle patterns that align with typical racing lines. There is no sign of the throttle sticking, sensor drift or unexpected flat spots due to mechanical issues, this further supports the quality of the sensor.

In addition to this, the captured TPS data is highly useful for overall vehicle dynamics as it provides excellent reference for correlating throttle inputs with brake pressure, suspension movement, RPM and wheel speeds.

5.1 Conclusion and Improvements

To conclude the analysis of the Pembrey laps the sensors upheld well both technically and physically, however as seen in the wire diagram not all the sensors were allocated to this bike as due to time conflicts the initial bike was unable to be used so the data collected from this is on an Aprilia rather than the ZXR.

The 2D logging system proved consistent and reliable through the conducted laps, providing strong connections to all the implemented channels with no gaps, dropouts, or synchronization problems. Although there were partial issues with some channels causing small amount of noise or chatter which will affect creating accurate calculations from the data.

The analysis reveals that the front and rear suspension channels suffer noise implications due to vibrations and electromagnetic interference. To improve signal quality, shielded cables could be implemented for all the analog sensors and routed away from high current cables and ignition systems. The brake pressure sensors and suspension potentiometers should be mounted with rubber or silicone vibration isolation which could be implemented into the brackets in the calibration section above. Similar shielding should be applied to the throttle position sensor too.

Finally, applying low pass filters in the 2D analyzer during post processing will output cleaner traces, while keeping raw traces intact. These changes will significantly enhance the overall data reliability and usefulness for future endeavors.

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