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Formula One Racing Car

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Abstract: Formula One (F1) metrology is essential for monitoring the performance of the racing car and for optimizing vehicle setup. In this sport, drivers and engineers must monitor several parameters about car systems such as engine, transmission, suspensions and wheels constantly and accurately.Telemetry is not merely a diagnostic tool in the top racing world, but it includes a specialized hardware device for detecting, storing and transmitting thousands of data channels.This paper critically reviews the most important metrological aspects of F1 car model in terms of control strategies, improving performance and ensuring safety.A modern Formula One (F1) Racing Car has almost as much in common with an aircraft as an ordinary road car.Aerodynamics has become a gateway to sporting success and teams spend millions of dollars each year on field research and development to improve performance.By analysing the corresponding structure and forces, different car features will be enhanced to make the entire car more structurally efficient.Structural efficiency will be achieved by considering the down force &force reaction, which is produced at a certain speed, weight, material, power, and other performance parameters to achieve the primary concerns described above.

Keywords: Automotive Sensors, Formula One Car, Hall Impact, Telemetry, Temperature, Vehicle.

INTRODUCTION

Formula One (F1) epitomizes the high end of auto racing.Fl cars are high-tech marvels, they are equipped with lightweight engines, connected to experimental transmissions, placed in a body designed for its aerodynamic properties and connected to electronic / electromechanical systems[1].The vehicle is heavily instrumented because constant collection and transmission of car information to the race team is necessary.This knowledge allows the team to constantly update its current race plan and to develop the design of the car for future competitions.The on-board sensors are numbered in hundreds, and often have technologies derived from aerospace[2].Typical quantities measured are currents, voltages, pressures for components like engine oil and hydraulic systems, gearbox oil and temperatures of engine, hydraulic fluids, ambient air, water, exhaust, brakes, strains on the suspension members, wheel speed, position and speed for servo valves, ride height, engine and gearbox rpm (Revolutions Per Minute), acceleration in three dimensions, impact acceleration during a crash and rotation.Sensors are highly critical components requiring maximum reliability and operating in a highly stressed environment, high temperatures and high vibrations.The data logger is built into the ECU (Electronic Control Unit); this has the function of collecting and storing ECU-generated information and retransmitting it to the off-board network via a telemetry connection when the car is running.The logger does not manage sensors directly it receives the information pre-processed from the ECU over a CAN (Controller Area Network). The telemetry transmitter and the telemetry receiver are system which includes preamps; splitter, receiver and antenna[3].

Vehicle information is used for evaluating engine, driver, and vehicle performance, simulating and forecasting operations with different mechanical and aerodynamic configurations, anticipating or investigating problems, and producing statistics[4]. Figure 1 shows the sensors, actuators, and cabling layout.

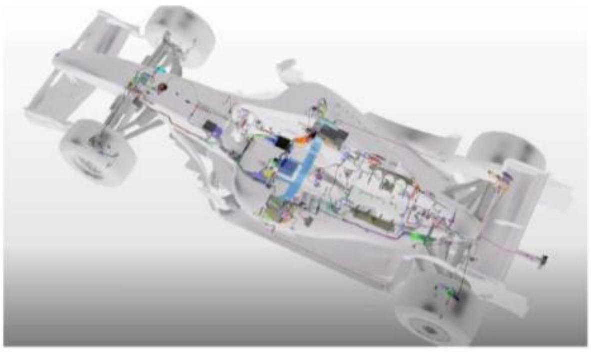

Figure 1: Sensors, Actuators and Cabling Layout

The paper is aimed at giving a critical overview of the race car signal acquisition from a metrological point of view. It is especially oriented towards the function of F1 sensors and transducers, even mentioning on-board and off board monitoring of equipment and data logging[5].

1. On Board Measurements:

Multiple inputs generate the massive amount of data needed in Ft activities: the sensors. To achieve a difficult balance between precision and robustness; each calculation entails uncertainties due to nonlinearity, hysteresis, sensitivity to temperature and vibration, repeatability.Fig.2 represents major system application areas for car sensors, and a list of the elements involved for each area.Coverage of all details is beyond this paper's scope and size constraints; attention is focused on most important Ft car sensors in terms of strategy control, performance and safety, classified for measurements.Figure 2 represents major system application areas for car sensors, and a list of the elements involved for each area.Coverage of all details is beyond this paper's scope and size constraints; attention is focused on most important Ft car sensors in terms of strategy control, performance and safety, classified for measurements[6].

a. Position:

Position sensors measure straight and rotational relocations running from under 1µm to over 200mm. Most diffused innovations are: LVDT (Linear Variable Differential Transformer), potentiometric, Hall impact and laser. Potentiometers can be utilized just to quantify an uprooting steer point, suspensions, gear drum, throttle pedal or to execute retroactive control as well throttle valves. Some natural conditions require LVDT sensors, precisely in nearness of hard conditions in temperature, vibrations and EMIs (Electro Magnetic Interferences) like brake callipers. A Hall impact component mounted on gear essential shaft is a little sheet of semiconductor material organized with a consistent current streaming across it. There are two kinds of Hall impact sensors utilized in F1: differential and zero speed; the previous is generally invulnerable to impedance yet it can't distinguish static field, while the last isn't direction subordinate however is less tolerant of large working air holes between the sensor and the objective wheel. At long last, laser sensors are valuable to characterize the body position thinking about ground as reference[7].

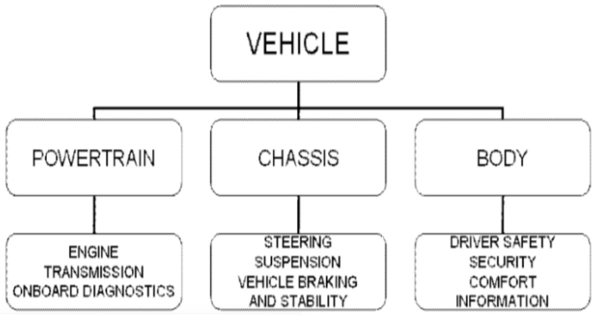

Figure 2: Major Areas of System Application for Car Sensors

b. Pressure:

The technologies used in automotive pressure sensors are: piezo-resistive micro machined, capacitive touch-mode micro machined, capacitive ceramic-module, and piezo-resistive poly silicon on steel.To calculate engine oil pressure (Pa), brake oil, engine cooling, tires, apparent wind, clutch, gearbox oil, differential, brake callipers and aerodynamic flat-bottom status.Many differential pressure measuring units are mounted on flat bottom of the car to reliably control the aerodynamic down-force[8].

c. Vehicle dynamic:

For complex measurements of racing vehicles, there are accelerometers one or two or three axes, gyroscopes, IMUs (Inertial Measurement Units) and no-contact optical sensors mounted. The main types of accelerometers employ MEMS technology (Micro Electro Mechanical System).They may be: piezo-resistive, capacitive, resonant-beam and less than 1% FS non-linearity + hysteresis is typical accuracy.Inertial Navigation System (INS) furnishes precise rate and increasing speed as for the body outline; it can works in Quaternion modes and in Euler points modes. On account of non-contact optical speed sensor it's conceivable to appraise precisely: separation, ground speed, and longitudinal increasing speed, slip edge, float point and yaw edge. Its sifting framework is programmable, to set the best exchange off among deferral and SNR[9].

d. Torque:

Torque estimation is utilized to break down motor eco-friendliness, to describe transmission move quality, and to examine vehicle power train torsional stress loads and vehicle driveability conduct; likewise torque estimation

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 3, March 2018

would give an alluring info sign to motor control framework. Motor torque estimation includes bargains as far as openness. Strain gage load cells and torque transducers are mounted on suspensions and on pivot shaft, motor, directing section, separately. Four strain gages are utilized to acquire most extreme affectability and temperature remuneration: two slip rings are utilized for excitation purposes, and two for the yield signal.

e. Temperature:

RTD (Resistance Temperature Detector), PRT (Platinum Resistance Thermometer), infrared (IR) temperature sensors, Thermocouples are widely used in motor sport.The thermocouples produce a differential output while PRTs generate a measured output; under measurement both devices are coupled to the system, usually engine / chassis components such as dampers, clutch for transmission.IR sensors are used for no-contact measurements; they have a working measurement distance from 30 mm to 70 mm and a viewing field equal to 150. Such measurements are useful for rotating elements such as brake disks and tires.

f. Vibration:

In the racing car environment the total noise level is very high, in fact the engine can reach 20000 rpm and the vehicle structure is very rigid.Upper grade levels in terms of shock and vibration require a thorough understanding of the mechanism of harm that is going to be involved in this area.The main sources of vibration include the engine, gearbox, power-train and vibrations that are transmitted during the run through the suspension.The peculiarity of Ft vibrations consists of no static boundary conditions, in fact each race and test session has a specific car set up; therefore the components can be permanently considered as prototypes.Vibration control introduced for vehicle F2007 simultaneously ensures that electronic devices are tested for the availability and production. Figure 3 shows the block scheme of vibration measurement system.

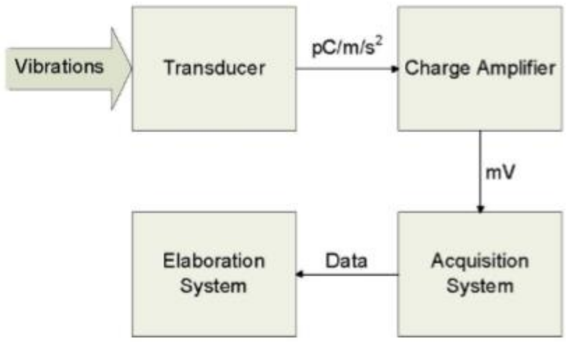

Figure 3: Block Scheme of Vibration Measurement System

Vibration measurement values are correlated in the device datasheet both with previous similar measurements and with the requirements of the working ranges. If an observed output loss is greater than a safety level, the component must be replaced; this warning specifically enables the problem to be investigated, multiple modifications tested and a more stable version of the system installed. It is reliable in terms of both historical measurements and datasheet ranges can device be installed for next session.In some cases, the same part can be remounted, enhancing vibration safety dimensioning and positioning of the absorbers, assembly techniques, restructuring of the housing, calibration fixation. Each change requires a new component vibrational characterisation. This third alternative is typical where the level of deterioration is low but the measurements are close to critical device values[10]. Figure 4 shows the scheme of vibration monitoring.

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 3, March 2018

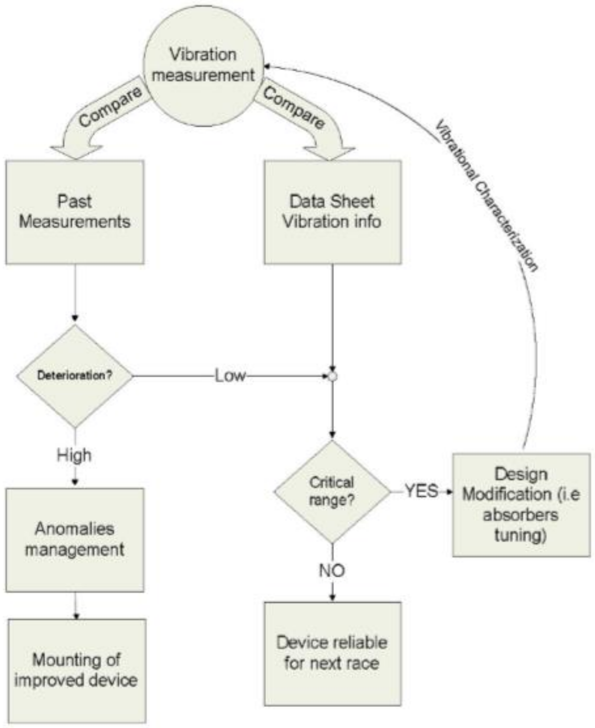

Figure 4: Scheme of Vibration Monitoring

2. Aerodynamics Background:

Aerodynamics is a branch of dynamics that studies the motion of air, especially when it interacts with a moving object. The motion of air around an object (often called a flow field) enables the measurement of the forces and moments acting on the object.Typical properties measured for a field of flow include speed, pressure, density and temperature depending on position and time[11]. Equations for the conservation of mass, momentum, and energy can be defined and used to solve the properties by specifying a control volume around the flow area.By streamlining it (smooth exterior surface), the drag over a body can be minimised. As a result, the fuel economy will possibly improve. An inverted aerofoil will generate a down force negative lift force.This leads to significant improvements in performance of race cars, particularly on tracks with numerous high-speed, unbanked turns.Aerodynamic down force increases the cornering strength of the tires by increasing the loads on the tires without raising the weight of the vehicle. The result is increased ability to corner, with no weight penalty, which results in reduced lap times[12]. Figure 5 shows a flow over a streamlined body.

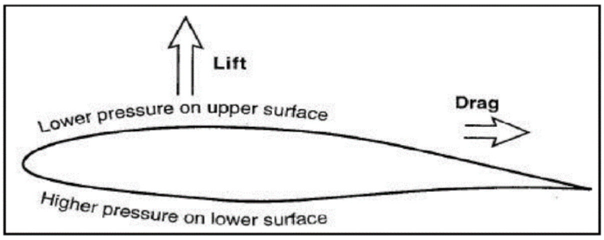

Figure 5: Flow over a Streamlined Body

CONCLUSION

Motor-sport electronic system contains integral sensors for measuring physical, chemical and dimensional parameters; for transduction into transmission-friendly electrical signals and for interfacing with the system's computational part.It is crucial that the critical tactical decisions can be taken quickly. The advanced metrology approach, the robustness of the sensors and actuators can be constantly improved, reduced weight and efficiency increased.A proper measurement comparison method allows responding with minimal delay to their changing requirements. A lot of analysis has done between races in terms of error tracking, alarms, performance statistics, lifetime of the components, and fuel consumption prediction under different conditions.It is possible to build a predictive model from these types of analyses; this is important to save time when deciding how to put the car together as a function of the particular race track and based on changing ambient conditions engine, maps, tires, etc.Fl cars are high-tech marvels, they are equipped with lightweight engines, connected to experimental transmissions, placed in a body designed for its aerodynamic properties and connected to electronic and electromechanical systems.

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