Introduction: Sports and Technology

There may be no other sport today that melds technology with competition more than motorsports. Whether it is Formula 1, NASCAR, drag, Indy, Kart, or Rally competitions, the hundreds of pounds of precision and intricate equipment is as important as the talents of the teams working and improving the guts of the car. The slightest tweak can shave milliseconds off a car's lap time. That may not seem like much to the everyday commuter, but for race vehicles, that variance can spell the difference between first and second place.

New technology and design modifications are created to give drivers performance advantages. However, without accurate data collection, quantifying the effectiveness of a new part or a changed design is difficult. Fortunately, technology exists to accurately document the movement of every instrument and component in the vehicle. From brake and gas pedal displacement to air foil deflection, valuable data can be gathered to fine-tune both the driver's performance and the vehicle's capabilities. For many motorsports teams, the use of Firstmark Controls position transducers are an integral part of this data collecting process. The strategic use of position transducers gives racing teams the data to perform a complete analysis.

Application: Position Transducers

Position transducers provide valuable data on race vehicle component use. This information is sent to a data collection system for analysis by the driver's team. Depending on the team's budget, data can be transmitted wirelessly in real time to team computers for immediate analysis. An alternative for teams on tighter budgets is to log data to flash RAM or similar. Data is downloaded from the interim memory device to a reader after a race/practice or during a pit stop for analysis by race engineers and technicians.

While each component is unique, position transducer cables are generally connected with a loop sleeve and secured with a screw. In most cases, the position transducer cable only needs to travel in one direction from the zero position, such as pedal movement. Final calibration is usually made by the data system. Data aqcquisition experts select specific position transducers to ensure the draw wire tension does not influence the user's action. For example, Firstmark Controls's Series 170 transducers have low tension that does not interfere when a driver depresses a brake or gas pedal.

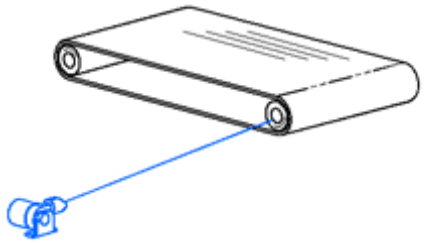

Figure 2 - A position transducer's displacement cable moves with components to collect position data over time

ILLUSTRATION NOTE: Animated gifs (drawings, not real photos) similar to the ones on the original link showing how position transducer cables connect and move with parts. Suggest showing suspension and pedal.

An area where position transducer mounting requires a little variation is on the steering wheel. Steering wheel data can use position transducers instead of the traditional rotary potentiometer attached to the steering gear box. For this situation, a draw wire position transducer can be drum mounted to the steering column with 50% of the travel distance extended.

The following sections detail how race teams use position transducers with specific components.

Steering Wheel

In a race, the steering wheel holds the key to both victory and safety. Smart use of the steering wheel, in conjunction with braking and accelerating, can maneuver a race vehicle past opponents and around obstacles without losing time on the course. When a mistake is made or when bad habits creep in, it's up to the driver and his or her technical staff to analyze how the steering wheel was used when a problem arose.

Motorsports teams use position transducers to accurately collect data about the rotational position of the steering wheel. The value of this is reflected both in practice to monitor habits and during the race to examine responses during critical junctures. Position transducer data also acts as a constant monitor of vehicle upkeep. If the wheel does not feel as responsive to the driver, exact data about steering wheel movement determines if there is a problem in the steering column or if parts need to be lubricated.

In addition to tracking data regarding steering wheel position, position transducers can be used to determine the best steering column angle for each driver's preference.

Brake/Gas (Fuel) Pedals (Driver Foot Controls)

Starting and stopping are the basics of any race. When it comes to motorsports, the driver's control of the brake and gas pedal dictates starting and stopping and also assists in avoiding hazards and safely passing opponents. The effectiveness of fuel injectors and other additives, as well as the conditions of brake pads and braking mechanisms, all contribute to the driver's success and safety. Careful analysis of brake and gas pedal usage can give quite a peek into the car's overall technical health - and the driver's performance.

Motorsports technicians use the flexibility of cable-based position transducers to monitor pedal positions. On a mechanical level, transducer data can tell teams how a car responds when specific pedal displacements occur. If there is an indication that more or less displacement is required than normal, it immediately throws up a cautionary flag for teams to analyze the vehicle's health. From the perspective of the driver, transducer data can offer insight into the exact actions that took place when something went wrong - or right - in a race. Was the driver giving too much gas? Were the brakes hit harder than they should have been? Was a new technique used to maneuver a turn that proved to be highly effective? By keeping moment-to-moment data of gas/brake pedal usage, all of the aforementioned questions can be answered by a driver's technical team.

Suspension

The suspension is important to the safety of any driver and more so race vehicle drivers. The reaction of a suspension to high-speed turns, wall collisions, off-road bumps and hills, and the acceleration/braking process can mean the difference between victory and defeat - or in some cases, life and death. Analysis of suspension reaction during practice and testing gives mechanical teams the ability to overhaul problems, test performance of new tweaks, and maximize the risk/reward of a suspension system.

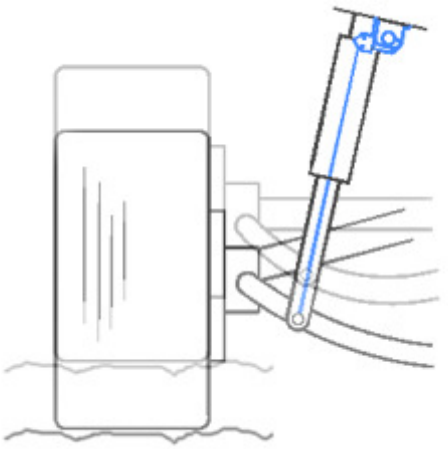

Figure 3 - Position transducers collect suspension data to evaluate driver and vehicle performance during different circumstances

ILLUSTRATION NOTE: Close up of suspension system with position transducer in action.

Position transducers attach to the suspension's springs and dampers to collect response data during movement. This data can be applied to a variety of different scenarios, but the general purpose remains the same: how is the suspension holding up under the most extreme of circumstances? Transducer data can give teams a quick indicator if a certain spring or damper is not performing well, or if a different amount of suspension system may fit in better with a driver's style.

Unique Motorsports Benefits of Firstmark Controls Position Transducers

Position transducers are used for many different things - aerospace, traditional car needs, industrial mechanical systems - but few situations will duplicate the severe conditions of motorsports. Besides the intense thermal conditions produced beneath a car's hood, race cars undergo severe vibrations, high-impact collisions, harsh turns, and other circumstances that could upset a delicate sensor. Firstmark Controls position transducers come with design benefits that thrive in these extreme conditions - just ask NASCAR what they think about it.

For obvious reasons, driver safety is of the highest concern to any racing team. When it comes to safety, position transducers have an advantage over other types of sensors simply from the draw-wire mechanism. Sensors such as rod-based transducers have many more parts that could be prone to shattering during an impact. If a sensor shatters, the debris could find its way into key systems, damaging the vehicle internally and potentially putting the driver at risk. Firstmark Controls position transducers are not only durable, they are compact with a design that houses the sensor, the cable retraction mechanism, and the displacement cable.

Position transducer parts are extremely flexible and can even survive a high-speed crash, as seen in Figure 6. In the event of on-the-fly maintenance, the position transducer's lightweight and compact nature, along with the ease of use of the draw-wire mechanism, allows it to be easily replaced or repaired without fear of interference or damage to other components.

Figure 6 - Even after a high-speed collision during a NASCAR practice lap, Firstmark Controls position transducers are still intact.

ILLUSTRATION NOTE: Close up of the NASCAR crash position transducer.

Position transducers come with another design benefit: a cable failsafe mechanism. Each Firstmark Controls position transducer cable is connected to a component designed to break away during a crash or cable failure. This failsafe either cuts the wire completely or causes a cable snap back. For position transducers usually used in motorsports, such as the Series 17X units, the relatively low tension on the cable ensures that the transducer itself is not destroyed and salvageable for further use with some minor part replacement.

There is a significant size and a slight weight advantage for position transducers in relation to other types of sensors, but the true beauty in their use lies in the flexibility and durability. Because of the cable-based draw-wire system, position transducers can provide measuring data in an accommodating manner. With the thinness of the high-strength cable, the cable can run across a variety of surfaces without any problems. Firstmark Controls cables are made of stranded stainless steel to withstand extreme vibration and environments. In addition, Firstmark Controls position transducers have high temperature thresholds (as high as +125° C (+257° F)) - perfect for the extreme thermal conditions produced by engines and other car parts.

Because of the displacement cable tension produced by the cable retraction mechanism, position transducer cables are taut to avoid cable sag, thus providing consistent data for the racing team even when the cable is run through awkward positions beneath the engine hood. Other design factors contributing to the accuracy of Firstmark Controls position transducers include displacement cable pre-stretching to effectively eliminate cable stretch error, a threaded drum to ensure repeatability, and a direct cable connection to the drum to avoid problems stemming from vibration, shock, and backlash. These features ensure a high repeatability that is critical when pit crews analyze data live during a race or test run. Without high repeatability, crews could over-tweak a part or mistakenly replace the wrong component, shaving precious seconds off a driver's time.

Firstmark Controls Position Transducers Versus Other Sensors

In the world of data collection for motorsports components, teams will often employ position transducers in favor of LVDTs, rotary sensors, and rod/cylinder potentiometers. Two of the biggest reasons for this are the overall durability of a position transducer (both thermally and mechanically) and the flexibility of the draw wire design. For components located under the hood, these traits are key to keeping the sensors undamaged and active.

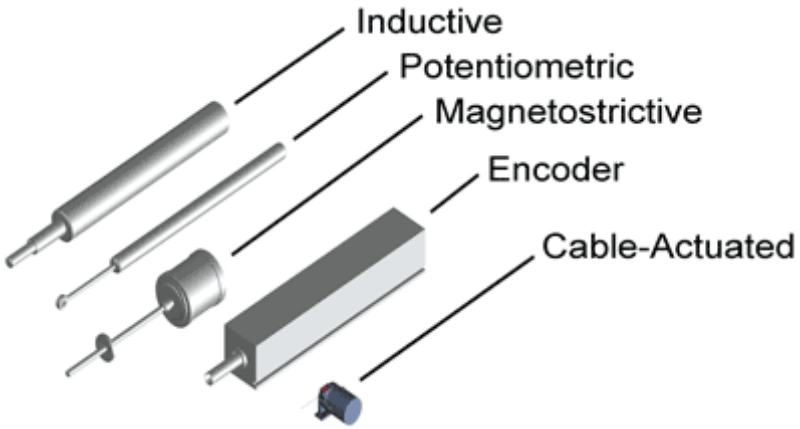

Figure 7 - Position transducers are considerably smaller and lighter than other measuring devices

ILLUSTRATION NOTE: Show side by side comparison of different measuring devices. Make sure to label each one. Purpose of picture is to show the size/weight advantage of position transducers.

Firstmark Controls Position Transducers Versus LVDTs

LVDTs require electronic connection through either direct integration or a signal conditioner box. This additional electronic integration increases the amount of at-risk components for data collection, causing LVDTs to be environmentally sensitive. Considering the extreme conditions under the hood of a car during a race, as well as the unpredictable nature of bumps, collisions, sharp turns, and sudden acceleration/braking, electrical components can be easily affected during a race. LVDT data can thus prove to be unreliable while the vehicle is in motion. In addition, the complex electronics involved with LVDTs tend to cause them to be more expensive than standard position transducers.

Firstmark Controls Position Transducers Versus Other Rod/Cylinder-Based Transducers

Because of their elongated body, rod/cylinder-based transducers such as LVDTs and linear potentiometers are subject to bending and/or breaking depending on the environmental circumstances. For example, the stiff and brittle nature of rod/cylinder-based transducers used for suspensions or near the axles could deform to the point of uselessness or shatter when a car crashes or experiences any other type of severe impact that produces harsh vibration. Rod/cyliner-based transducers require precise alignment - a difficult situation considering the intricate designs of many car components, as well as the limited space available. Vibrations are also a concern when using a rod-based transducer, as severe vibrations can knock the rod-based transducer out of alignment and cause improper data. In a worst-case scenario, the shattering, bending, or misalignment of a rod-based transducer's elongated body could interfere with a variety of systems to create a potential safety threat to the driver and the vehicle.

Firstmark Controls Position Transducers Versus Rotary Sensors

Rotary sensors are typically used for gathering steering wheel information. Position transducers can be mounted onto the steering column for the same application; while standard rotary sensors have some similar attributes, such as infinite resolution and operating temperature, there are several features favoring position transducers. Standard rotary sensors can have an error of less than 1° of rotation, but the accuracy is still based on overall rotation. For example, a rotation of 220° produces an error of 0.2% while a rotation of 100° produces an error of 1%. Position transducer error is a set value (generally 0.5%) that does not fluctuate based on distance traveled.

However, the greatest advantage for position transducers comes where it counts the most: safety. Rotary sensors have a rigid connection from the axle to the measuring point. When this system is the steering column, parts from the rotary sensor could cause interference with the steering mechanism in the event of a collision. With

both a cable failsafe function and external mounting on the steering column, the chances for debris interference upon a catastrophic situation are far less.

Additional Resources

- Calculators
- String Potentiometer and String Encoder Engineering Guide
- Sensor Total Cost of Ownership
- Application Note for Ground Vehicles/Transportation
- Application Note for Aircraft/Aerospace
- Application Note for Draw Wire Transducer Accuracy
- Position Transducer Data Sheets
- Position Measurement & Control Archives