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ELECTRONIC INDUSTRY NEWS

DESIGNLINES

E-Wasted on the Way
By Rebecca Day

I wish I had a dollar for every pound of audio and video, computer, smartphone, tablet, peripheral and digital camera e-waste I've discarded over the years. Oh, and all those cables, power adaptors and earphones I've scrapped, too. I do it as responsibly as possible — trading in or giving away gear that still works and finding a recycling event for the rest. I don't even want to think about how much I spent for all the obsolete gear that was once shiny and new.

Multiply my contribution times millions of people per year. The Environmental Protection Agency website says that in 2014, over 720 million new electronic products were sold and 3.36 million tons of used electronics were ready for end-of-life management in the U.S.

A 2019 World Economic Forum report said e-waste is the fastest-growing waste stream in the world, reaching 50 million tons the year before. Globally, society only deals with 20% of e-waste appropriately, "and there is little data on what happens to the rest, which for the most part ends up in landfill, or is disposed of by informal workers in poor conditions."

A 7-year-old chart from the Electronics TakeBack Coalition seemed to show a positive recycling trend at the time: 40% of the 3.1 million tons of e-waste generated in in the U.S. in 2013 was recycled, it said. The bad news was it was "unclear whether the large increase in the electronics recycling rate from 2012 to 2013 is due to an actual increase in recycling or the result of improved and expanded data."

It's also unclear what falls into the category "e-waste" in studies, but my trail of expired electronics over the years spans generations of chips and circuit boards. Besides smartphones I've traded in to wireless carriers, I've discarded obsolete cassette, CD, laserdisc and DVD players; stereo and AV receivers, loudspeakers, headphones; CRT and plasma TVs; desktops, laptops, monitors, printers, scanners, keyboards and surge-protecting power strips; fax machines and phones; e-readers, a DirecTV receiver and a WebTV — and then all the cables and remote controls required to make them work. That's a jot of e-junk.

Electronics recycling laws are a state-by-state thing. Twenty-five states and Washington, D.C. have passed laws related to electronics recycling, says recycler ERI, whose website links consumers to their states' e-disposal programs. My state, New York, uses the Producer Responsibility approach: Manufacturers pay for recycling costs, as it should be.

New York State pointed me to Staples and Best Buy as e-cyclers in my area, and a map showed plenty of locations where we could dump our electronics responsibly. When I clicked through, I found e-cycling is another way of life put on hold due to Covid-19. The recycling program has been "temporarily suspended" at Staples "to keep our customers and associates safe." Best Buy's appears to be up and running, according to a recorded message at my local store. I wasn't able to get a live person to confirm that.

Among manufacturers, Apple and Samsung have taken leadership roles in e-cycling. Apple has committed to someday sourcing 100% recycled and renewable materials across all of its products and packaging. The company accepts unwanted Apple products in stores for recycling. Next time I want to upgrade an iPad — and it's too old for a trade-in — I can take the tablet and chargers to an Apple store and let them handle the dirty work.

Samsung's website directed me to Call2recycle, where I learned that all those dead alkaline batteries I've been saving can't be recycled like rechargeable batteries, whose recycling is funded by device manufacturers. There's currently no national stewardship solution to allow for free recycling of single-use batteries, "except in Vermont," it says. Other states may charge a small fee for it, says the recycling company.

Rumor has it Apple will ship the next generation of iPhones without adapters or those starter earphones that everyone tosses to upgrade to better ones. If it's true, that's a money-saver for Apple, but I also see it as a good thing for the environment – *if* I can use my existing lightning cables and chargers. Otherwise, I'll have to trash my existing chargers and cables and buy new ones on top of the pricey upgrade phone.

Apple has a tendency to force transitions to new technologies, leaving more collateral e-waste damage. I still lament the demise of the iPod and I had a few cute iPod mini music players along the way, which wound up at recycling events. I hate when I don't upgrade fast enough to have any value left for a trade-in; that happened a couple of times with iPads.

I'm still smarting from when I bought an integrated amplifier with a 30-pin dock built into the top that allowed me to pop in my iPod, or a pre-2012 iPhone, as a direct source. The iPod is long gone, but the dock is still there, mocking me. I cringe when I see one of those old

30-pinner docks atop a hotel room's clock radio. The industry was so young and innocent then, thinking the 30-pin connector would carry us from generation to generation.

My mind is on electronics cycling because I'm contemplating another audio migration, forced by a transitioning manufacturer. Then it'll be out with the old, in with the new, as another generation of feeds and speeds enters the picture. That brings a whole other set of thoughts and aggravation for another day. Meanwhile, time to hunt down a place to recycle.

The Importance of Electronics in Formula 1

Maurizio Di Paolo Emilio

What provides the better edge in Formula 1 — a driver's skills or finely-tuned machine? This debate broke out in the 1980s with the growth of electronic systems on Formula 1 cars. Engineers toil ceaselessly to optimize race-cars, tweaking the configuration of the over 18,000 components including sensors, ECUs, and mechanical parts.

Lando Norris, McLaren MCL35

Formula 1 engineering crews span scientific fields, from mechanics and electronics to data analysis and aerodynamics. The competition between race teams translates into a technological tour de force to improve their understanding of the dynamic behavior of the cars, down to the microsecond.

The strict regulations of the FIA (Federation Internationale de l'Automobilie) have severely limited the technology, in order to ensure that the driver's ability still remains an important element. Many solutions found in commercial cars such as ABS and automatic gearboxes are banned in the Formula 1 environment.

Racing cars have radically changed in recent years. Thanks to telemetry, race engineers can monitor and improve the performance of the car by analyzing data from over 300 sensors from different devices located at various points in an F1 car. Hundreds of parameters can be measured in real-time. All data are collected by a logger and sent to the teams via radio, using the antenna in the front of the car.

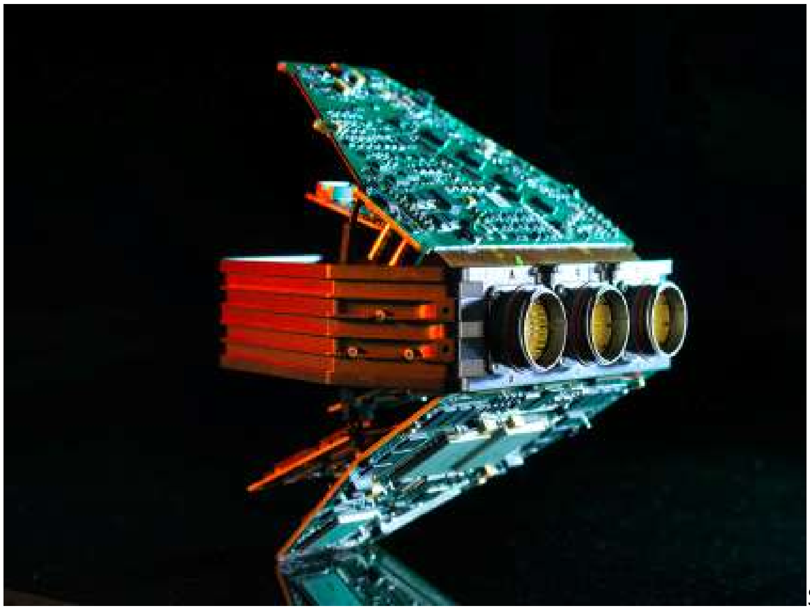
Speaking to EE Times, Stephen Watt, head of electronics at McLaren Racing, said “The car on track is only the tip of the iceberg; teams are now heavily data-driven, feeding on data received over the paddock-wide 5 Mbps telemetry link as well as offloaded from various onboard loggers to allow the engineers at the trackside and back at the factory to analyze the performance of the car in isolation as well as perform strategic analysis by studying the performance of other teams.”The modern Formula 1 car is an intelligent, connected data system that can travel at over 200 km per hour. A lot of data are sent from the cars to the teams every second, transmitting various types of information about everything from tire wear to engine temperature.

ECUs and sensors

Each car is studded with multiple ECUs. At the center of the system is the standard ECU or SECU. The SECU is essentially a small but very powerful computer that controls, processes, and transmits large amounts of data from F1 cars to teams. The SECU consists of optimizing the exchanges with the engine, gearbox, and differential, but also with the aerodynamic system. The SECU is also the main data storage and acquisition service that provides real-time values via telemetry to teams and race control. This allows teams to visualize the performance of their cars in real-time, checking engine health, tire degradation, and fuel consumption.

The SECU is provided by the McLaren Applied (sister company of McLaren Racing) TAG-320B and being mandated in the regulation it must be run by all Formula 1 teams. The TAG-320B provides a shared platform used by the team, the power unit provider and the FIA. The TAG-320B hosts functions ranging from the core operation of the power unit to the often taken for granted seamless shifting of the 8-speed gearbox as well as allowing the FIA to restrict the functionality of the control software to ensure that driver aids such as traction control cannot be implemented — or at least their effect can be detected if teams were to use them.

The car has around 300 sensors and the SECU monitors over 4,000 parameters. During the course of a typical race the car will transmit around 3 GB of telemetry data as well as around 4 GB of logging, however this is just the seed for computation. When processed and combined with other sources such as audio and video analysis it can mean a team leaves a typical race weekend with over a terabyte of valuable data — data that is drawn on again and again before and during future events and seasons.


Standard ECU

The sensors placed on the single-seater are used to monitor for potential problems; engineers can make immediate decisions based on the data collected. For example, if an increase in engine temperatures is detected, it may be because the driver is too close the car ahead; the driver's team can alert him to get out of the hot trail of exhaust until the temperatures drop below sensitive values.

There are 3 categories of sensors: control sensors associated with drive-by-wire functions such as accelerator pedal sensor; monitoring sensors to monitor the health of the car such as hydraulic system pressure; and then instrumentation sensors such as non-contact temperature sensors to monitor friction material.

"A Formula 1 car has many lives; during qualifying and the race, it becomes a lightweight racing car with only the minimum of equipment fitted to it that we need to complete the race but even in this configuration the car will have over 1.5Km of wiring onboard and over 200 sensors. At the opposite extreme is winter testing when we're proving out the car and it almost becomes a test lab on wheels.

The demand for high-quality data shapes a lot of what we do. The changes in both the technical and sporting regulations over the years and the reduction of track testing has put an increased emphasis on having a deep understanding of the car every time it is running on track.

"The recent changes in the Formula 1 regulations following the COVID-19 pandemic aimed at reducing spending by freezing certain areas of car developments are again reshaping that challenge and making us look harder than ever at cost and supply chain aspects as well as maximizing the benefits from the areas of freedom we still have," said Watt.

Since 2014, the FIA has started to require the use of fluid flow meters (FFMs). FFMs also use ultrasound to measure fluid flow, which ensures a very accurate reading and instantaneous analysis of the fuel performance of the vehicle. Ultrasonic fluid flow measurement requires the use of two piezoelectric transducers. These transducers send ultrasonic pulses back and forth to each other and use flight time calculations to determine the fluid flow rate.

Telemetry
Telemetry was introduced in the late 1980s and has developed considerably over the years. A much greater wealth of data is now being collected and transmitted withing just a few hundredths of a second, allowing race technicians give drivers tactical advice in near real-time.

The areas involved using a Telemetry and Data Analysis system are different. Engine, engine brake, torque control, engine injection, and ignition are parameters that can be managed thanks to this technology. Other components, closely related to the use of Telemetry and Data Analysis systems, are the chassis, tires, accelerator operation, vehicle speed, and aerodynamics regulation through the penetration coefficient of the mechanical vehicle.

Talking with Stephen Watt about telemetry in Formula 1 he offered the following: “Telemetry can sometimes be a misused term in Formula 1 but it is usually used to refer to the wireless transmission of on car data generated in the SECU and sent to the team trackside in the pits. The telemetry systems used in Formula 1 have been subject to some very pragmatic changes in recent years.

“It used to be the case that each team took its own independent radio telemetry system to the tracksidem,” he continued, “and the pits ended up looking like a forest of pump up masts of ever-increasing heights. Of course, the radio spectrum became increasingly congested and when you think that this has to be taken around the world and subject to regional radio spectrum regulations it was starting to become a nightmare,” Watt said.

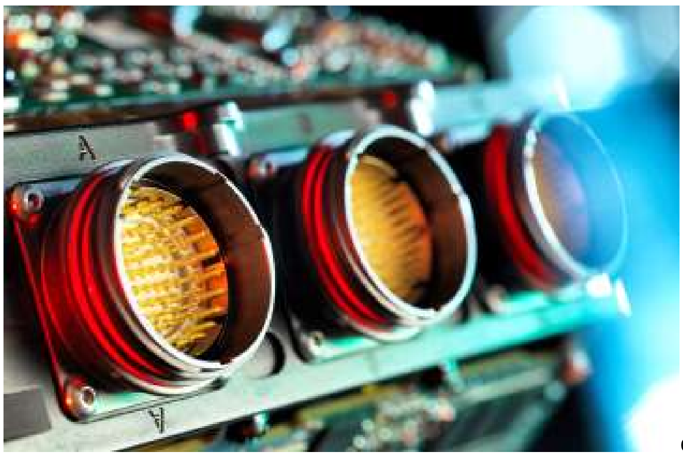
“On top of this these systems often couldn’t support full coverage at certain tracks such as Monaco and Singapore so some teams started to deploy repeaters on the roofs of hotels and alike. Fortunately, the FOM and FIA stepped in and introduced the Standard Communication System that provides both driver voice radio and telemetry link for all teams. The FOM now places a shared system of access points around the track and delivers the encrypted data from each car to the team’s garage via a fiber link,” he said.

He added, “…these days the telemetry link is a critical part of the operation of all Formula 1 teams. Due to a combination of the complexity of the cars and the power units and the sporting regulations meaning that teams have to keep engines and gearboxes for multiple races, teams will almost certainly not run a car on track without the visibility of the car’s health that the combination of sensors, ECU and telemetry link gives and the resultant possibility for the trackside engineers to intervene before a fault leads to catastrophic damage of valuable power train components. If not prevent, such an incident could result in a loss of valuable track running or even future penalties for the team.”

The sensors help to monitor, control, and optimize both the car and the driver by collecting data on braking, cornering speed, gearbox, wheel rotation, gearbox life, and the range of speeds in which the engine runs most efficiently. The acquired data are used for real-time analysis of engine performance so that team engineers can act accordingly, to solve problems remotely and thus improve the efficiency of the car.

One of the biggest obstacles to success is the harsh environment that racing offers in terms of excessive temperatures and vibrations that destroy the accuracy of the sensors and, ultimately, the device itself. The electronic components must operate at maximum efficiency, designed with a low design error such as drift reduction. Drift is the tendency of a sensor to lose accuracy over time, resulting in permanent component damage and irreversible engine failure. With a hundred or so sensors in a typical racing car, the total burden of data acquisition accuracy can be enormous.

The racing environment also introduces dust, oil, and moisture. The solution to this challenge leads to high demand for materials and, therefore, to a science that can produce components with highly reliable materials under difficult conditions. Conventional vibration protection is focused on mounting hardware. Reliability is compromised over time if electronic components are not protected against vibration or are not inherently designed with critical material fatigue resistance.


connectors

Data acquisition system

The measurements recorded by a data acquisition system are actually taken by sensors installed throughout the machine. For example, the speed of the vehicle can be measured by a Hall effect magnetic sensor installed on the wheel, a Correvit optical sensor, a Pitot tube (a typical Formula One car uses the three sensors at the same time).

“Air speed sensors in the form of a Pitot tube are also used by Formula 1 cars but of course the wind has to be factored in. So even asking how fast an F1 car is going can be a difficult question to answer accurately and usually involves statistical analysis of multiple sources of data combined with models and post-processing, said Watt.

The rotation speed of each wheel is measured with a standard model to account for slippage. Other sensors are optical sensors that watch the track and GPS.

Specific sensors can measure temperatures, angular and linear velocity, angular and linear displacements, pressures, material stresses, accelerations, magnetic field variations, and so on. Accelerometers are used to measure lateral G-force, also called “cornering,” or can be used to detect longitudinal forces such as braking in a range from 0 to 4G.

The position of the sensor determines which direction is detected. A dual-axis sensor measures both steering and braking forces. Non-contact temperature detection is often directed at the braking, motor, and tire devices. Infrared MEMS sensors are used for temperature measurement, allowing non-contact temperature testing. Usually, these sensors use a thermopile material to absorb the infrared energy emitted by the object being measured, and the change in voltage determines the temperature of the object. A series of thermal cameras aimed at the contact areas of the tires allows wearing monitoring and heating control.

Some parameters, such as transmission torque and load cells, are recorded at frequencies of the order of 200Hz, i.e. 200 times per second. If there is a strong vibration, it is possible to put an extra log on the machine and change the rate to get a vibration analysis on various parts of the machine. As a precaution, F1 engineers collect the data every time the car returns to the box by uploading it to a dedicated server. “When it comes to analyzing suspension movement sampling rates of 1KHz are common and these can rise to 100KHz or higher when performing vibration analysis that is often part of reliability validation work,” said Watt.

Telemetry and correct data acquisition are important factors in F1 because they allow engineers to collect a huge amount of data during a race. The data can then be interpreted and used to ensure that the car is running at its best. An F1 car can use two types of telemetry: real-time information, which is sent in small packets, a microwave burst, which is sent as the car enters the pits.

Maurizio Di Paolo Emilio

Maurizio holds a Ph.D. in Physics and is a telecommunication engineer and journalist. He has worked on various international projects in the field of gravitational wave research. He collaborates with research institutions to design data acquisition and control systems for space applications. He is the author of several books published by Springer, as well as numerous scientific and technical publications on electronics design.