Improved Harness Technology

The break-through new process for making FPCs of unlimited length, explained by **Philip Johnston**

Flexible Printed Circuits (FPCs) have come a long way since they were first envisioned in the early 1900s. However, up until relatively recently, FPC applications have been limited by their comparatively short length, with only a few companies having the capability to manufacture them longer than a couple of metres. All that looks set to change, with the advent of a new FPC manufacturing process called Improved Harness Technology (IHT). Patented by UK-based electronic parts company Trackwise, it has transformed the dynamics of the FPC manufacturing process, paving the way for the production of multilayer FPCs of limitless length.

Prevalent across many sectors, UAV projects is one area expected to benefit from a whole range of new applications opened up by this ground-breaking manufacturing process.

Flexible PCs represent a multi-billion-dollar global market, but were first conceived of by German inventor and scientist Albert Hanson in the early 20th-century and described in his patents as multiple layers of foil conductors laminated onto an insulating board. In the same way as their rigid counterparts, FPCs are fabricated by means of a subtractive process, chemically etching copper away from its substrate in order to expose the conductive circuit elements underneath. Manufactured from a variety of materials, the most common substrates are polyesters and polyimides, with further advanced polymers emerging such as thermoplastic variations which have the added benefit of being able to function at exceptionally high temperatures.

Flex PCs can be manufactured in numerous configurations, including single or double-sided variations, with multi-layered FPCs available for higher density interconnects. Multilayer FPCs are made by bonding a number of single or double-sided flexible circuits together, then plating through to form a compound interconnected design.

FPCs can be categorised further along their application type: static or dynamic. Within a static application, its flexibility is only required at installation, for example, to fit inside an aerodynamic or confined space. On the other hand, a dynamic application requires that an FPC be flexed numerous times during the course of its life; think of a car door hinge.

For the system designer, FPCs present multiple advantages, especially when it comes to weight and space savings, together with lower manufacturing costs and better circuit performance. What's more, after additional processing, FPCs have the capability to function as a final circuit assembly and their 3D features mean they can be folded and shaped into specific form factors.

Left: Circuit inspection – checking for electrical isolation between tracks (Source: Trackwise)

FPCs are prevalent across the automotive, aerospace and military sectors, but given their numerous advantages, it's no surprise that flexible PCs can be located in a wide range of electrical and electronic applications such as laptops, smartphones, games consoles and cameras together with wearable devices for sports and medical applications from IT, automotive and industrial gear, to consumer, entertainment and medical products.

IHT manufacturing process

Although a few manufacturers have been able to offer circuits of a few metres long, the majority of conventional FPC manufacturers have limited the length of their circuits to 610mm. However, the new IHT manufacturing process side-steps these limitations by employing specially adapted machinery and custom software – dynamic and intensive roll-to-roll processes in place of established static ones – resulting in the cost-effective manufacture of multilayer FPCs of any length. Additionally, the IHT processes use materials in roll form, as opposed to the fixed size sheets which most materials are supplied in.

Careful analysis and planning is required before embarking on any FPC implementation project. When specifying requirements, the customer must liaise closely with the manufacturer to ensure that an FPC is actually suitable for the application. Also, in order to ensure that the end product performs as intended, a detailed design process should be followed, covering the end product requirements, the intended operating environment, package configuration, mechanical and electrical characteristics and assembly method. The output from this process will provide the specification required by the FPC manufacturer in order to validate the design and provide relevant quotations.

Above: PCB chemical process lines at Trackwise's Tewkesbury-based manufacturing plant (Source: Trackwise)

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With IHT, Trackwise is primarily targeting the replacement of conventional wire harnesses, where assembled components are limited to connectors. The long FPCs produced by the IHT process are however, essentially PCBs and can be populated with components, using either PTH or SMT techniques so as to produce a 'smart' harness.

Among the first sectors to benefit from these IHT production techniques are the telecommunications, automotive and aerospace industries, revealing applications that previously relied upon bulky and heavy wire harnesses, now being transformed by FPCs. As an example, in the aerospace sector, large, complex and heavy wire harnesses are being supplanted with new, extended-length FPCs, making it possible for the space and weight restrictions of an increasing number of on-board and in-cabin systems to be met.

FPCs and UAVs

One area that looks set to benefit markedly from the design and manufacture of FPCs of unlimited length are UAV projects. Through their proven weight savings of up to 75% over conventional wire harnesses, flexible PCs demonstrate clear advantages for payload and energy efficiency considerations. In addition, the ability of FPCs to operate as a subsystem allows for the integration of distributed electronics like sensing and signal conditioning functionality, essentially producing a smart interconnect, facilitating a high sensor and/or instrument density inside the UAV.

Where smaller vehicles are concerned, sensor density is supported further with the 3D features of FPCs, allowing inventive layouts to be integrated into small spaces. Demonstrating how larger UAVs can benefit from the capabilities of FPCs, Trackwise recently supplied a 26m-long shielded FPC to a UAV manufacturer for a project to transfer the power and signals across the wingspan of the client's vehicle.

Created on a polyimide substrate, the planar structure of the FPC dissipates heat more effectively than conventional wiring, allowing for a higher current carrying capacity for a given weight of copper conductor.

The capacity to manufacture FPCs of unlimited length has the potential to deliver a whole new generation of applications, most notably in the automotive and aerospace sectors where environmental protection and sustainability are significant considerations. Longer length FPCs are already being supplied to a number of UAV projects, engendering substantial weight savings and cost benefits. With their characteristic features, FPCs are well-matched to meet the electromagnetic and environmental conditions faced by UAVs and, as such, this break-through IHT manufacturing process holds great promise in delivering exciting projects in the future.

Benefit	Description
Space saving	Ultra-thin dielectric substrates, some as thin as 25µm or less, alongside their planarity, make it possible to bond circuits to, or within, the structure of a given product.
Weight saving	Subsequent weight reduction is amplified as less fixings and connectors are required. Similarly, a lower copper content and smaller conductors have a further impact.
Versatility	FPCs are custom-made to bend, fold and fit into almost any shaped housing.
Ruggedness	FPCs exhibit robust connections compared to wire harnesses as their flat foil conductors dissipate heat more efficiently, as well as carrying more current than their round wire counterparts. Fewer interface connections improve reliability; and physically they're more resistant to vibration and shock than rigid PCBs.
Higher operating temperature	Improved thermal stability, in particular with polyimide materials, allows the circuit to tolerate more extremes of heat than rigid PCBs; plus, reduced thermal mismatch.
Crosstalk and noise	More easily controlled using a uniform conductor pattern within the flexible circuit. Ground plane options comprise solid copper, aluminium, lightweight cross-hatched or lightweight shielding films
Effective EMC performance	Lowered radiated emissions due to smaller ground loop, produced by the guard traces; and enhanced differential-mode transmission loss features
Data bus applications	Improved control of impedance features, lowered transmissions loss and reduced radiated field emissions due to shorter current return paths
Simple, reliable installation	Rapid assembly with less component parts; improved repeatability with less manual intervention, without the need to colour-code wiring. Results in lower installation costs, reduced risk of rejects during assembly and less in-service failures