Development of High-speed Long Transmission FPC

- Enables 3m Long; 10 Times Longer than Conventional FPC -

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Digital equipment including image processing equipment is increasingly going high-speed. High-speed is achieved from the transmission properties of the surrounding peripherals, interfaces and other circuits that configure the system.

OKI Electric Cable's high-speed transmission FPCs (flexible printed circuits) have proven applications in various fields and have contributed to speeding up, thinning and lightening the weight of equipment. However, previous products have been less than 0.3m long making them too short for large equipment and interface applications.

"High-speed long transmission FPC" is the industry's first FPC to extend high-speed transmission to a length of 3m. This FPC can contribute to higher speed, thinner profile, lighter weight and higher functionality of large equipment and interfaces. The high-speed long transmission FPC and efforts to improve the quality of next-generation high-speed transmission are described below.

Product Features

The features of the high-speed long transmission FPC are given below, and some examples of those features are shown in **Photo 1** through **Photo 3**.

① **Impedance matching**

It is possible to match impedance whether the line is a differential transmission line or a single-ended line. For example, 98Ω, 85Ω differential and 55Ω, 67Ω single-ended designs are possible to take into account the balance of the system.

② **Structural design according to application**

Wiring patterns, shields and various structural designs can be amended to the basic structure shown in **Figure 1** according to the needs of applications.

③ **EMC countermeasures**

EMC countermeasures can be proposed with various shielding patterns and materials.

④ **Light-weight, thin-profile, and high-density wiring**

FPC has overwhelming advantage over other materials for light-weight, thin-profile, and high-density wiring.

As far as thickness of the products is concerned, 50μm for single-sided and 150μm for double-sided structure is possible.

For wiring, 180μm pitch (minimum) high-density wiring

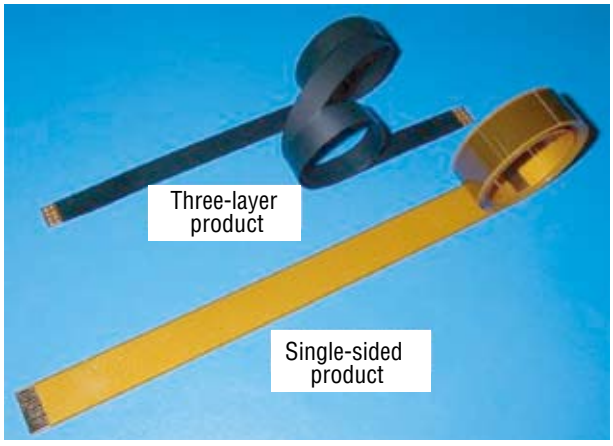


Photo 1. High-speed Long Transmission FPC

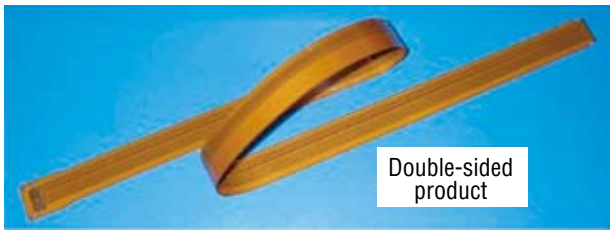


Photo 2. FPC for HDMI 1.3 (Cat.2)

Photo 3. Fine Long FPC

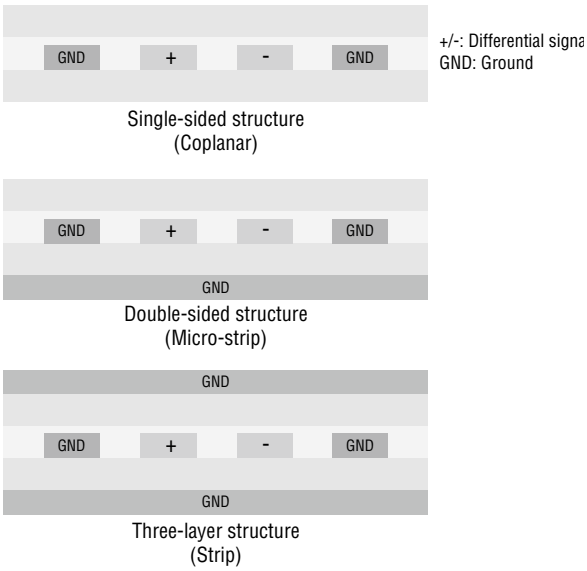


Figure 1. Examples of High-speed Long Transmission FPC Structures

can be achieved.

⑤ **High flexibility (high durability)**

It is not possible for other materials to achieve the level of flexing durability available with the FPC. Phenomenal flex life can be achieved at micro-R movements that are unthinkable with other materials. For example with a 1.5mm bend radius, flex life of more than a million times is possible.

⑥ **Usability in small spaces**

As mentioned in item ④, FPC is a thin film and capable of being bent or folded. For instance, it can be bent at 0.1R. When FPC is bent or folded, a force will work to bend it back to the original state. This force can be minimized for higher flexibility. FPC is well suited for use in small spaces and helps contribute to smaller, thinner, and lighter equipment.

Targeted market

The market currently seeing downsizing and higher functionality alongside higher speeds is the imaging equipment market, and this is where the use of high-speed long transmission FPC is believed to be most beneficial.

Results of the market research conducted by Fuji-Keizai Group in the field of image processing equipment1) are shown in **Table 1**. The research summarizes six markets that surround the industrial (FA) image processing equipment including security and automotive. According to the research, the market is expected to grow to 729.6 billion yen in 2010 (up 29.1% from 2006). The research also speculates an increasing demand for a wide range of applications in various industries with automotive and security fields showing the most considerable growth. Furthermore, the demand for image processing equipment is likely to spread to electronics, food and other industries.

Table 1. Market Forecast for Image Processing Equipment

	2006	2010 estimates	% change
Processing equipment (5 products)	61.5 billion yen	81.5 billion yen	132.50%
Industrial cameras (2 products)	25.3 billion yen	30.4 billion yen	120.20%
Inspection applications (21 products)	180 billion yen	234.1 billion yen	130.10%
Security (10 products)	118.5 billion yen	165.1 billion yen	139.4%
Automotive/ITS (5 products)	21.2 billion yen	39.9 billion yen	188.2%
Medical (5 products)	158.6 billion yen	178.6 billion yen	112.6%
Total	565 billion yen	729.6 billion yen	129.1%

Source: Fuji-Keizai Group https://www.fuji-keizai.co.jp/market/07083.htm

Trends in image processing equipment

Image processing refers to the process of utilizing camera images to perform pattern matching for inspecting and verifying an object or to perform position measurements.

Based on the previously mentioned research report, the trends and issues in the image processing equipment field are presented and the range to which the high-speed long transmission FPC can contribute is indicated.

Adoption of systems that combine processing equipment, industry (FA) cameras and test applications is becoming commonplace in this field. Furthermore, there is a continuing trend to include image processing in the design of a production line. Due to digitization (high-speed) and evolution of software technologies, applications are expected to expand leading to various new imaging equipment being offered and birth of new businesses. Systems in test applications often employ small robots equipped with cameras. The processing speeds of the imaging equipment need to match the operating speeds of the robots.

Monitoring is the main application in the security field, and surveillance cameras lead the market. Recently, there has been progress in systems utilizing biometrics and other image processing. From single-function security systems

to systems integrated with attendance management, these systems back up the adoption of image processing technologies. Digitization of image transmission and miniaturization is also advancing in the security field.

In the automotive/ITS field, backup cameras will remain the primary application, and demand is assumed to rise once car navigation becomes standard equipment. Also expected to increase is car-mounted cameras for image recognition. Application is not limited to driving support and can be expanded to authenticate drivers or detect drivers falling asleep behind the wheel. High reliability and ruggedness will be required from automotive equipment.

In the mist of sluggish X-ray market, the medical field is considering the adoption of versatile FPD-equipped models for use in other areas besides gastroenterological such as urology and orthopedic surgeries. Interest in MRIs, high magnetic field machines mainstream in Europe and the U.S., is growing in Japan and likely to be adopted by large hospitals. Insurance use and expansion in the range of screening will spur the growth of advanced PET/CT. Digitalization of fundus cameras is also progressing, and solid transitions are expected in the areas of physical examination and specific insurance guidance.

A common issue shared by all the fields is finding an innovative way to deliver large volumes of information “more beautifully and more quickly”. Additionally, wiring components must evolve into high-density products to cope with equipments that are getting faster, smaller, thinner, lighter and packed with more functionalities. This technical trend will accelerate even further in the future.

High-speed long transmission FPC is a new wiring component that can contribute to solving issues faced by image processing equipment.

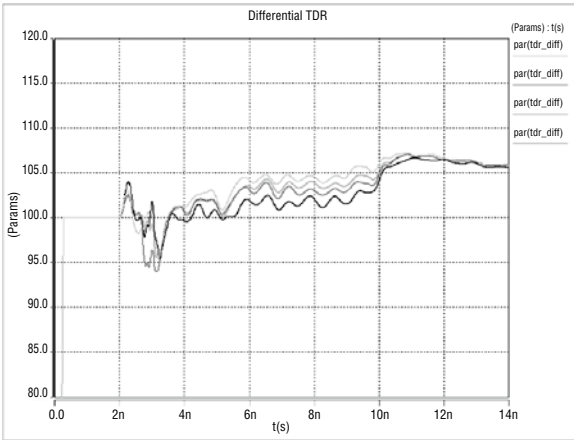


Figure 2. Impedance of High-speed Long Transmission FPC (100Ω Differential)

Transmission properties of high-speed long transmission FPC

The transmission properties of high-speed long transmission FPC are outlined below.

① **Characteristic impedance**

Impedance matching is the basics of high-speed transmission. FPC is a circuit board, and since circuitry is formed using photolithographic photolithic methods, high-resolution high-precision impedance matching is possible. Value of Zo±5% can be secured. The circuit is coated with thermoset resin enabling the FPC to retain a constant structure when it is bend or folded, and there is little change in impedance. Board material is a highly heat-resistant (300ºC≤) polyimide film, so impedance variation is small even in a high heat environment.

Figure 2 is impedance (100Ω differential) measurement data for a HDMI 1.3 Cat.2 standard (3.4Gbit/s) FPC. It can be confirmed that all differential lines are controlled within 100 ± 5%.

② **Insertion loss (IL)**

Figure 3 shows the insertion loss (IL) data for a single and double-sided structure using polyimide material and double-sided structure using higher-grade liquid crystal polymer material.

No problems were observed with any of the structures up to the 3GHz band. The differences between the structures are explained below.

First, comparing the two polyimide-based structures, the single-sided structure exhibited lower loss. This can be attributed to the large cross-sectional area and small conductor loss of the single-sided structure’s wirings. The cross-sectional area of the single-sided structure is 1.4 × 10^{-2}mm² as opposed to 4.8 × 10^{-3}mm² for the double-

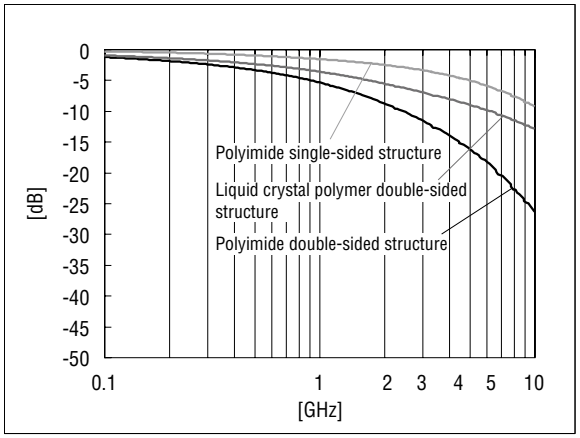


Figure 3. Insertion Loss (IL) of High-speed Long Transmission FPC

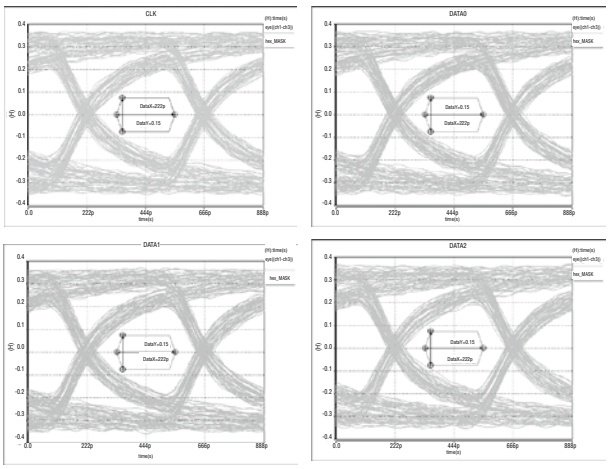


Figure 4. Eye Pattern of High-speed Long Transmission FPC

sided structure. Since the thin double-sided FPC takes the cross-sectional structure shown in **Figure 1**, it is greatly affected by the GND on the backside. Impedance matching cannot be performed unless the width of the wiring is narrowed. However, the single-sided structure does not have a backside GND, and impedance matching is done with the adjacent GND on the same layer enabling a wider wiring design.

Next, when the two double-sided structures, one polyimide and the other liquid crystal polymer, are compared, the liquid crystal polymer provides lower loss. This is because liquid crystal polymer is a low-loss dielectric material, but the material is expensive.

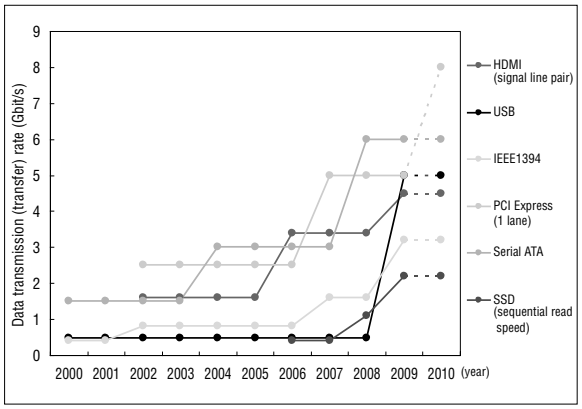
High-speed long transmission FPC material can be selected from a wide variety of products to balance use, properties and cost.

③ **Eye pattern**

Figure 4 shows the eye pattern data of a polyimide double-sided structure. Markings shown in the diagram indicate HDMI standards, and it is considered no good if the measurements make contact with the markings. Measurements taken for the high-speed long transmission FPC show an opening that sufficiently clears the standard opening and proves the performance of the product is good.

High-speed trends

Demand for faster image processing equipment is accelerating. Currently, the interface standards for image processing equipment are in a transitional period to the next generation standards. The trends of the standards are shown in **Figure 5**. The figure shows transition to the higher speeds and acceleration of the transitioning in recent years.



Source: Nikkei Electronics No.998, p.41, 2009

Figure 5. Next Generation Interface Trends

Future development

The high-speed long transmission FPC is capable of 2Gbit/s transmission up to 3m. This long transmission (10 times than before) was achieved due to OKI Electric Cable's expertise in FPC design and manufacturing.

However, high-speed demands and technologies are only headed in the direction of evolution. This is evident from the trend toward higher speeds. Further improvements in transmission quality is required for high-speed long transmission FPC longer than 0.6m to comply with next generation standards.

OKI Electric Cable is advancing technical innovation and product development in response to market needs, and we aim to contribute to the development of future markets.

In closing, an example way of improving performance to meet the next generation standards is given. Component implementation is possible with FPC. If a repeater is implanted into the FPC, the length can be extended to more than 2m while still satisfying the next generation standards. This approach is not possible with any other wiring material, and it shows one of the advantages of the FPC. ◆◆

■ References

1) Fuji-Keizai Group Market Information, https://www.fuji-keizai.co.jp/market/07083.html

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