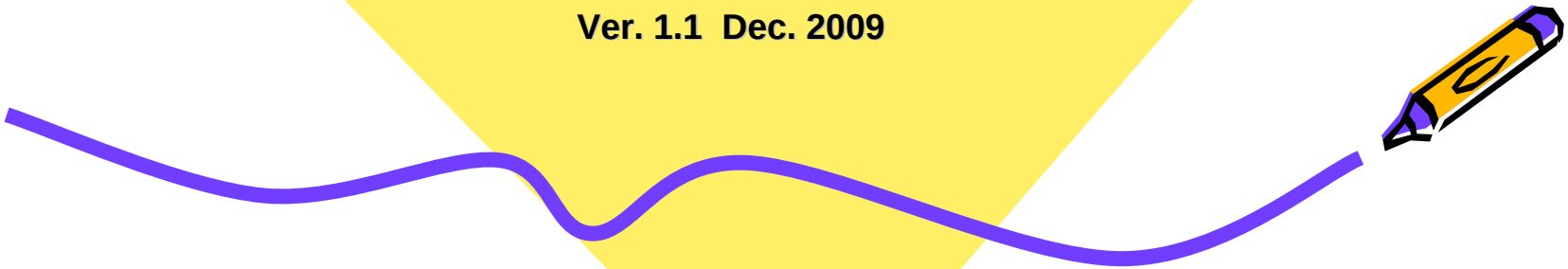
Selection Guideline of SEI's Internal Wiring Materials for High Speed Transmission

through
Mechanical and Electrical Perspective

Ver. 1.1 Dec. 2009



SUMITOMO ELECTRIC
Ingenious Dynamics

Specification Requirements on Internal Wiring Materials

Internal wiring materials can be generally classified for fixed and moving wiring.

Small・Mobile Equipment

Fixed Area

Structure Requirement

- High Density Parts Mounting, Short Distance, Thin Material, Narrow Width Conductor
- Sophisticated Shape Possible

FPC is suitable.

Electrical Common Requirement

- Priority Given to Thinner Material rather than Small Loss due to Short Distance
- Anxiety of Noise Reaching RF Circuit peculiar to Mobile Equipment with Various Wireless Functions.

(Self-poisoning Symptom due to Near Magnetic Field etc.)

Moving Area

Structure Requirement

- High Density Parts Mounting
- Mechanical Reliability on Twisting, Bending, Sliding etc.

FPC or MFCX is suitable.

Fixed Equipment

Structure Requirement

- Lower Cost of Widely Used Wiring Materials due to Long Distance Usage
- Easy Handling due to Enough Setting Space
- Thick Material Acceptable due to Fixed Wiring

FFC , EX-FFC or Coaxial Cable is suitable.

Electrical Common Requirement

- Thicker Material for Low Loss Requirement due to Long Distance Usage
- Anxiety of Becoming Antenna due to Long Distant Wire for Frequency
- Skew (Balance) Taken Seriously at Differential Transmission
- Total Anti-EMI Property including Shield with Cover/Case

Structure Requirement

- Trade-off between Thinner Material and Electrical Property based on Bending/Flexing Requirements

FFC or Coaxial Cable is suitable.

Please refer to individual document.

Other Items

- UL (Non-flammability)
- Environmentally Hazardous Chemicals (RoHS, Halogen Free)
- Water Resistant Property
- Anti-Heat Property
- Anti-Chemical Property
- Anti Whisker Property
- Anti Migration Property

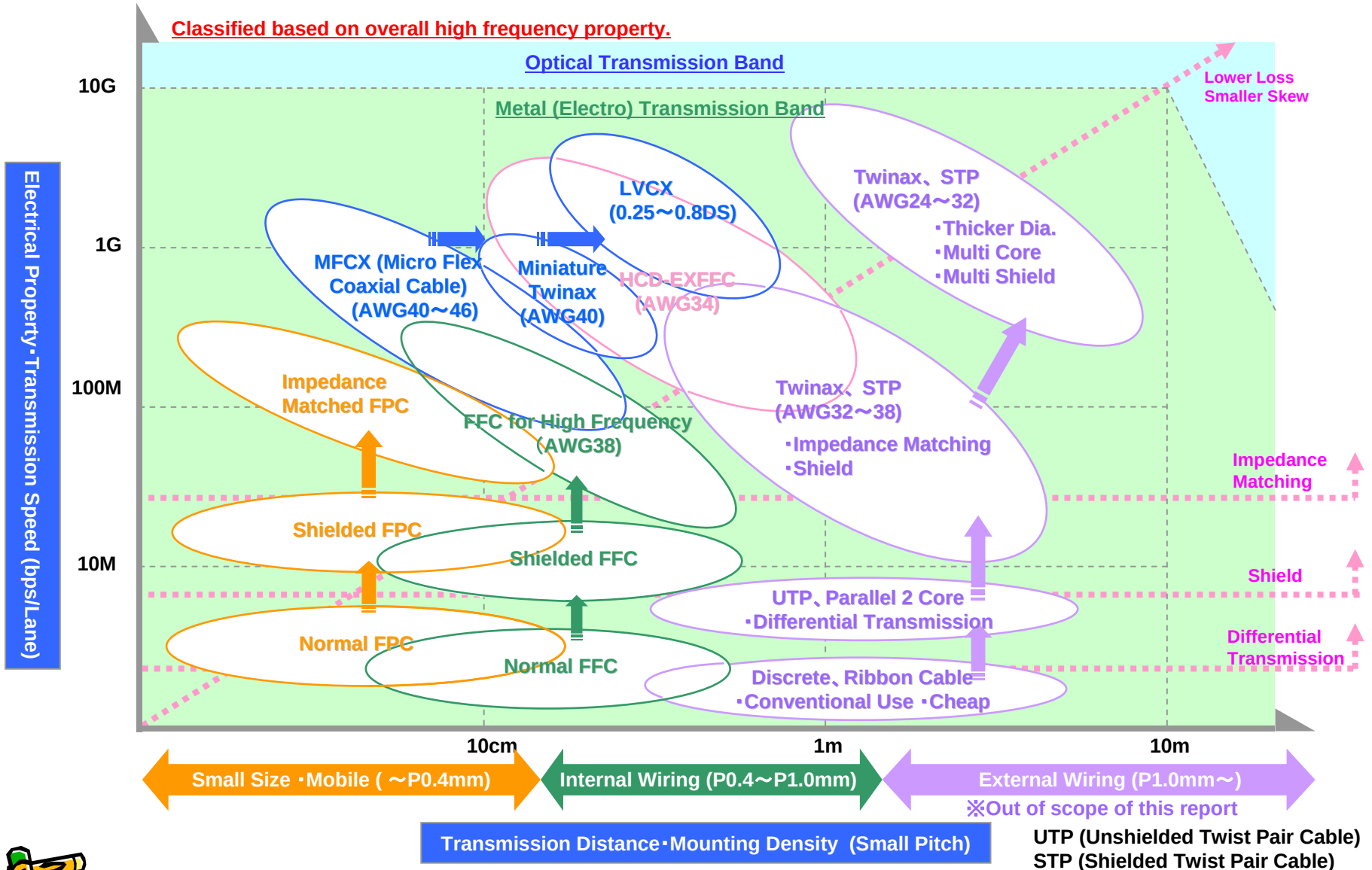
etc.

Other Wiring Applications

- Various Interface
- Multi Core Cable
- Automotive Field
- Battery Lead

etc.

Electrical Property vs. Wiring Length

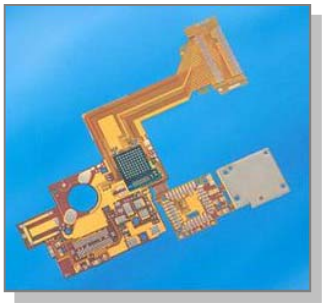


UTP (Unshielded Twist Pair Cable)
STP (Shielded Twist Pair Cable)

Outline of FPC Product

We focus on and explain properties as wiring material, though FPC has excellent properties as thin circuit board.

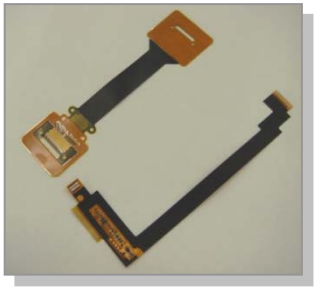
FPC (Flexible Printed Circuits)



- FPC is thinner and more flexible than PWB (Printed Wiring Board) because polyimide is used as base film, and suitable for high density parts mounting or the usage to moving part.
- Multilayered production and various electronic parts mounting, especially SMT (Surface Mount Technology) are possible.
- Switch of circuit layout between front and back side is possible by way of through-hole.
- Arbitrary circuit shape is possible because circuit is shaped with etching method.
- Tooling cost is initially incurred.

The fact that the area of main circuit board and wiring material can be seamlessly united is a large advantage. Furthermore, FPC excels FFC in flexing property.

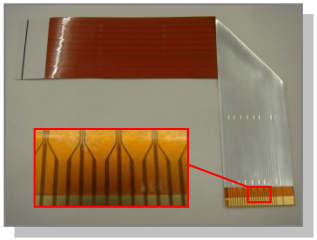
Shielded FPC



- Silver paste type shielding material is widely used, because it can be printed to arbitrary area or shape. This material can freely shield not only wiring area, but also terminal land area.
- Copper foil for GND on base film fulfills the function as shield as well.

The method of pasting FPC to metal stiffener is extensively used by expecting the stiffener to act as a shielding board.

Impedance Matched FPC



- This kind of FPC maintains excellent signal quality with impedance matched transmission line as (micro) strip line.
- We can propose on selection of materials used and circuit, based on the information of impedance control needed wiring.
- Low dielectric constant material can be used for base material to enhance high frequency property.

There is a tendency that conductor width becomes thinner if impedance matching is given priority while maintaining flexing property.
(Conductor can be widened to connector pitch at terminal area.)

Outline of FFC Product

SUMI-CARD® Standard Type FFC (Flexible Flat Cable)

- This is wiring material where the same size rectangular conductors are put side by side with uniform space.
- This is thin with the thickness of 0.3mm or less, flexible and light, which corresponds to smaller and lighter electronic equipment.
- We have the line-up with the standard pitch between conductors of 0.5, 1.0, and 1.25mm.
- This has excellent bending and flexing properties.
- The line-ups of terminal plating are tin plating, whisker counter measured tin plating and gold plating.
- There is a possibility that solderability or electrical property differs depending the kind of terminal plating.

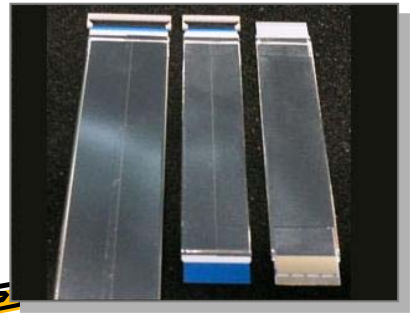
The initial tooling cost and product cost are much less expensive that those on FPC. There is restrictions in terms of shape and heat resistance, so special attention must be made if this is used as an alternative of FPC.

SHIELDED SUMI-CARD®

- This is shield attached FFC to control the effect of noise, such as EMI.
- We prepare pitch between conductors of 0.5, 1.0, and 1.25mm as standard.
- We maintain high bending property as it is by adopting thin shielding material, so this can be used for moving area.
- Shield is connected to a designated conductor and then to GND by way of a signal terminal on the connector.

Shielding property depends on shielding material adopted.
Generally, deterioration occurs in case of high speed signal with low characteristic impedance.

HIGH FREQUENCY COMPLIANT SUMI-CARD



- This has anti-noise property of SHIELDED SUMI-CARD while achieving impedance matching.
- We realize impedance matching by adjusting the distance between terminal for signal and shield.
- Shield is connected to GND separately from terminal for signal. Specific connectors are available.
- We have the line-up of thin shield for SHIELDED SUMI-CARD and thick AL PET shield.
- We prepare pitch between conductors of 0.5mm as standard.
- There is a possibility that electrical property at high frequency band differs depending on the kind of terminal plating.

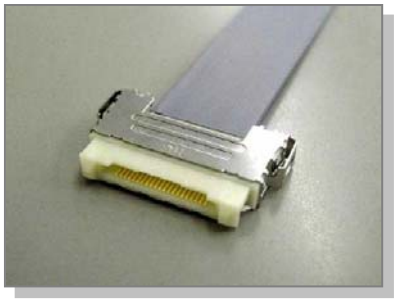
The total thickness increases by giving priority to impedance matching, because there is a restriction in terms of conductor shape. Consequently, bending property deteriorates and , in some cases, that can be used only for fixed wiring.

Outline of HCD-EXFFC Product

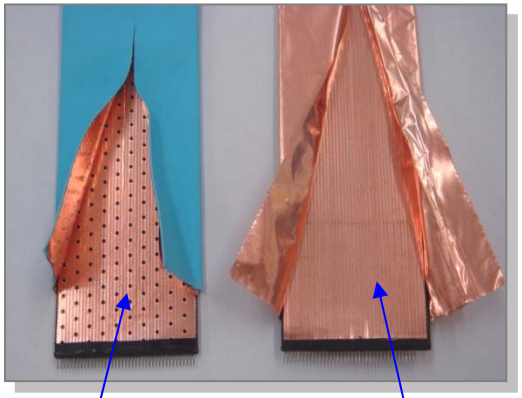
HCD-EXFFC® (High Coupling Differential – Extruded Flexible Flat Cable)

※Wiring Structure Peculiar to SEI (Patent applied for)

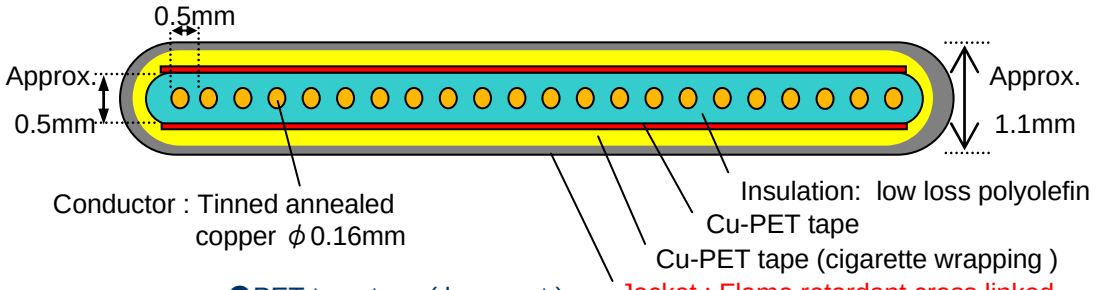
- We prepare two types with different kinds of jacket.
- Production with extrusion method is possible, and this product is less expensive than HIGH FREQUENCY SUMI-CARD which is longer than a given length.
- Decrease of resistance loss is intended due to round and thicker conductor. (The largest AWG34 in case of Pitch 0.5mm)
- This product reduces dielectric loss at high frequency by using low loss polyolefin.
- This product shows excellent differential transmission property by high coupling between conductors and smaller skew due to simultaneous extrusion.
- This product has more excellent EMI property as well with strong double shield treatment.



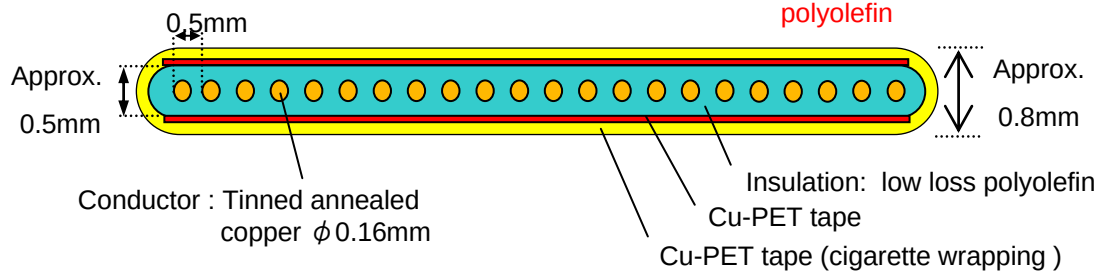
Example of Termination
(FX-16：HIROSE)



●Extruded type (less external damage)



●PET tape type (less cost)

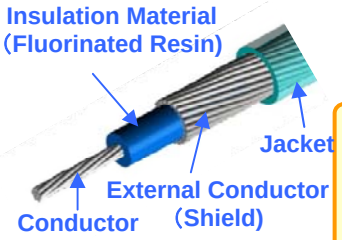


This product shows the most excellent electrical property as wiring material for fixed use in electronics equipment and is less costly. The only disadvantage is that there is restriction on internal radius at bending, because lower loss has been given priority.

Outline of Coaxial Cable Product

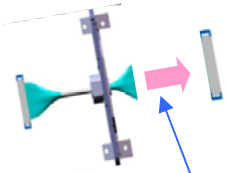
MFCX® (Micro Flex Coaxial Cable)

- We have the wide range of line-up from AWG40 to46.
- This is an excellent product which simultaneously has high frequency property and mechanical property with coaxial structure.
- This product shows high bending and twisting properties with stranded conductor and spiral shield.
- This has the highest performance, but the most expensive among wiring materials.



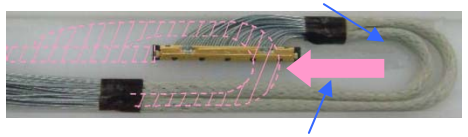
Cable Outer Dia.
AWG40：0.35mm
AWG42：0.26～0.31mm
AWG44：0.22～0.26mm
AWG46：0.22mm

This product has advantageous property of high bundling flexibility because discrete wires are bundled with tape or sleeve afterwards.



Pass this through hinge first, and then connect this to connector

Division to 2 or more branches

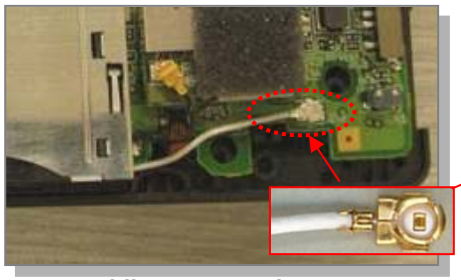


Applicable to sliding system by using bending property.

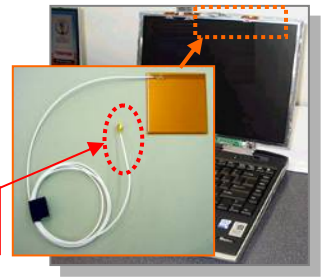
- Random pin assembly at both sides
- Hybrid assembly of different types of wire
- Able to re-bundle of plural harness
- Able to implement multi-shielding with copper foil thread, metal sleeve. etc.

LVCX® (Low VSWR Coaxial Cable)

- We have the standard line-up from 0.25DS to 0.8DS now.
- This product has achieved both low VSWR and low attenuation.
- This product has more excellent EMI properties with braid, spiral (double) shield.
- Spiral shield type shows excellent bending property as well.
- This product is extensively used as RF (antenna) cable for mobile equipment. (Specific RF coaxial connector is used.)



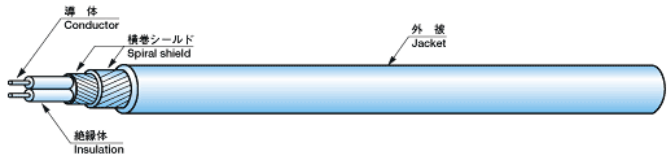
Mobile Game Equipment



NOTE PC

Miniature Twin Coaxial Cable

- We have standard spec. of AWG40 now.
- This product shows excellent differential property because 2 pairs of conductors are connected electro-magnetically.
- There is no offset of electro-magnetic field due to stranding unlike STP, but shield compensates it.
- Further, wiring length is short with no stranding and this product has the advantage of making wiring length uniform. We have the standard specification of AWG40 now.

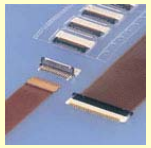


※We have various types for multi core products for thick dia. Twinax.
Please contact us for further details.

Selection of Connector

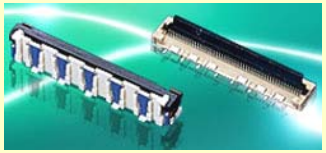
Connector can be classified into one for rectangular conductor and the other for round conductor.

One Piece Connector for FPC/FFC (For rectangular Conductor)



JST

KYOCERA ELCO



MOLEX

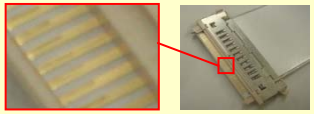
Mechanical Characteristic

- This is the structure of directly contacting *contact* with rectangular conductor of wiring material.
- Connector on plug side is unnecessary, and the structure of connector on receptacle side is simple in most cases. These lead to high cost advantage.
- Outer dimension of connector can be minimized, and consequently this is suitable for high density parts mounting.
- ZIF/Non-ZIF structure are typical.

Electrical Characteristic

- This excels in transmission property because of long contact length.
- Shield is connected to terminal for signal.
- GND terminal for shield is separately For high speed transmission, there is a type whose GND terminal for shield is separately located.

Two Piece Connector for FPC/FFC



- This type is to be directly contacted to rectangular conductor, though two piece for enhancing insertion strength.
- Transmission performance is enhanced, and anti-EMI property is also enhanced with metal shell.

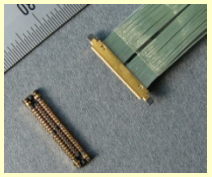
Common Receptacle Two Piece Connector

HIROSE

- This type enables various types of wiring materials to be inserted by changing the structure on plug side, while using common receptacle connector. As a result, this has the advantage of having no spec. change on circuit board.

Two Piece Connector (For round conductor)

JAE



I-PEX

Mechanical Characteristic

- This type has high contact reliability and is resistant to vibration because contacts, which are structure-designed for suitable shape, inserted to each other.
- Wiring material is connected to plug connector with solder or IDC (Insulation Displacement Contact) method.

Electrical Characteristic

- Anti-EMI property can be easily enhanced by covering connector as a whole with metal shell.
- This type excels in return pass as GN because shield of wiring material is connected to separate metal shell.

Other Terminal Spec.

Board to Board Connector

- In case of FPC, ordinary board to board connectors can be used and there is a wide choice of connector.

Interconnection Circuit Board

- Round conductor is connected to connector for FPC/FFC by way of circuit board. FPC or thin rigid printed board is used.

Direct Termination

- It is mechanically, electrically and costly excellent if wiring material can be directly connected to main circuit board without using connector, provided that It is possible in terms of process. There are various methods, such as solder connection, ACF connection etc.

(Remark) Connectors quoted here are only some examples. We consider that information on some suppliers be not biased.

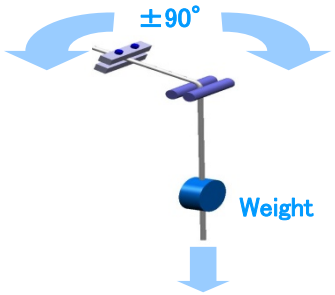
Evaluation Test on Mechanical Property

Wiring materials used for moving are required to have anti-fatigue or long life property etc., and the following 3 tests are implemented.

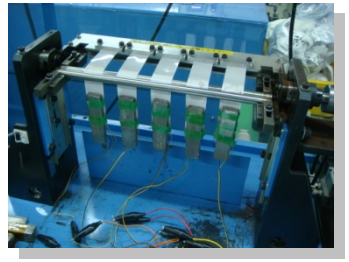
In general, life of 10,000 time or more, 100,000 time or more, 1million time or more etc. are required at each test depending on its application.

Bending Test

- This is endurance test for bending.
- Bending life differs depending on bending radius, rotating angle/speed and suspending weight.



Bending Test of Wire



Bending Test of Wire FFC

This test is basic item for mechanical reliability

Twisting Test

- This is endurance test for twisting of wire.
- Twisting life differs depending on the length of twisting area, rotating angle/speed.

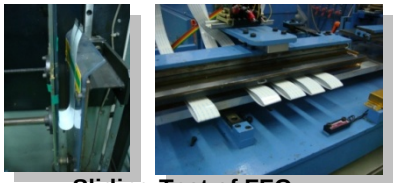
Twisting Test of MFCX

Only round type wire can be twisted in terms of structure.
MFCX can withstand more than 100,000 time twisting test.

Sliding Test

- This is endurance test for sliding.
- Sliding life differs depending on thickness (bending radius), sliding length/speed.

Sliding Test of FPC



Sliding Test of FFC

Flat type, such as FPC or FFC can be used for sliding applications in terms of structure.

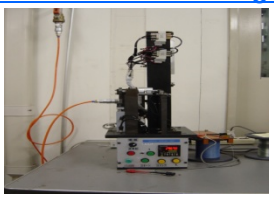
Other Test

- Compound test combining these 3 tests
- Test at harness assembled state（Vibration, Shock etc.)
- Test imitating the actual equipment
- Compound test with environmental tests, such as temperature, humidity, heat-shock etc..

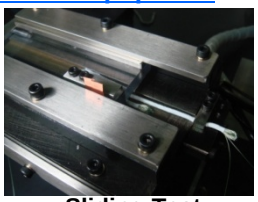
We can cope with various tests required flexibly.

Examples of Various Tests Imitating Actual Equipment

Open & Close Test



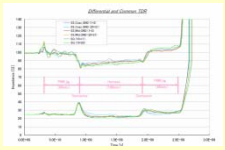
Open & Turn Test



Sliding Test

Evaluation Test on High Frequency Property

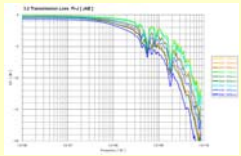
TDR Measurement



We measure various transmission parameters for respective time bands with Time Domain Reflection.
・Characteristic Impedance ・Differential Impedance
・Common Mode Impedance ・Cross Talk
・Inter/Intra Skew ・Time Domain Transition (TDT)
etc.

Characteristic Impedance

VNA Measurement

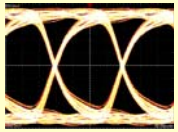


We measure various high frequency properties for respective frequency bands by using 4Port Vector Network Analyzer. (Max. ～20GHz)
・Reflection Loss ・Input Loss ・VSWR (Voltage Standard Wave Ratio)
・Isolation ・Common Mode Transformation
・Mix Mode S Parameter ・Phase Difference/Skew
etc.

Input Loss

EYE Pattern Measurement

We measure EYE pattern by inputting close to Random pattern after creating digital signal with pulse generator. (Max. ～12.5Gbps)



EYE Pattern

Shielding Property Measurement with Copper Pipe

We measure shielding properties by regarding copper pipe as external GND.
・Measurement of Surface Transmission Impedance
This is especially suitable for measuring thick coaxial cable based on IEC or MIL etc. We evaluate shielding property by obtaining the ratio between applied voltage(V1) to external coaxial cable and voltage(V2) induced between conductors of measured cables.
(Max. ～Several hundred MHz)
・Cross Talk Method
・Others

Measurement Scene

Probing Technology

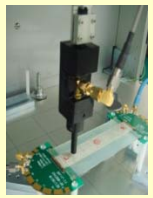
We have design know-how on test jig necessary for measurement of high frequency properties, and can implement high precision measurement.
We can also cope with fine probing which uses RF wafer probe.

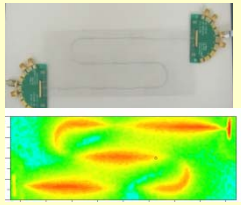
Measurement Scene

Measurement of Near Electro-magnetic Field

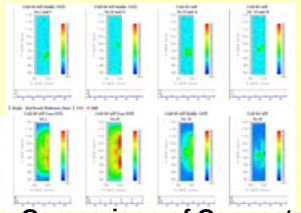
Measurement of near electro-magnetic field is based on IEC (MP method). MP method is to detect high frequency current by scanning high resolution magnetic field probe with no contact near the electro source, and identify the noise source and measure the size of it. We evaluate noise level by detecting common mode current running through shielding material for various wiring materials or harness assembled products, and recommend peak value in distant field. (Max. ～10GHz)

Measurement Scene





Standard Wave on MFCX Shield

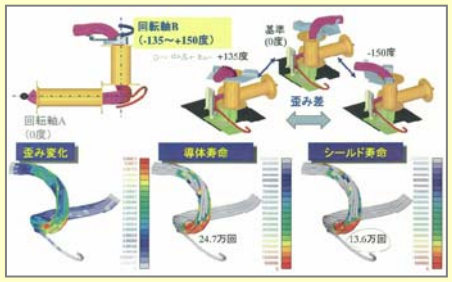


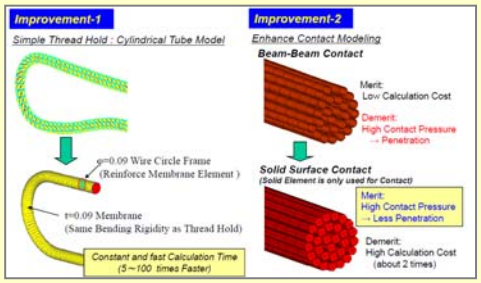
Comparison of Connector Shielding Property

Kinds of Simulation & Analysis

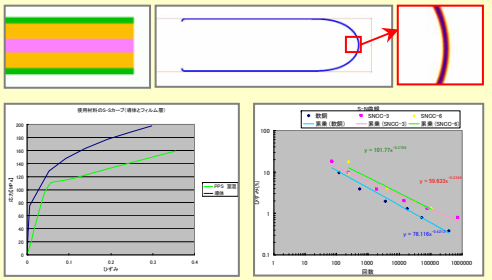
Mechanical Simulation

Example of Prediction on Twisting Fatigue of MFCX.





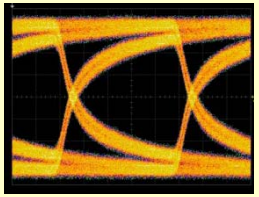
Example of Prediction on FFC's Sliding Life



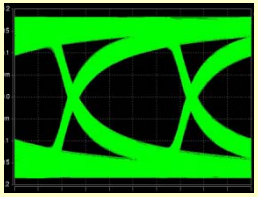
・We predict twisting, bending and sliding properties of kinds of wiring materials, based on simulations, and then select the most suitable material or optimize structure of each material.

Simulation on High Frequency Property

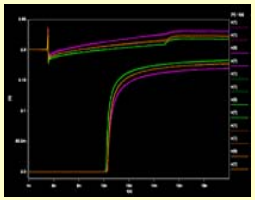
Prediction on Transmission Property by Circuit Simulator



Actual Value
(500Mbps)



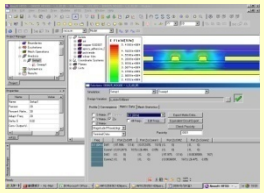
Simulation Value
(H-Spice)



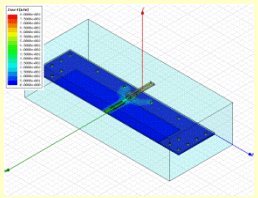
Extraction of Circuit Model by TDR/TDT Base

・We measure transmission parameter of wiring materials and harness product, and implement high level analysis based on specific software.
・We predict signal movement by extracting value for circuit model based on actual value.

Calculation/Analysis by Electro-magnetic Field Simulator



Impedance Calculation of FPC



Distribution of Return Current

Leakage Electro Field from Coaxial Cable

・3D electro field simulator is useful for analysis of sophisticated 3D structure.
・These are used for product design, such as impedance calculation etc.
・These enable us to visualize distribution of return current or irradiation noise, which is useful for identifying cause which is difficult to do so only by measurement or predicting EMI.

We implement prior prediction and analysis on kinds of properties with analysis soft or numerical calculations, and use the information for the development of products.