Conforming to RoHS Directive

Conformity to RoHS Directive: This means that, in conformity with EU Directive 2002/95/EC, lead, cadmium, mercury, hexavalent chromium, and specific bromine-based flame retardants, PBB and PBDE, have not been used, except for exempted applications.

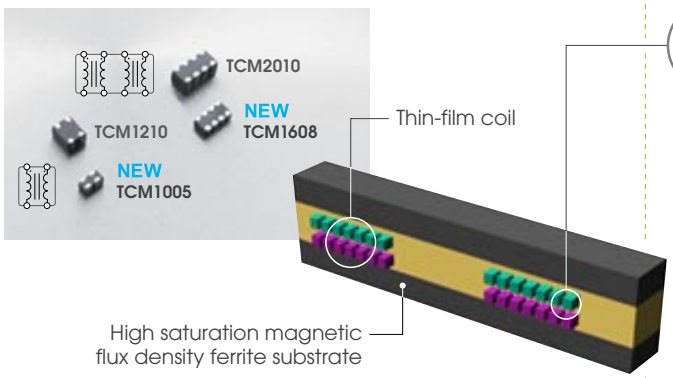
Thin-film Common-mode Filter / Filter Array For EMI Countermeasures Of High-speed Differential Data Transmission Lines

TCM series 1005, 1210, 1608, 2010 type

TCM1210 and 2010 array type offer tough EMI deterrence while maintaining high-quality signal waveforms. The most-advanced, world's smallest*, 1005 chip and 1608 chip array with further downsized super-small thin-film coil multi-layered structure and brilliant impedance-frequency characteristic are introduced.

*As of February 1, 2007
(Based on our research)

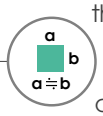
The 1005 type which includes a set of common-mode filters with two elements of super-small thin-film coils has realized a reduction of implementation area of 60% compared to the previously smallest 1210 type. Also, the thickness is 0.42±0.05mm: a 30% reduction compared to 0.6±0.07mm of the1210. This is in order to respond to the latest needs of portable digital devices such as mobile phones, digital still cameras, small digital video cameras, memory audio players, and so on, which are increasingly smaller and thinner.



Also, a 4-line compatible array type 1608, which supports the IEEE1394 interface by itself, has a low-profile shift with a thickness of 0.4±0.1mm, achieving a breakthrough in thickness reduction of 50% compared to 0.8±0.1mm for the previously smallest 2010. The crosstalk characteristic, which is a vital specification for the performance of the array type, easily satisfies the IEEE1394 standard which requires –26dB or less (1 to 500MHz band) in the differential mode.

A similar level of impedance-frequency characteristics as those of 1210 and 2010 is achieved. Superb common-mode noise reduction is expected while maintaining the quality of the signal waveform.

Through application of the thin-film magnetic head/wafer mass-production process technology where the optimum control accuracy was maintained, a high-definition pattern thin-film coil is formed where the aspect ratio is made as close to one as possible.



Through a high-definition pattern shape design which reduces stray capacity between thin-film coils, the common-mode resonance frequency was largely shifted to a high frequency range and the differential mode impedance, which affects the signal waveform, was reduced to the industry's lowest level. The cut-off frequency (attenuation 3db point) of the same mode transmission characteristics reaches the 3GHz range, producing almost no effect on the signal waveform, and achieving good high-speed differential data-transport characteristics.

Also, the use of the high magnetic flux density ferrite materials in which the best high-frequency low-loss characteristic is sought, is an original technological feature giving the TCM series an enormous advantage in the GHz band.

Offering the optimal frequency characteristic for **USB2.0**(480Mbps) **and IEEE1394**(400Mbps/100Mbps)

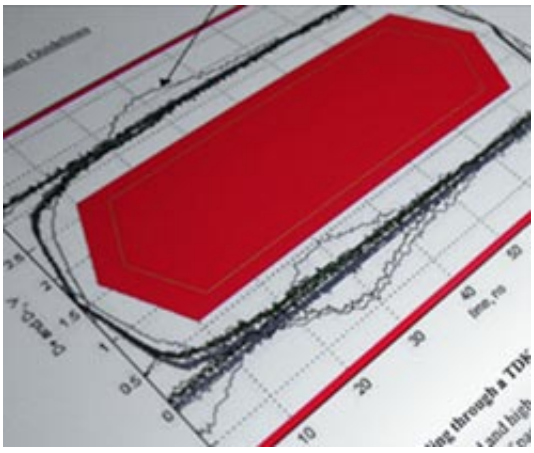
TCM series
1005, 1210, 1608, 2010 type

Satisfying the USB2.0 eye pattern standard, SYNC field (32 bit interval signal) standard with the industry's highest-level performance, offers an ideal impedance characteristic without distorting the speed signal waveform, even with IEEE1394.

Of course, superb absorption/stabilization effects against the common-mode elements (skew fluctuation) due to the phase lag, or voltage difference of differential signals, are offered, making it optimal as a countermeasure against the radiation from the VDS lines of laptop PCs and high-definition digital display DVI lines, and for reinforcing the immunity.

Requirements of USB2.0 regarding transmission waveform

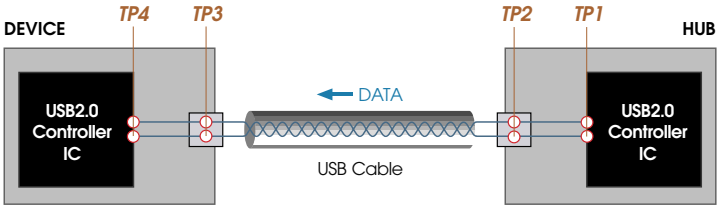
Diverse standards are set for USB2.0 in order to prevent operational troubles. The eye-pattern standard, where the allowable range of transmitted differential signal waveform is specified, and the requirement of the first bit's voltage lower limit of the 32bit interval signal (SYNC field), which is sent at the start of every data transmission, should be especially considered in connection with EMI countermeasures.



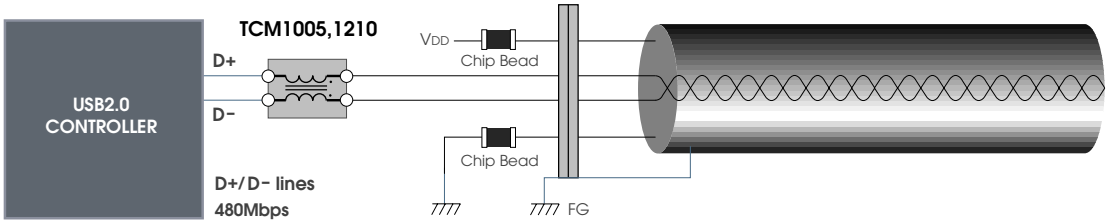
Four observational points of eye-pattern standard

While USB2.0 transmits data in 400mVp-p differential signals, the eye-pattern standard, as shown in the diagram below, represents the templates specifying the limitation ranges of waveform distortion at four observational points on the standard transmission model connected by a USB cable between the transmitting (HUB) and receiving sides (DEVICE).

——— It is required that the transmission waveform does not enter the red area on the template.



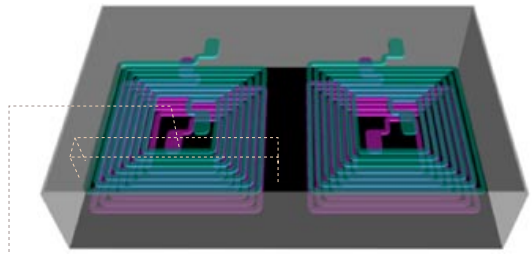
The template TP1 at the USB2.0 transreceiver output end of the transmitting side is strictest; TP2, TP3, and TP4 are less strict: the further they are from the output end, the less strict. Also, the longer the cable length is, the smaller the pulse voltage width (D+ and D− values) of the operational signal will become due to cable resistance.



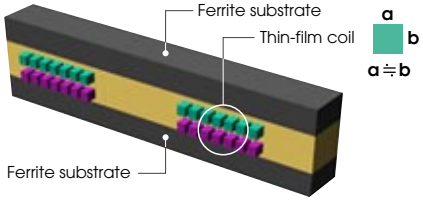
Structural superiority/ Electrical characteristics Environmental conditions

Thin-film conductor layout of TCM series

Array type model



Cross-sectional shape model of TCM series



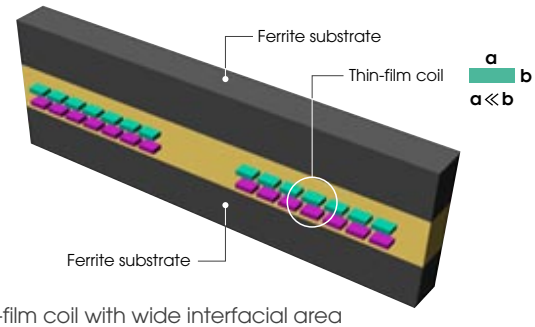
Our approaches

- Small thin-film coil (reduced stray capacity) with a high-definition pattern design where the aspect ratio is made as close to one as possible.
- Application of high saturation magnetic flux density/high-frequency low-loss ferrite material

Achieved characteristic superiority

- Common-mode resonance frequency is shifted to a high frequency range
- Significant improvement of the high-frequency differential transmission characteristic

Cross-sectional shape model of conventional thin-film type



- Thin-film coil with wide interfacial area
- Ferrite material of conventional characteristic

Limitations in responding to the latest needs

- Limitations of high-speed differential transmission due to the stray capacity between coils
- Downsizing and thinning is difficult for ferrite material because of its characteristic limitations

Typical electrical characteristics

Type		Common-mode impedance (Ω) (at 100MHz)	Rated current Idc (mA)	Rated voltage Edc (V)	Part No.
Single element / 1005 Type (One common-mode filter element)	T 0.4±0.1mm	35 typ.	25 max.	5 max.	**TCM1005-350-2P**
		65 typ.	25 max.	5 max.	**TCM1005-650-2P**
		90 typ.	25 max.	5 max.	**TCM1005-900-2P**
Single element / 1210 Type (One common-mode filter element)	T 0.6±0.07mm	65 typ.	100 max.	10 max.	**TCM1210-650-2P**
		90 typ.	100 max.	10 max.	**TCM1210-900-2P**
		200 typ.	100 max.	10 max.	**TCM1210-201-2P**
		300 typ.	50 max.	10 max.	**TCM1210-301-2P**
Array / 1608 Type (Two common-mode filter elements)	T 0.4±0.05mm	35 typ.	50 max.	5 max.	**TCM1608-350-4P**
		65 typ.	50 max.	5 max.	**TCM1608-650-4P**
		90 typ.	50 max.	5 max.	**TCM1608-900-4P**
		200 typ.	50 max.	5 max.	**TCM1608-201-4P**
Array / 2010 Type (Two common-mode filter elements)	T 0.8±0.1mm	65 typ.	100 max.	10 max.	**TCM2010-650-4P**
		100 typ.	100 max.	10 max.	**TCM2010-101-4P**
		200 typ.	100 max.	10 max.	**TCM2010-201-4P**
		260 typ.	40 max.	10 max.	**TCM2010-261-4P**

Measuring instrument of common-mode impedance : Impedance Analyzer E4991A (Agilent Technologies)

Application environmental conditions

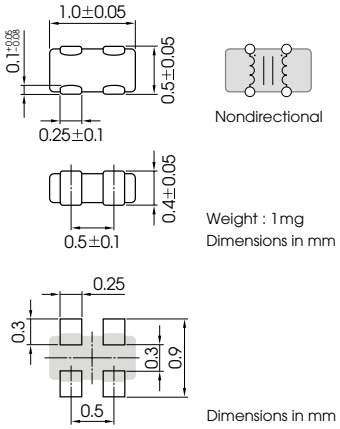
Operating temperature range : −30 to +85°C Operating humidity range : 0 to 90%RH*

*Maximum wet-bulb temperature : 38°C Non-condensing

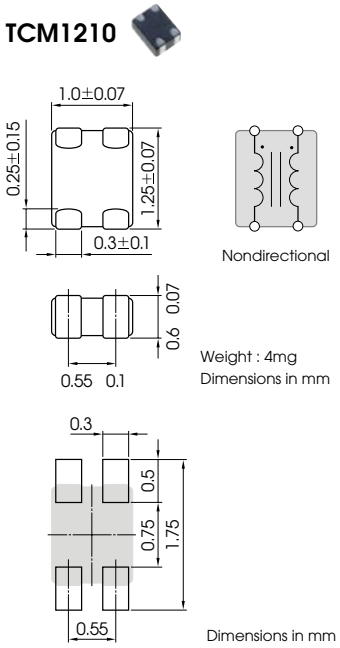
Shapes and dimensions/Equivalent circuit
Recommende PC board pattern (Reflow process)

TCM series
1005, 1210, 1608, 2010 type

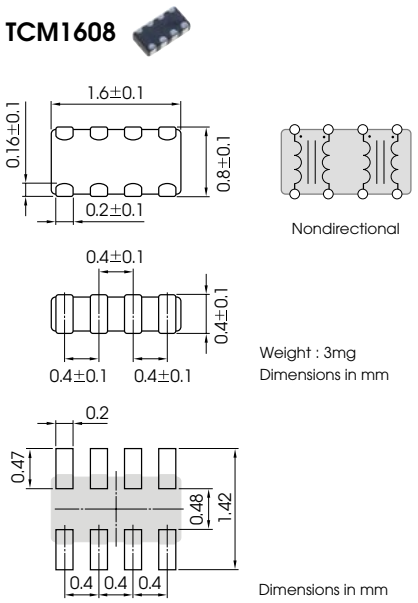
TCM1005



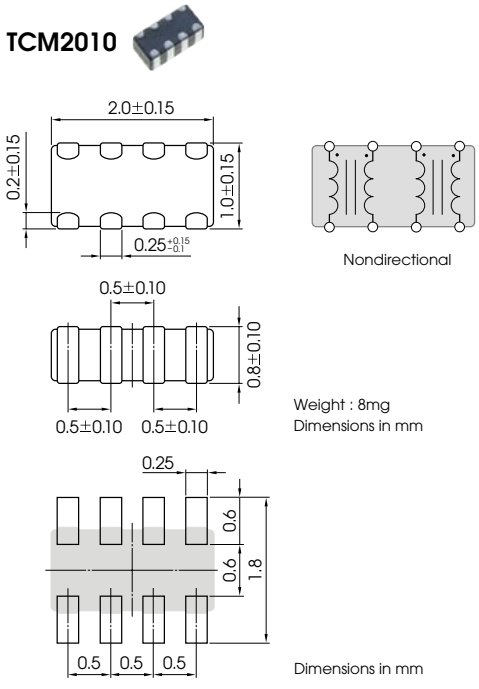
TCM1210



TCM1608

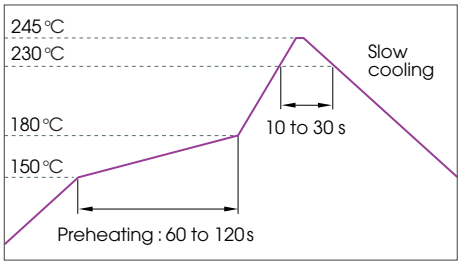


TCM2010



Recommended soldering conditions

Lead-free solder/High-temperature reflow process

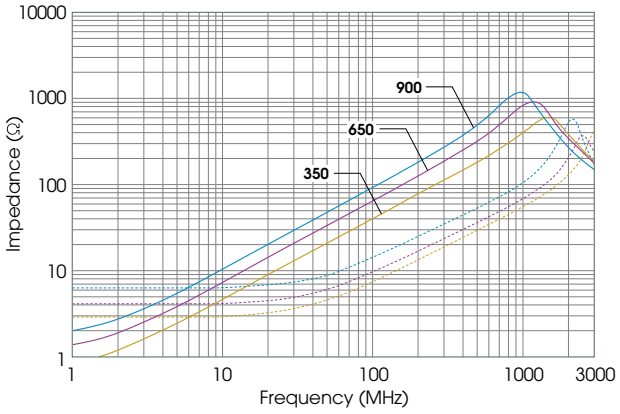


Impedance vs. frequency characteristic

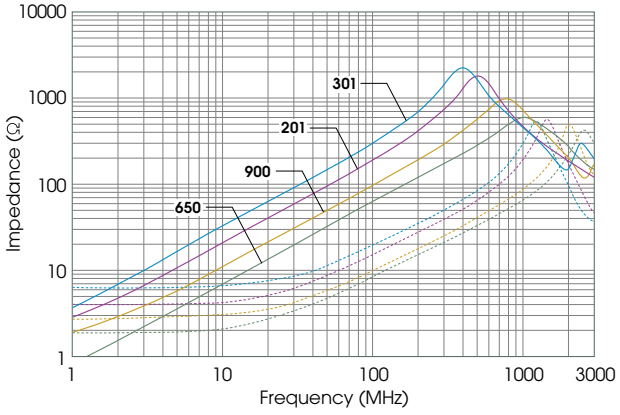
Measuring instrument
Impedance Analyzer E4991A (Agilent Technologies)

Common-mode Impedance
Differential-mode Impedance

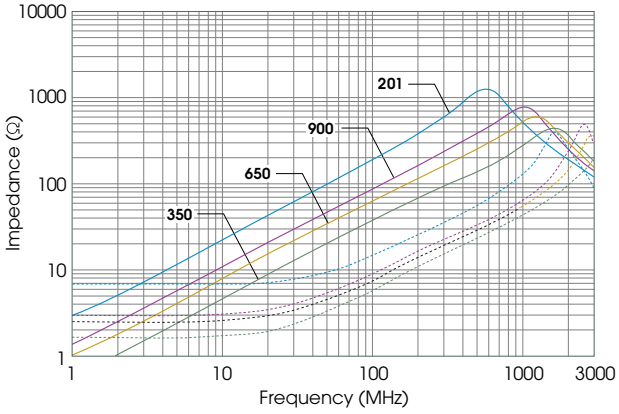
TCM1005-XXX-2P



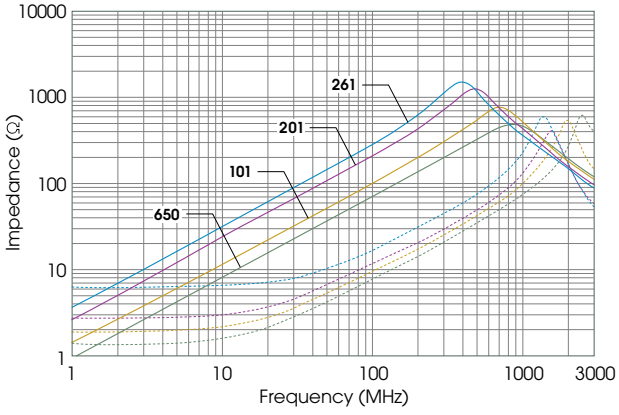
TCM1210-XXX-2P



TCM1608-XXX-4P



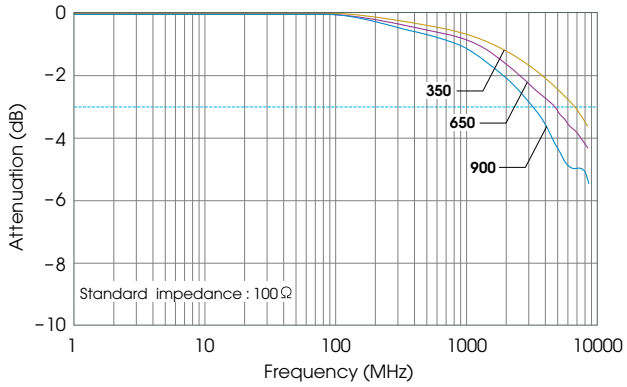
TCM2010-XXX-4P



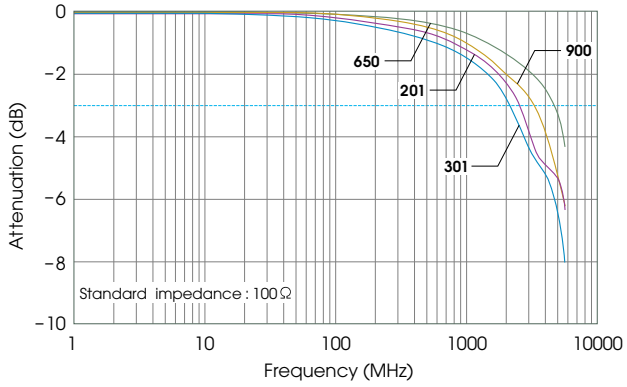
Differential mode transmission characteristics

Measuring instrument
Impedance Analyzer E4991A (Agilent Technologies)

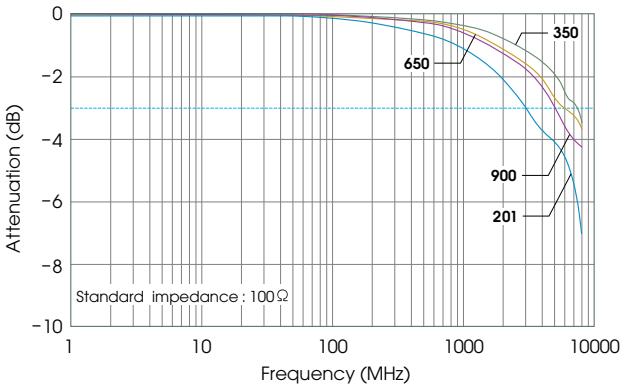
TCM1005-XXX-2P



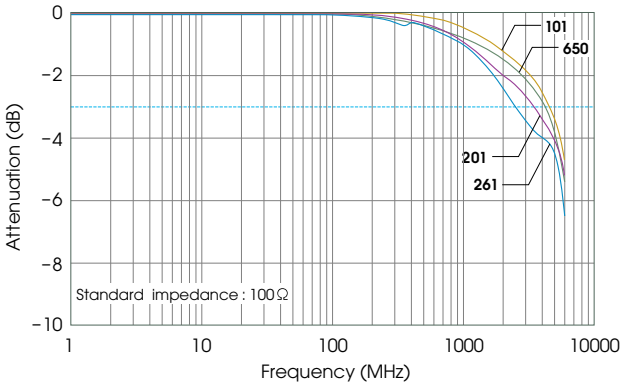
TCM1210-XXX-2P



TCM1608-XXX-4P



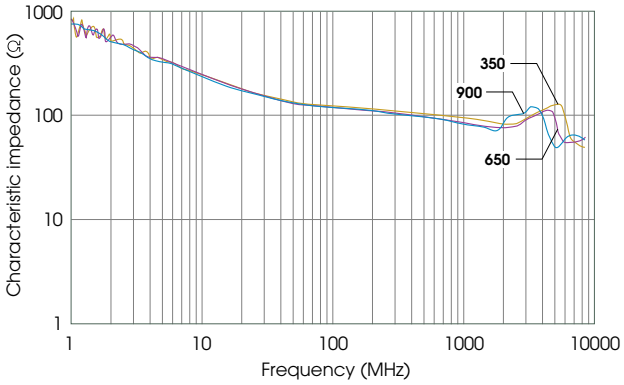
TCM2010-XXX-4P



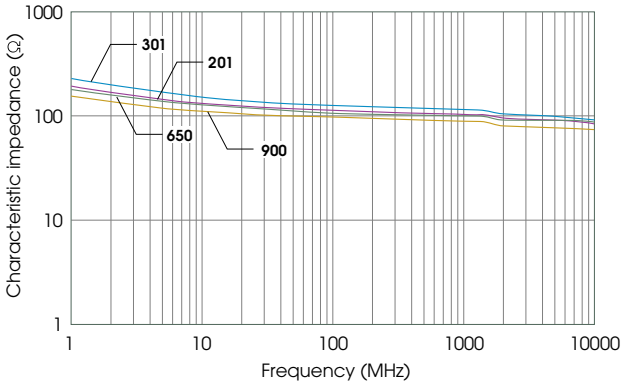
Characteristic impedance vs. frequency characteristics

Measuring instrument
Impedance Analyzer E4991A (Agilent Technologies)

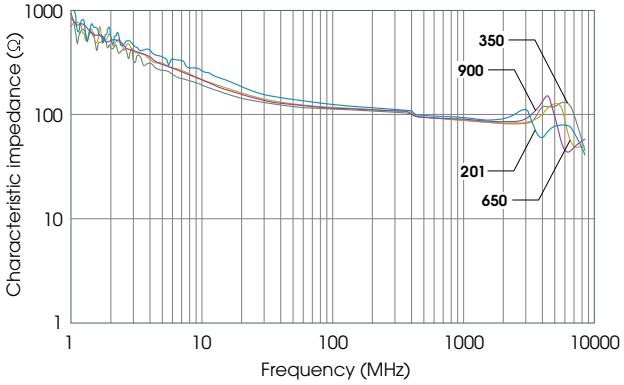
TCM1005-XXX-2P



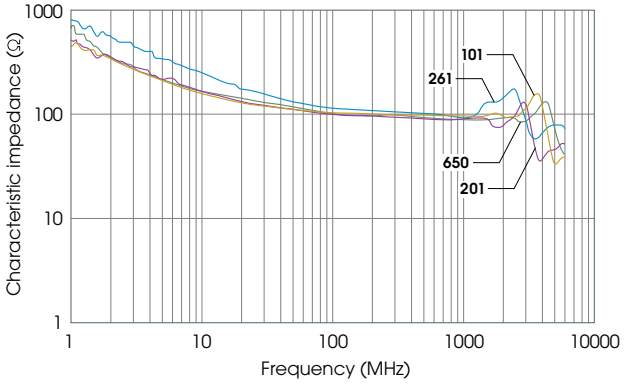
TCM1210-XXX-2P



TCM1608-XXX-4P



TCM2010-XXX-4P



Crosstalk vs. frequency characteristic

Array type TCM1608

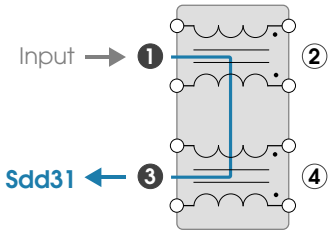
Not to mention the 2010 type, the world's smallest 1608 type easily satisfies the required values of the IEEE1394 standard. With the fine design of the magnetic circuit, a figure below −26dB is maintained in the 1MHz - 500MHz band of the differential mode.

Measurement board

Glass epoxy(FR4) board of 0.4mm thickness
Permittivity 4.6:at 1GHz/backside:entirely copper-foiled

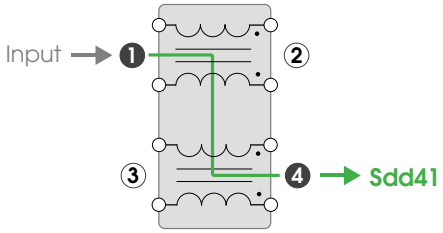
Sdd31

Differential mode/ Near-end crosstalk (NEXTd)

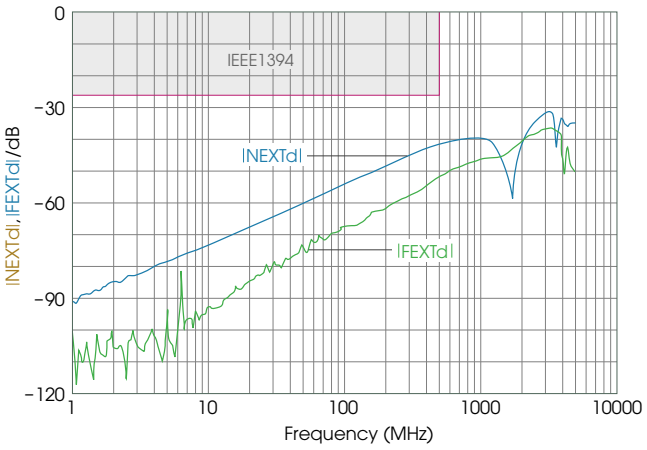


Sdd41

Differential mode/ Far-end crosstalk (FEXTd)

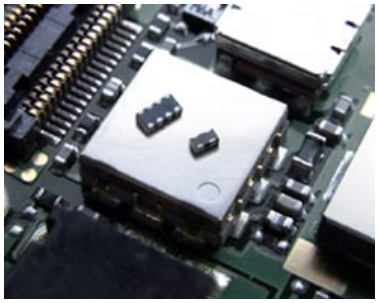


TCM1608-201-4P



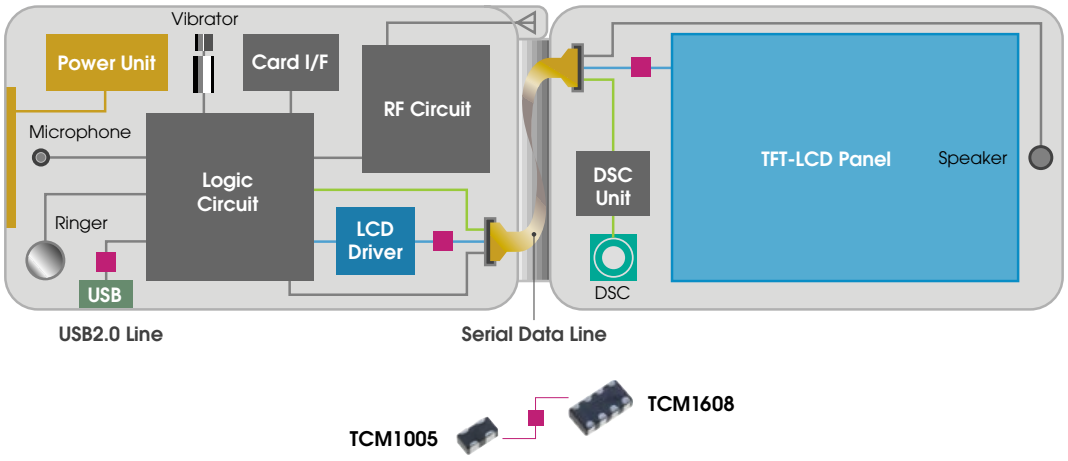
Representative use and application effects

Not to mention radiation noise reduction for small digital devices with high-speed differential signal interfaces, such as Cellular phone, Memory audio player, HDD audio player, USB hub, IEEE1394 hub, PDA (Personal Digital Assistant), Notebook PC, Portable HDD, Portable MO drive, Portable CD-ROM drive, Portable DVD-ROM drive, Printer, Digital camera, Portable video camera, Digital TV and DVD+HDD recorder, the transmission signal waveforms are stabilized with increased immunity, including improved EMC environment in the set and ESD tolerability.



Example of application

Cellular phone

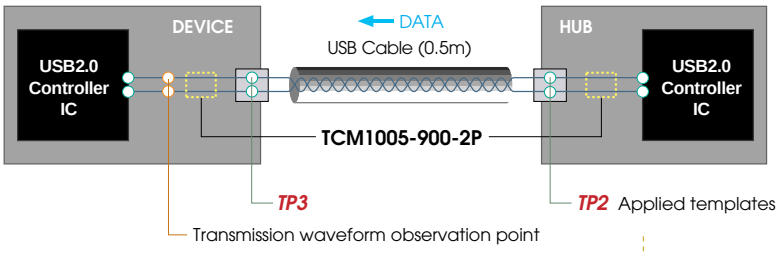


Actual measurement example of USB2.0 differential signal waveform

TCM1005

At the USB2.0's data transmission speed (High speed) of 480Mbps, repetitive pulse frequency is 240Mhz, which requires sufficient consideration for effects on the signal waveform when selecting EMI countermeasure components to deter the radiation noise from the cables, etc.

The USB2.0 transmission signal waveforms where no EMI countermeasure components are attached, and where TCM1005-900-2P is attached near the connectors for both HUB and DEVICE are as follows:



Measurement condition

For operational test, the same EMI countermeasure components are implemented on both the signal sending and receiving sides, assuming actual use conditions.

The measurement data below are the results of observation at a point near TP3 using 0.5m cables. To observe the characteristic superiority of TCM, the TP2 template, which is more severe than TP3, was used.

Measurement results

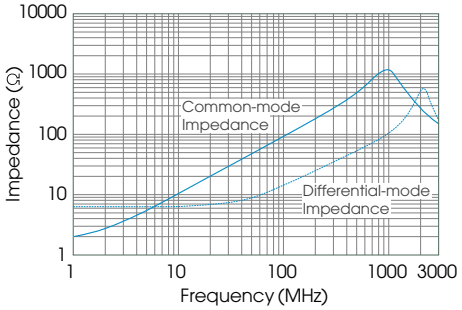
Favorable transmission waveforms are achieved with appropriate CMF(common-mode filter) characteristic impedance* and low differential-mode impedance.

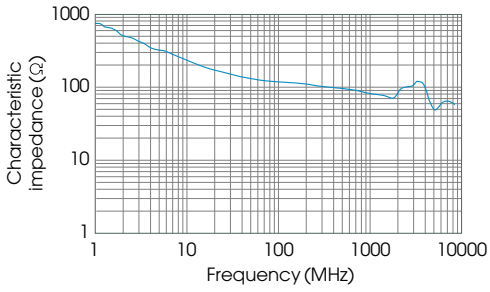
* CMF(common-mode filter) characteristic impedance:
With the USB2.0 standard, the required characteristic impedance of a common-mode filter is 90Ω.

TCM1005-900-2P

Frequency characteristics

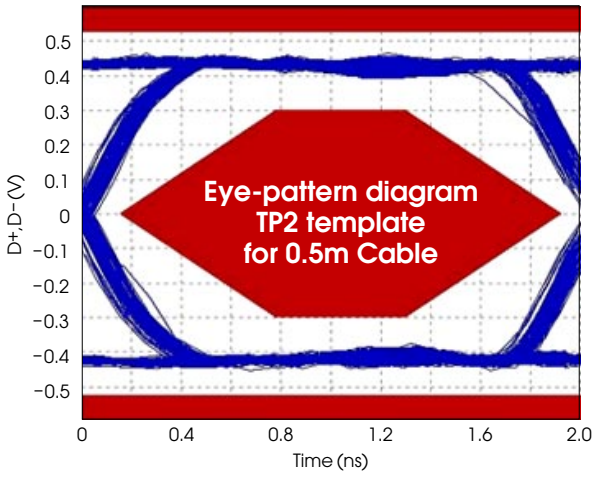
Impedance Analyzer E4991A (Agilent Technologies)





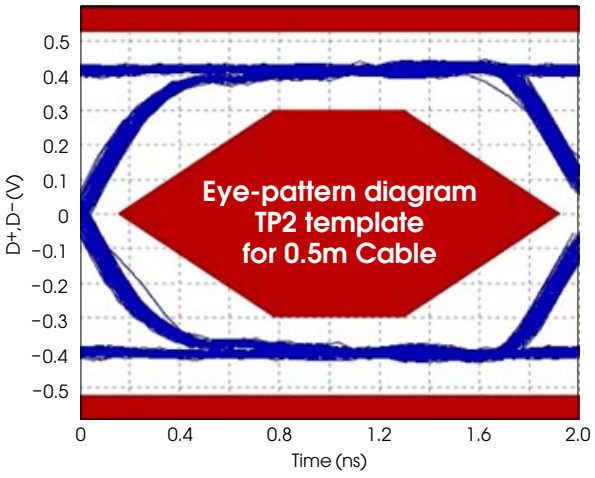
Transmission signal waveform

Without EMI preventive components



Transmission signal waveform

With TCM1005-900-2P



SYNC Field response waveforms of USB2.0

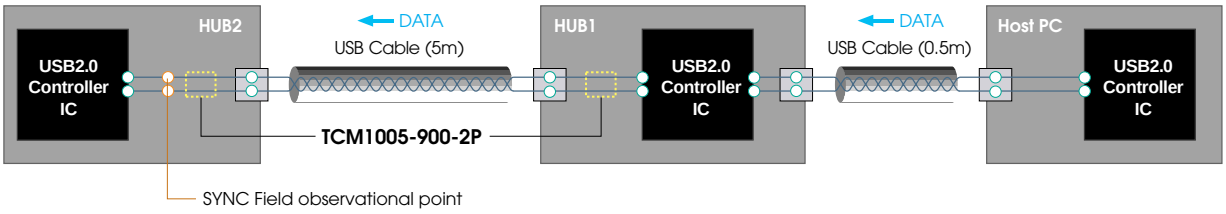
TCM1005

USB2.0 transmits data over a differential signal of 400 mVp-p. When it completes a session of data transmission, it sends a 32bit interval signal before the next data transmission.

With a common-mode filter applied as an EMI preventative, the initial signal of the 32bit signal field (SYNC Field) is shifted to the negative, so the voltage peak value decreases far below the initial level when no countermeasure is taken.

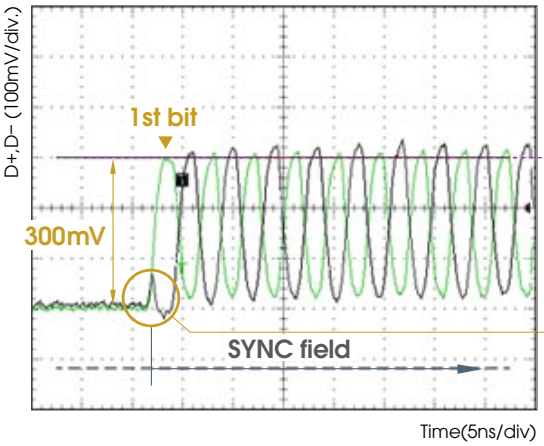
To prevent transmission errors caused by this feature, it is vital to maintain a voltage over 150mV starting from the initial bit of the SYNC Field. It is very important to consider this when choosing the correct common-mode filter, as well as the Eye pattern wave forms standard.

Measurement condition

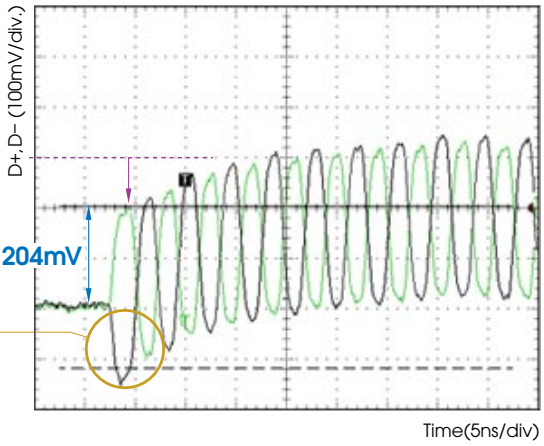


Measurement results

Response waveforms
Without EMI preventive components



Response waveforms
With TCM1005-900-2P



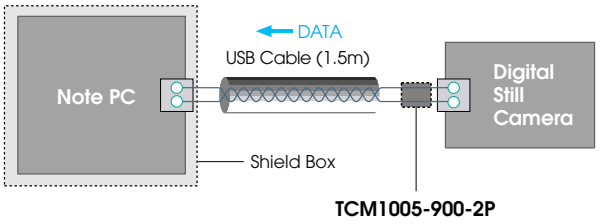
Example of radiation noise countermeasure for USB2.0 transmission cables

TCM1005

Measurement example of radiation electric field strength (Referential data)

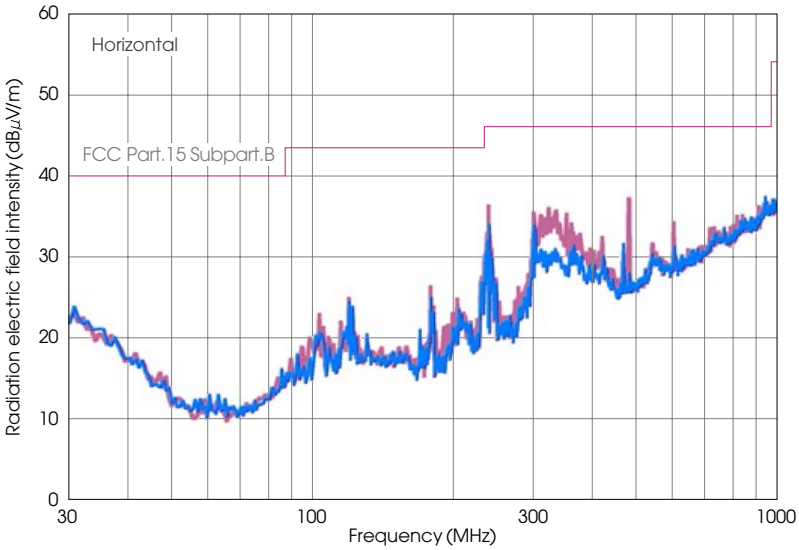
Measurement condition

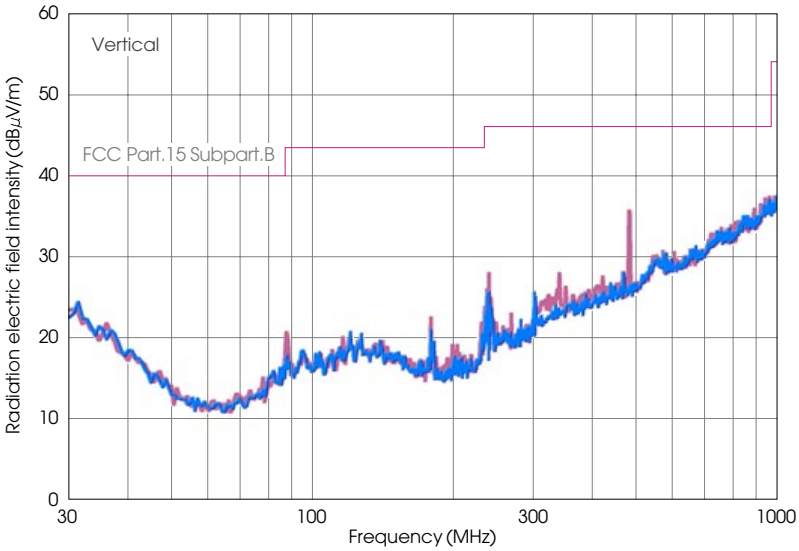
Radio wave anechoic chamber/3m method



Measurement results

Without EMI preventive components With TCM1005-900-2P





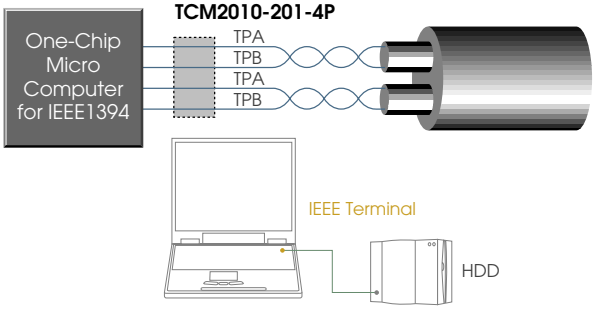
Reduction effects of horizontal polarization: 6dB and vertical polarization: 8dB has been achieved in the 300-400MHz band and at the peak of the double harmonic component(480MHz) of USB2.0 repetitive pulse frequency(240MHz).

IEEE1394 differential signal waveform actual measurement example/Speed Signal waveform EMI countermeasure example

TCM2010

TCM series
1005, 1210, 1608, 2010 type

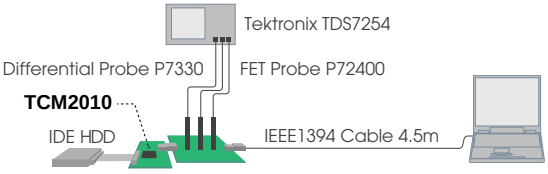
IEEE1394 interfaces



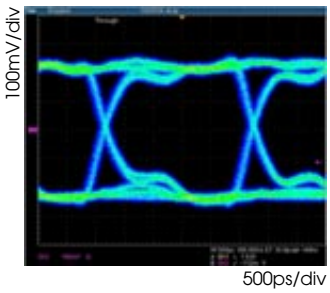
Eye pattern of data signal

Comparison (before/after countermeasure)
400bps

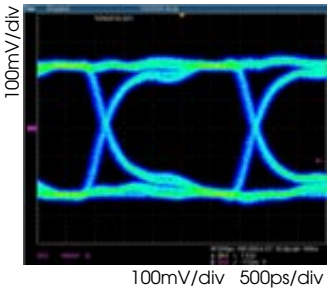
There is no deformation or degradation of eye pattern.



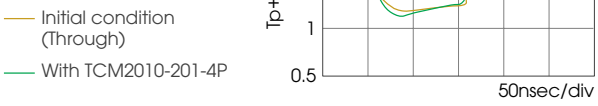
Initial condition(Through)



With TCM2010-201-4P



S400 Speed Signal (TPB)



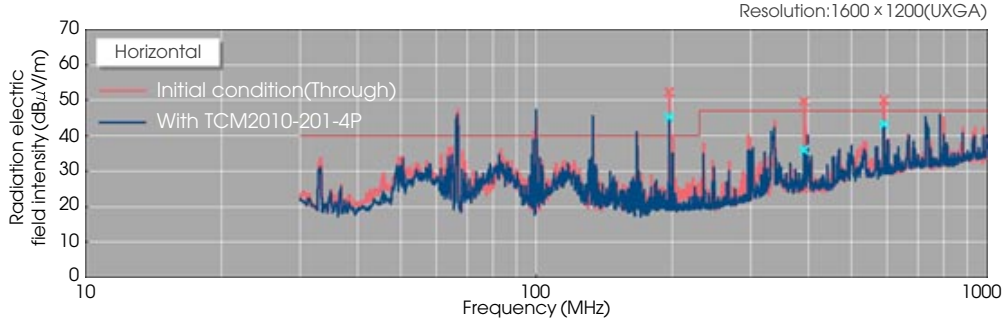
Aside from the eye-pattern waveform, the essential consideration in selecting a common-mode filter for the IEEE1394 interface line is the level of effect on the speed signal waveform. This signal is sent to detect data transmission speed (100, 200, and 400Mbps).
But because it is sent in the common mode, it is an essential control factor to set a common-mode impedance value that will not significantly distort the waveform. As shown in the measurement data on the left, the TCM series has achieved a superb characteristic in this regard.

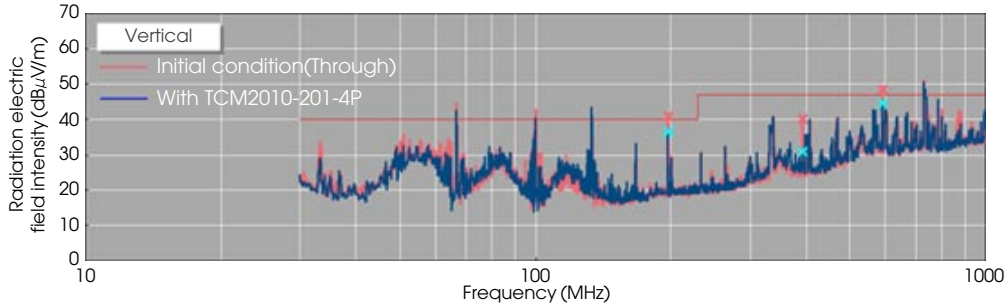
Radiation electric field intensity

Comparison (before/after countermeasure)

A large suppressive effect was gained for, in particular, the fundamental wave and harmonic component of IEEE1394(S400) signal 200MHz.

Resolution:1600 × 1200(UXGA)



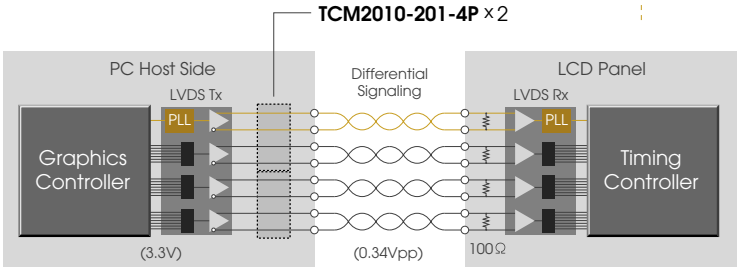


Actual measurement example of VDS line differential signal waveform /Actual measurement example of clock waveform

TCM2010

TCM series
1005, 1210, 1608, 2010 type

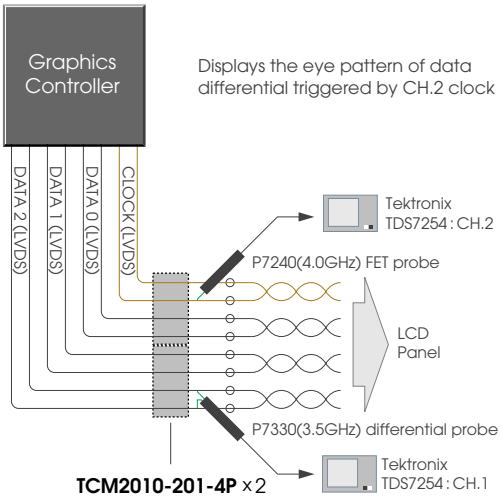
Notebook PC/LVDS lines



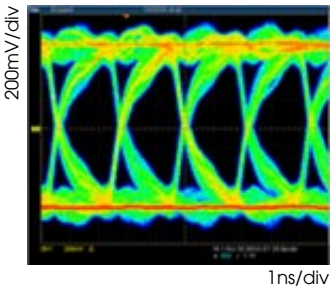
Eye pattern of data signal

Comparison (before/after countermeasure)
227.5MHz

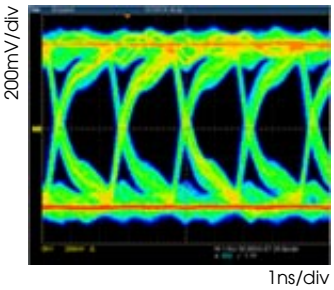
There is no deformation or degradation of eye pattern.



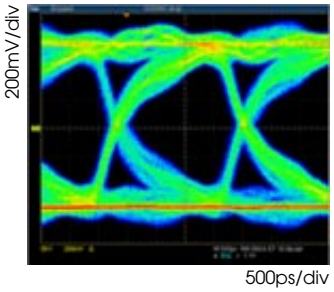
Initial condition(Through)



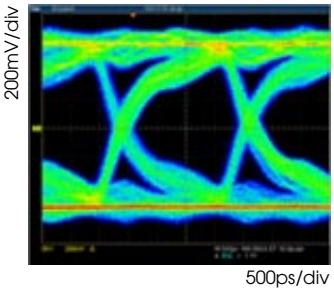
With TCM2010-201-4P



Initial condition(Through)

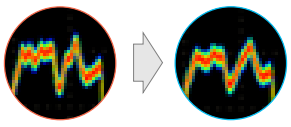


With TCM2010-201-4P



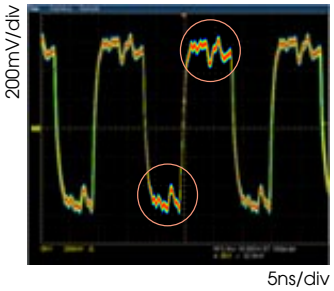
Clock waveform

Comparison (before/after countermeasure)
XGA:65MHz

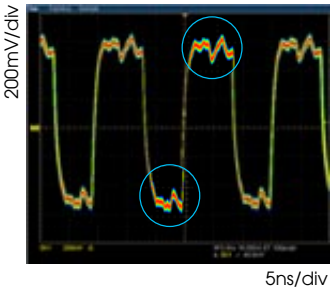


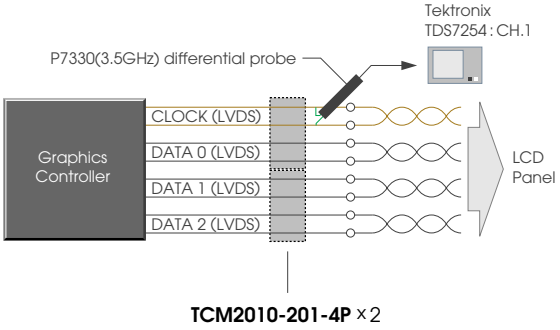
Sharp ringing elements are suppressed.

Initial condition(Through)



With TCM2010-201-4P



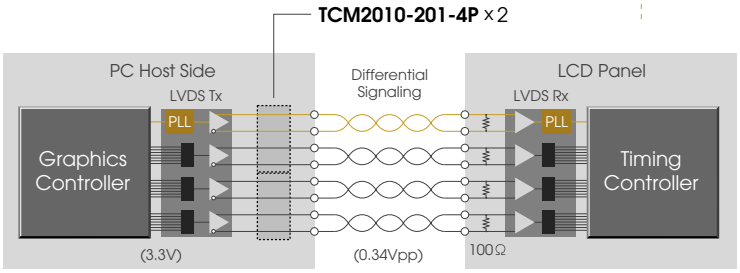


Example of LVDS line radiation noise countermeasure

TCM2010

TCM series
1005, 1210, 1608, 2010 type

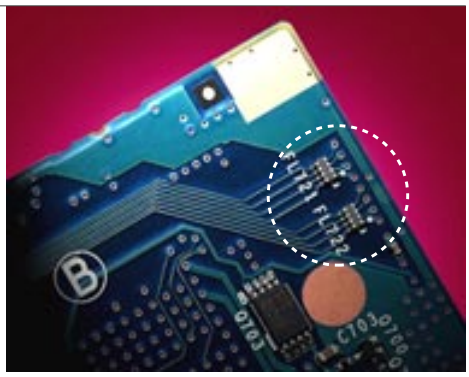
Notebook PC/LVDS lines



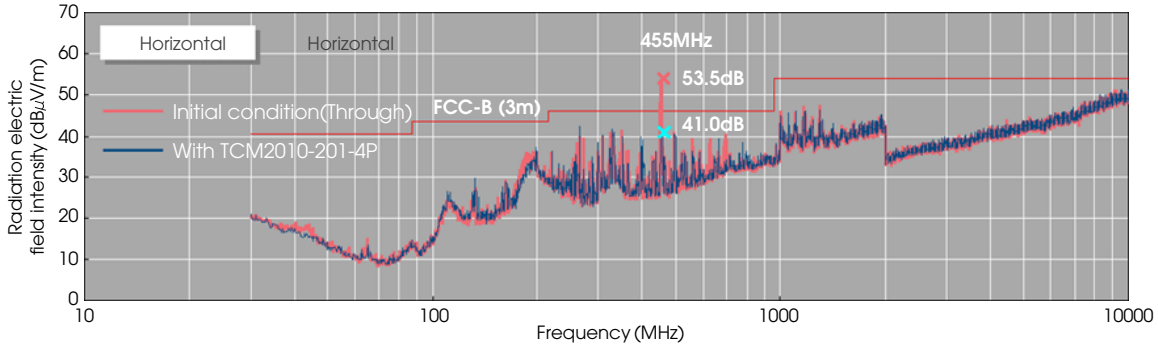
Radiation electric field intensity

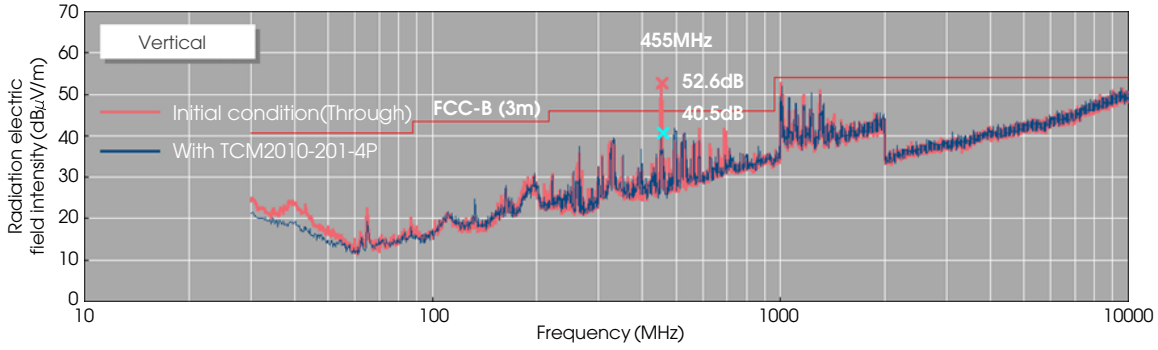
Comparison (before/after countermeasure)

Reduction effects of over 12dB are achieved with both horizontal polarization and vertical polarization for the double harmonic component(455MHz) of LVDS signal.



Example of LVDS line implementation



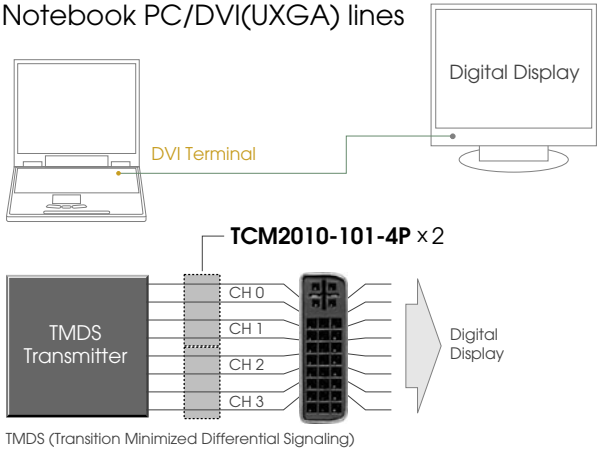


Actual measurement example of DVI line differential signal waveform/Example of radiation noise countermeasure

TCM2010

TCM series
1005, 1210, 1608, 2010 type

Notebook PC/DVI(UXGA) lines

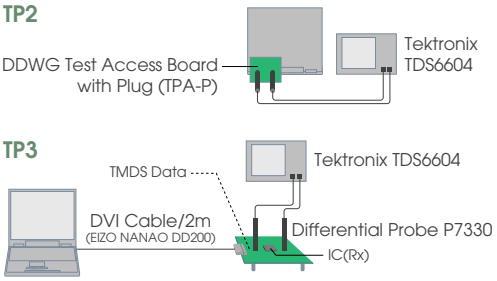


TMDS (Transition Minimized Differential Signaling)

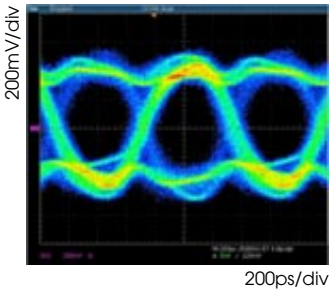
Eye pattern of data signal

Comparison (before/after countermeasure)
810MHz

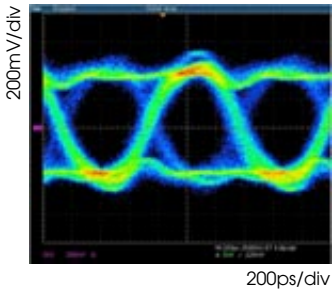
There is no deformation or degradation of eye pattern.



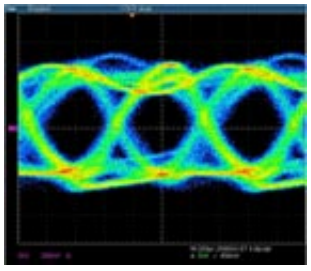
TP2 Initial condition(Through)



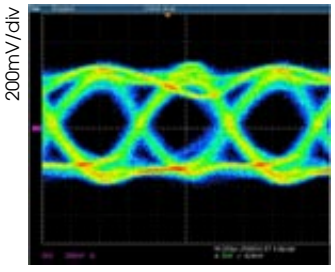
With TCM2010-101-4P



TP3 Initial condition(Through)



With TCM2010-101-4P



Radiation electric field intensity

Comparison (before/after countermeasure)

The multiple harmonic peaks appearing in the fundamental wave and in GHz bands are suppressed, and the peaks exceeding the standard value were reduced within an acceptable level.

Resolution:1600 x 1200(UXGA)