

TOSHIBA

Leading Innovation >>>

2015 International Technical Exhibition seminar

USB3 Vision, its potential...



Date & time : 15:30~16:20, (Thu) Dec. 3rd 2015

Venue : Seminar room in exhibition hall, Pacifico Yokohama



Sales & Marketing Div.

TOSHIBA TELI CORPORATION

Notification about this material

- ◆ This material contains Toshiba Teli's technical development information.
- ◆ Product information in this material are under planning but product commercialization is not confirmed. And specifications under development are subject to change without notice.
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※ Some of the names and logos of company, organization, standard might be registered trade mark of each.

Company overview

- **Name** TOSHIBA TELI CORPORATION
- **Established** Feb 17th 1950 (from Toshiba Co.)
- **HQ Location** 4-7-1, Asahigaoka, Hino, Tokyo, Japan
- **Capital** JPY 260 mill.
- **Shareholder** 72.8% by Toshiba Co.
- **Employees** 352 persons (as of Apr. 1st 2015)
- **Business** Design, manufacturing and sales of Industrial camera, medical camera, purveyance camera, RF power unit, remote controller etc.
- **Facilities** Head Quarter & works, Chubu branch, Kansai branch, Shanghai office

Agenda

- **Advanced feature of USB3.0**
- **Introduction of USB3 Vision**
- **Advantage of our USB3 Vision camera BU/DU series**
- **Challenge to high reliability & quality**
- **Advanced function of BU/DU series camera**
- **TeliCamSDK**
- **Application example**
- **Standard product range**
- **New proposal by Toshiba Teli**

Advanced features of USB3.0

USB3.0 interface spec. (Overview)

1

■ Bit rate : max. 5Gbps (Super Speed)

- Uncompressed HDTV (1920x1080) image can be transferred in 60fps

2

■ Cable length : ~5m

7m, 8m depend on system

- Longer cable with complementary devices are getting available by vendors
- Over 20m transfer by active optical cable (AOC)

3

■ Signal lines : 9 lines

- 4 lines: for ordinary USB2.0
- 4 lines: for expanded Super Speed
- 1 line :GND



4

■ Communication mode: Full duplex

- More effective communication than USB2.0 in semi duplex

5

■ BUS power: max. 900mA

- Up to 4.5W with 5V supply

Image transfer of our USB3.0 camera is supported by USB3.0 standard

6

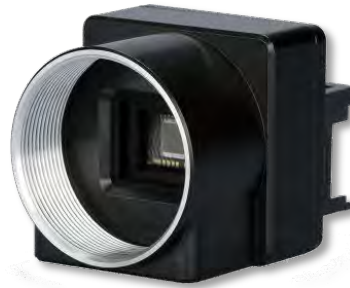
■ Lower compatible

- USB3.0 device can be connected to USB2.0 port (works as USB2.0)
- USB2.0 device can be connected to USB3.0 port

USB3 Vision

What's USB3 Vision ?

USB³TM
VISION



- **Machine vision standard**

(IEEE1394 by IIDC, Gig-E by Gig-E Vision

)

- **High band width of 5Gbps (440 MByte/s)**

- **Easy connection with Plug & Play**

- **5m cable length (passive cable)**

(Longer in case of active optical cable)

- **Standardized software interface with GenICamTM**

- **Much improved robust than USB2.0**

Major members of USB3 Vision standard



※ Names and Logo might be trade mark or registered trade mark.

High band width transfer

HIGH Bandwidth

- Full use of high speed image sensor's feature ... USB3.0
- High band width transfer by burst ... USB3.0

Sensor : Sony IMX174
Resolution : 1920 x 1200 (2.3MP)

Gig-E Vision Camera

Max. frame rate: 50fps
Data rate: 115MB/s



USB3 Vision Camera

Max. frame rate: 165fps
Data rate: 380MB/s

Sensor : CMOSIS CMV4000
Resolution : 2048 x 2048 (4.2MP)

Gig-E Vision Camera

Max. frame rate: 25fps
Data rate: 105MB/s

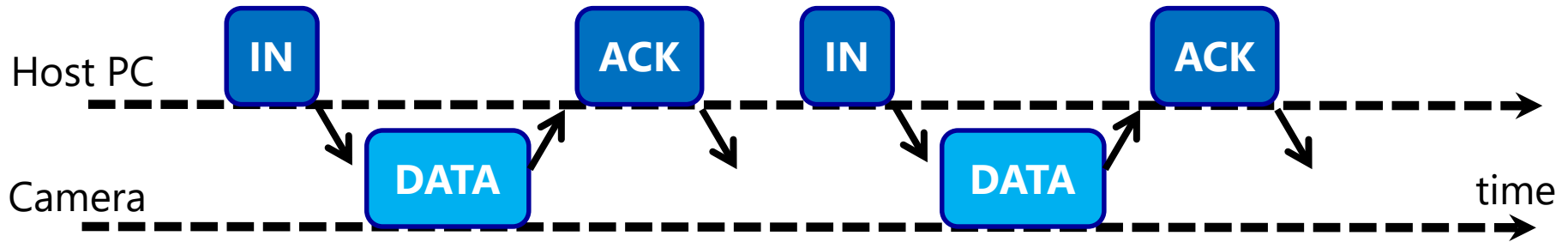


USB3 Vision Camera

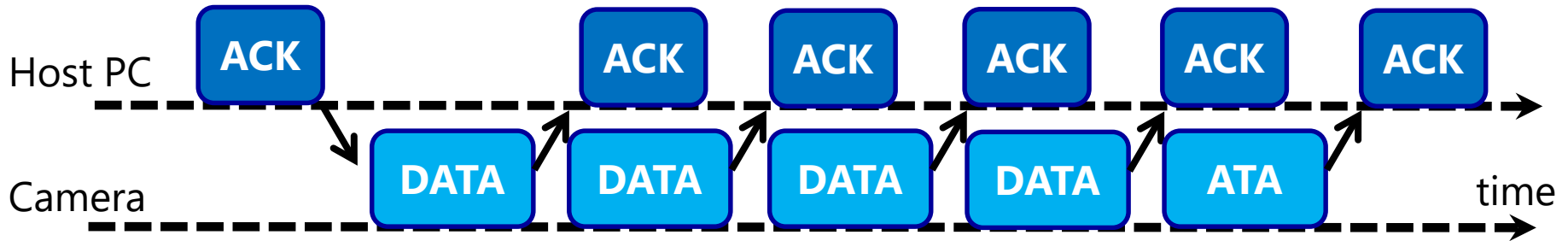
Max. frame rate: 90fps
Data rate: 377MB/s

For burst transfer

■ USB2.0 : Not for burst transfer

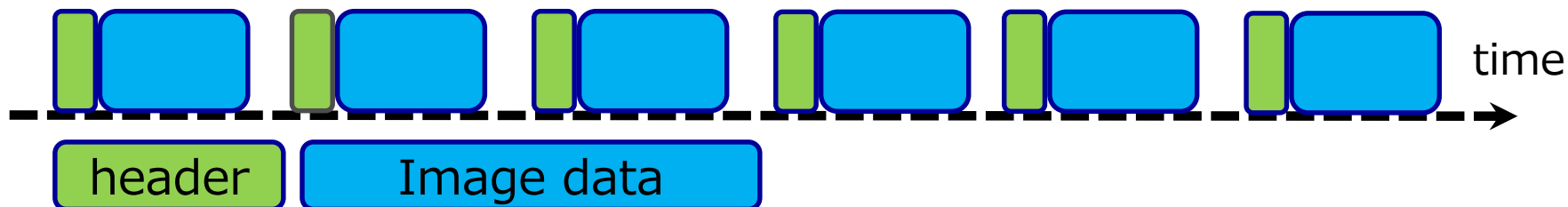


■ USB3.0 : for burst transfer

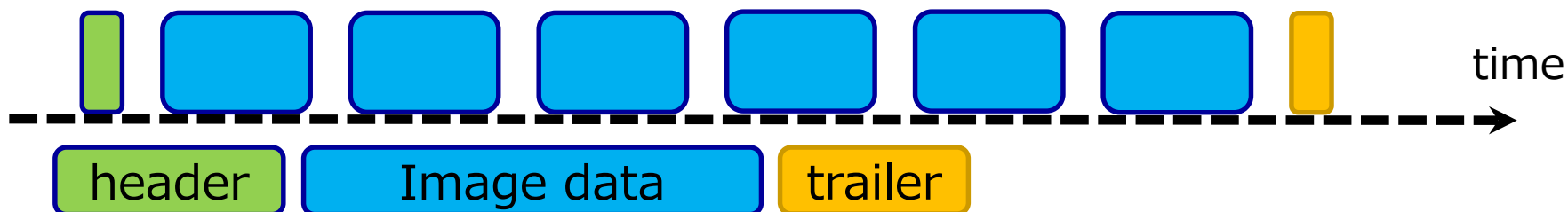


Packet format of USB3 Vision

■ UVC (USB Video Class) packet format



■ USB3 Vision packet format



System cost comparison

LOW COST

- Low cost accessories ...USB3.0
- No power supply is needed ...USB3.0

	USB3.0	Gig-E	1394.b	Camera Link
Frame grabber	Low	Low	Mid.	High
Cable	Low	Low	Mid.	High
Power supply	Bus	External/ PoE	Bus	External/ PoCL
Camera	Low	Mid.	Mid.	Low
System cost of 4 cameras	Low	Mid.	Mid.	High

Applicable range of USB3.0



CameraLink
Medium Configuration
(4Gbps)



USB3.0
(4Gbps)

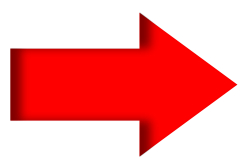


<example>
about JPY144k
for a camera
With big cost down

CSC6M100BMP11

DU657M

A camera (CL-FullConfig)
About JPY420k
camera (6.5M) : JPY280k
board : JPY100k
cable : JPY30k
(power) : JPY10k



A camera (USB3 Vision)
About JPY276k
camera (6.5M): JPY260k
board : JPY8k
cable : JPY8k

Big cost down by replacing Camera Link system with USB3.0 system!

High reliability

HIGH Reliability

- Reliable data transfer is ensured ...USB3.0
- Packet format, Appropriate for DMA transfer ...USB3 Vision

Protocol Layer

data check by CRC

packet retransmission in protocol layer level

Link Layer

data check by CRC

packet retransmission in protocol layer level

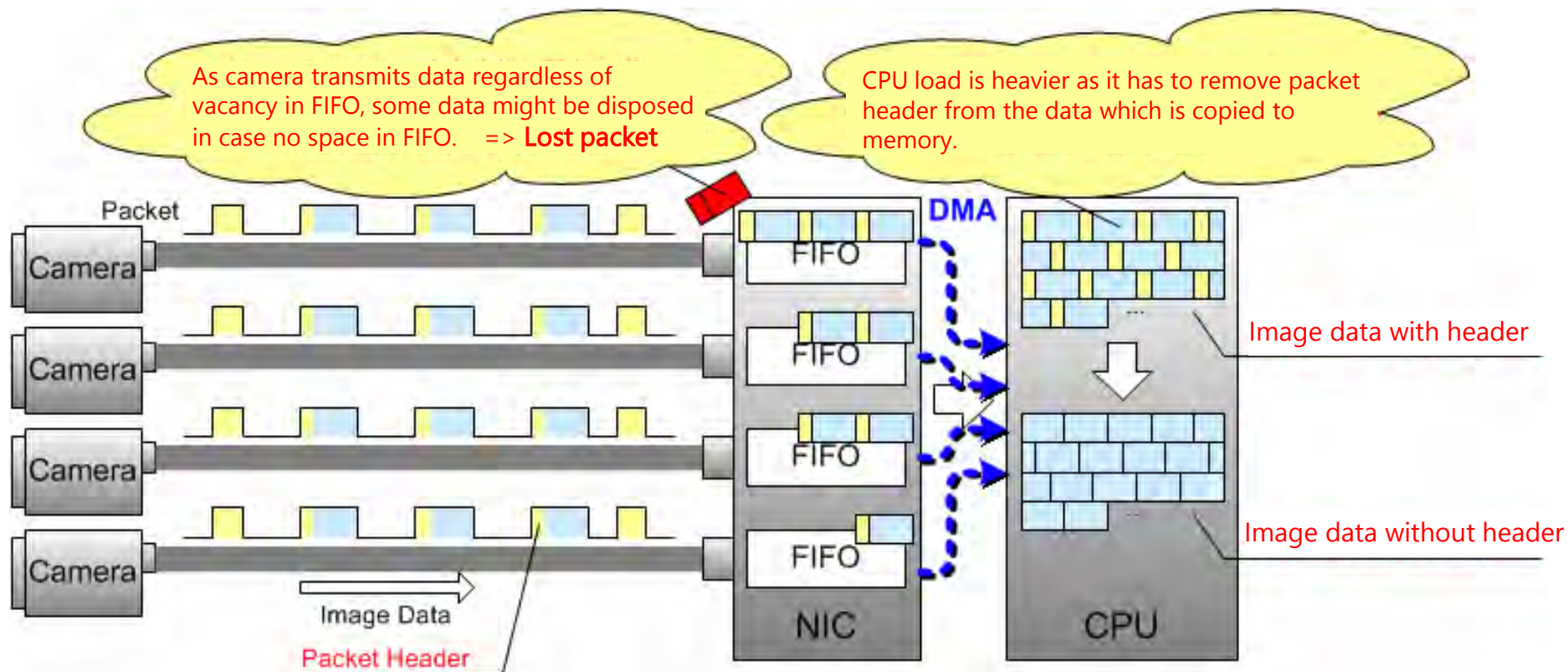
Error protection of USB3.0 is much improved from USB2.0

Physical Layer

bit error ratio in physical layer level is less than 1×10^{-12} bits

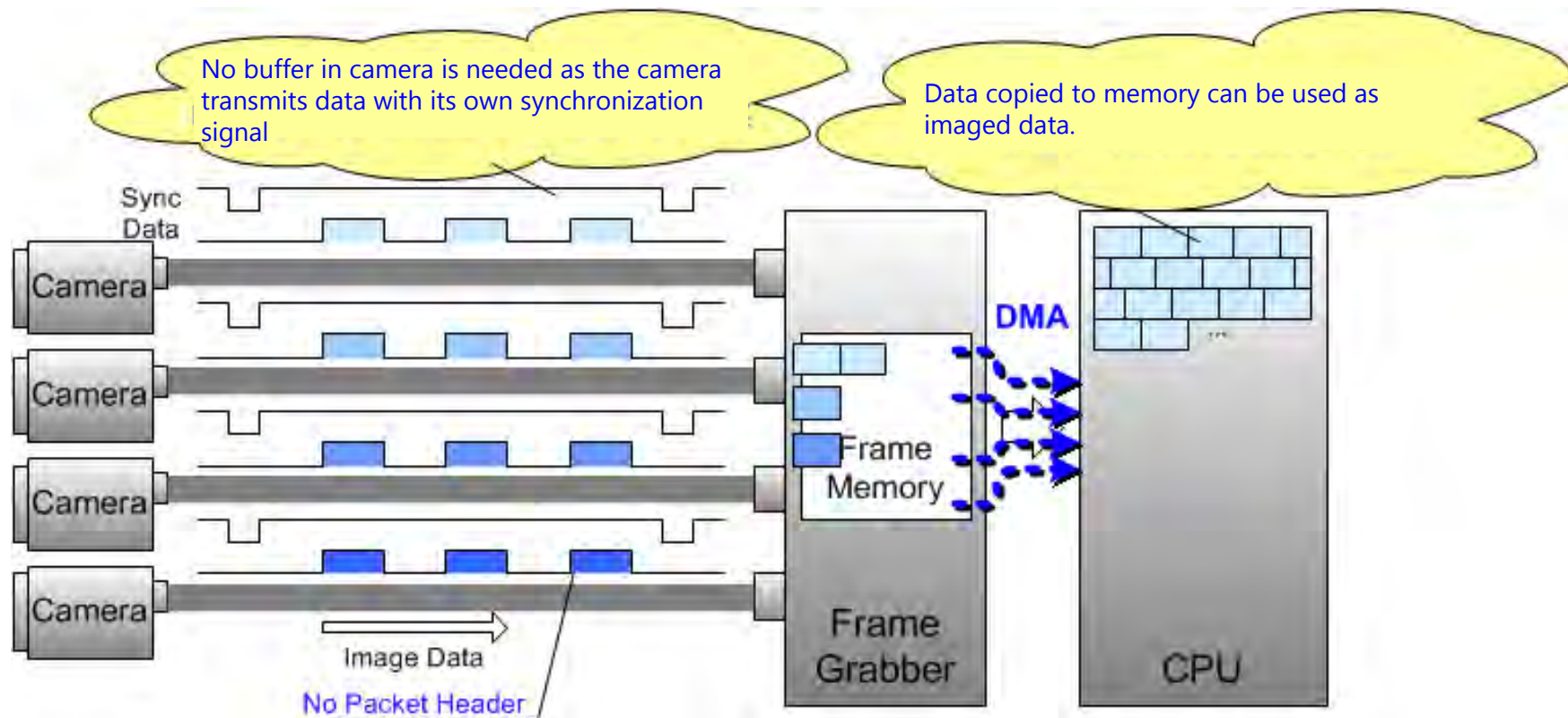
Data transfer reliability in CPU load aspect

■ Gig-E Vision



Data transfer reliability in CPU load aspect

■ Camera Link

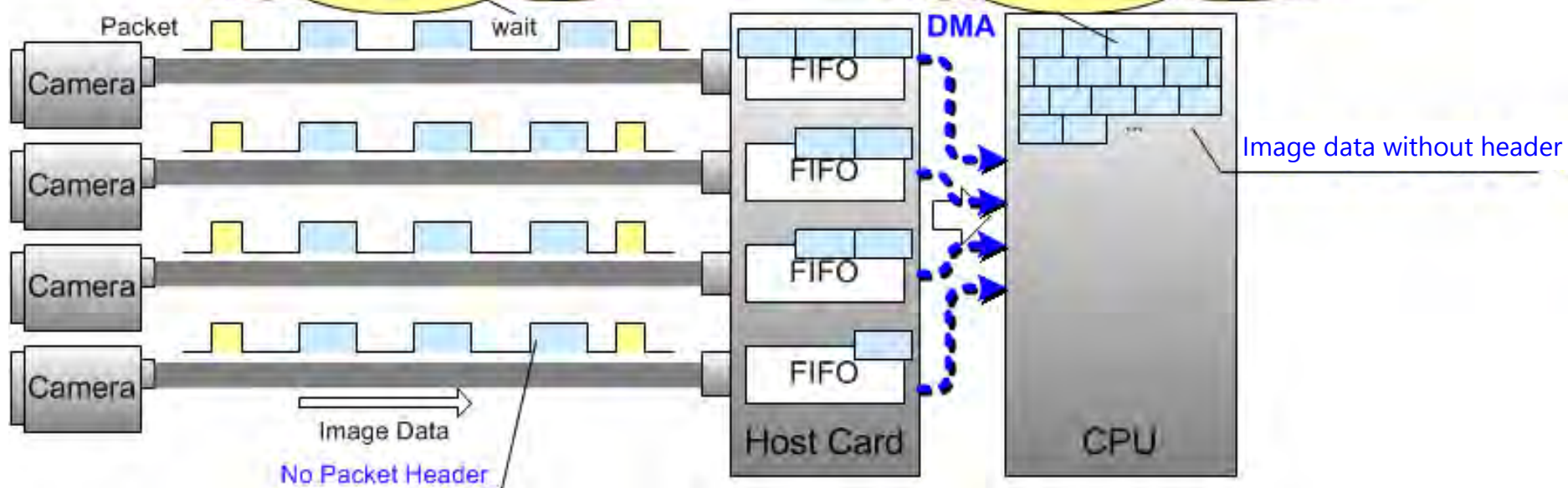


Data transfer reliability in CPU load aspect

■ USB3 Vision

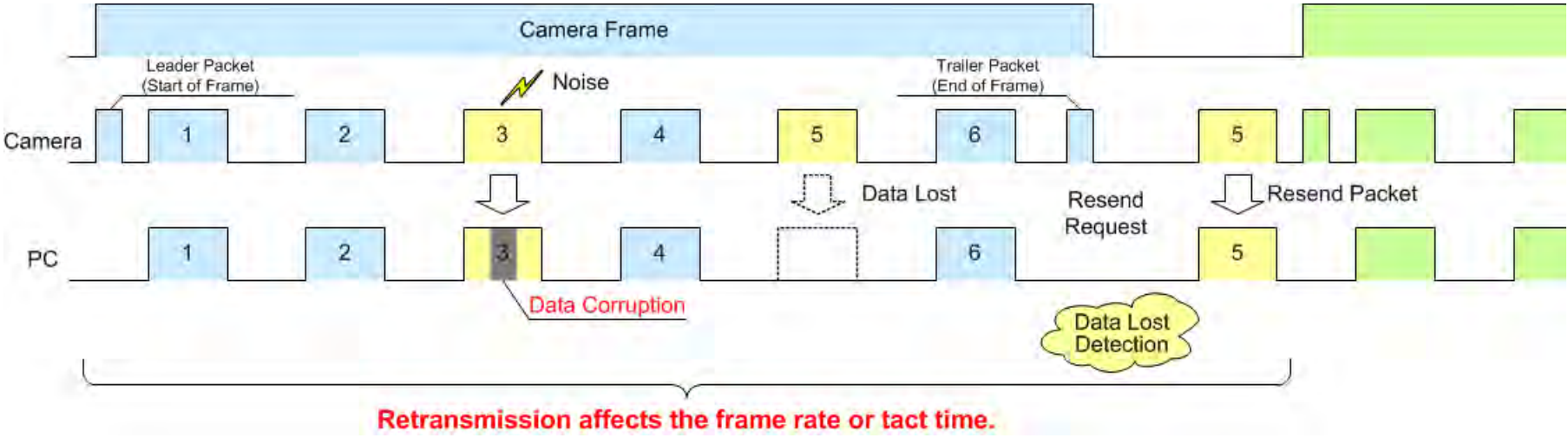
As camera transmits data upon a request by host, it holds transmission due to no request in case no space in FIFO. => **No lost packet**

Data copied to memory can be used as image data because it does not have packet header.



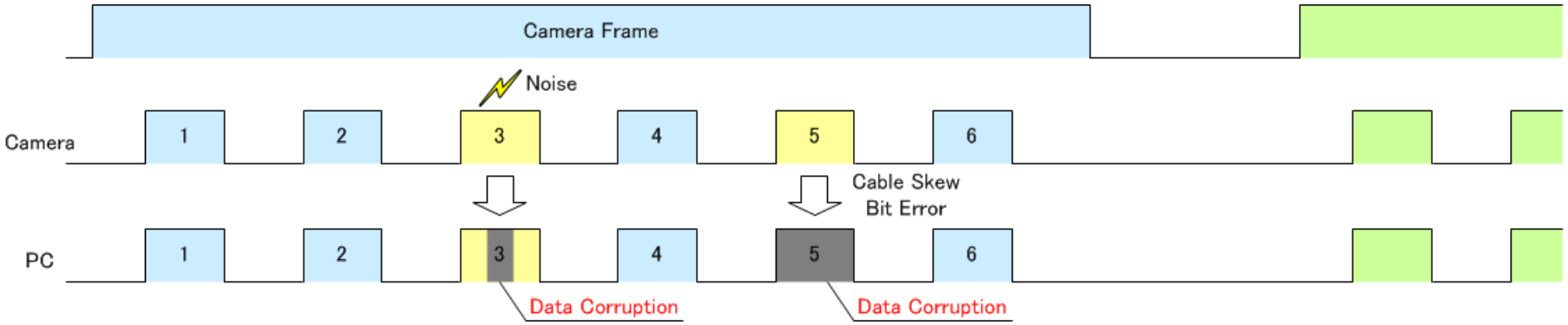
Comparison of error detection and packet retransmission

■ Gig-E Vision



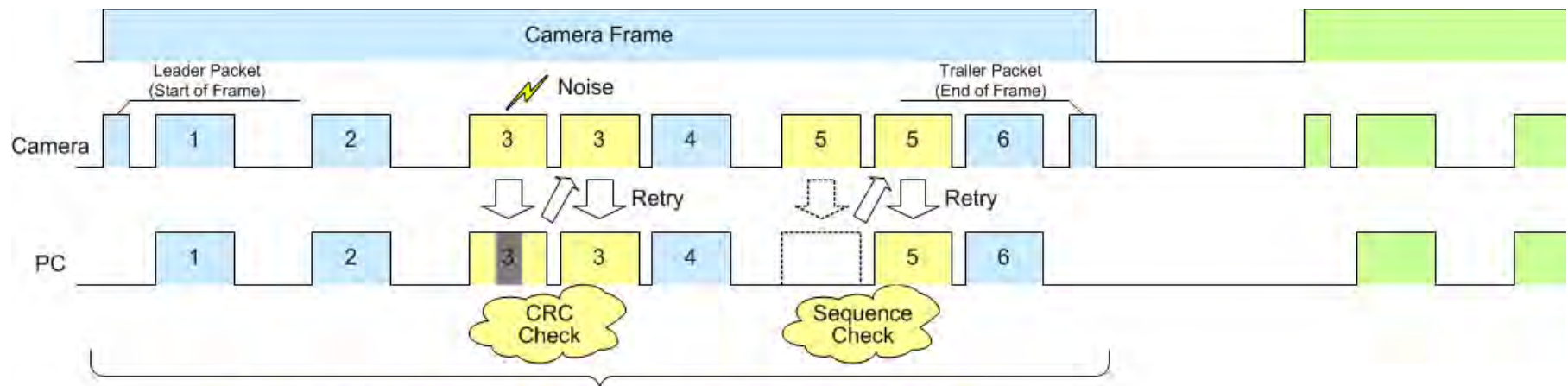
Comparison of error detection and packet retransmission

■ Camera Link



Comparison of error detection and packet retransmission

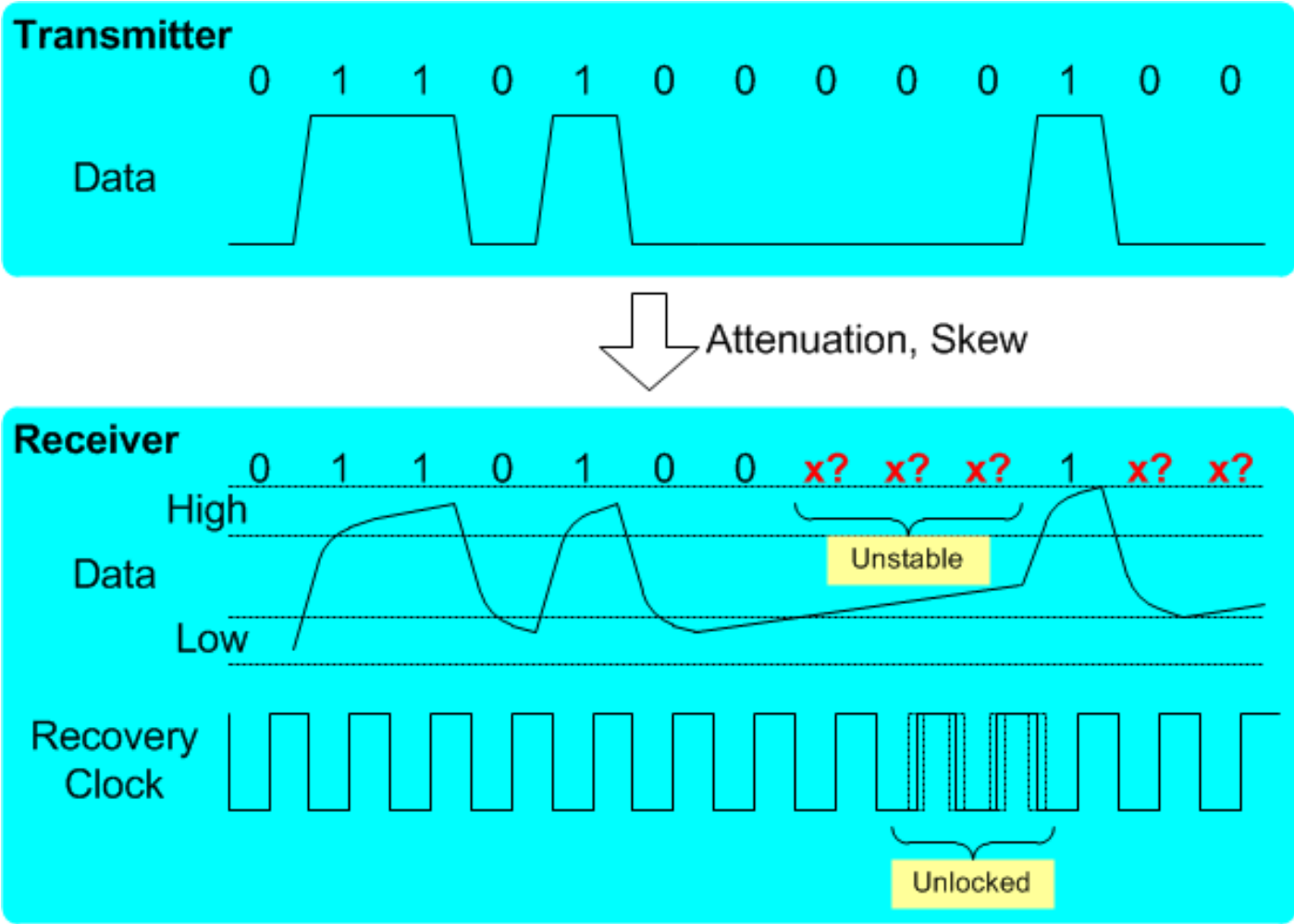
■ USB3 Vision



Retransmission doesn't affect the frame rate and tact time.

Expanded data reliability by USB3.0 (Physical Layer)

■ DC balance in physical layer



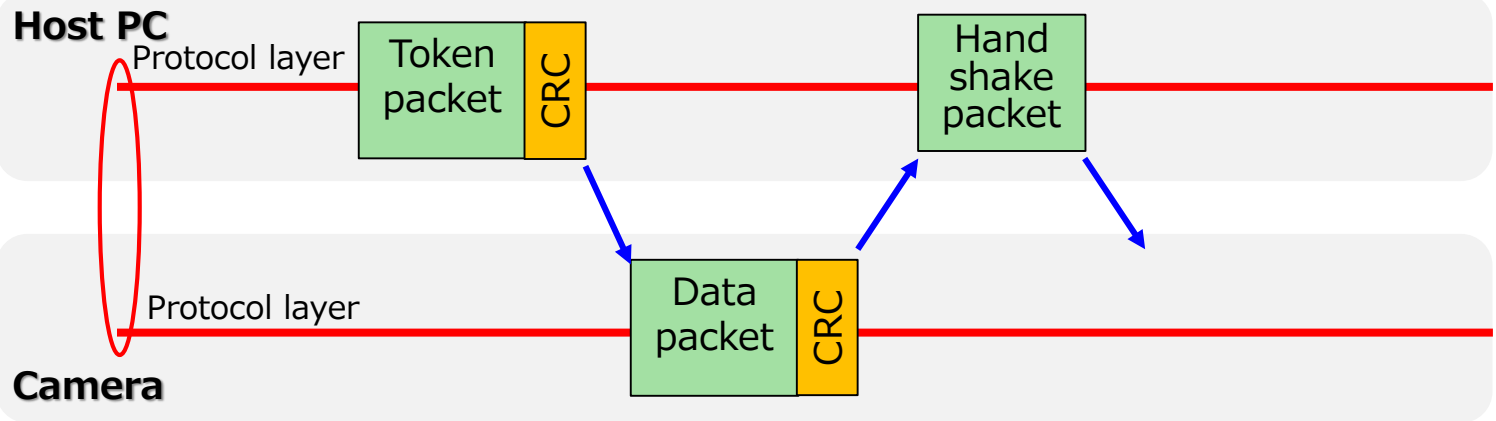
Expanded data reliability by USB3.0 (Physical Layer)

- 8b/10b encode is used in USB3.0

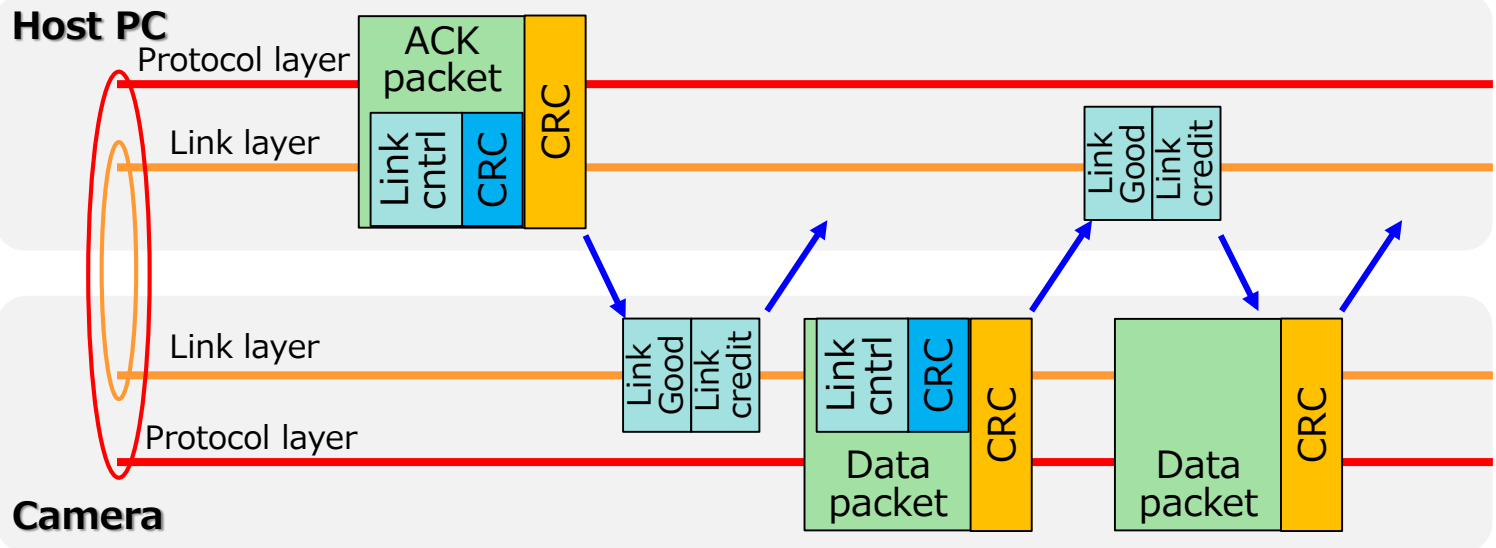
	Encode method	DC balance
CameraLink	none	Bad
IEEE1394.b	8b/10b	Excellent
Gig-E(1000Base-T)	PAM5	Excellent
USB2.0	NRZI	Good
USB3.0	8b/10b	Excellent

Expanded data reliability by USB3.0 (Link/Protocol Layer)

USB2.0



USB3.0

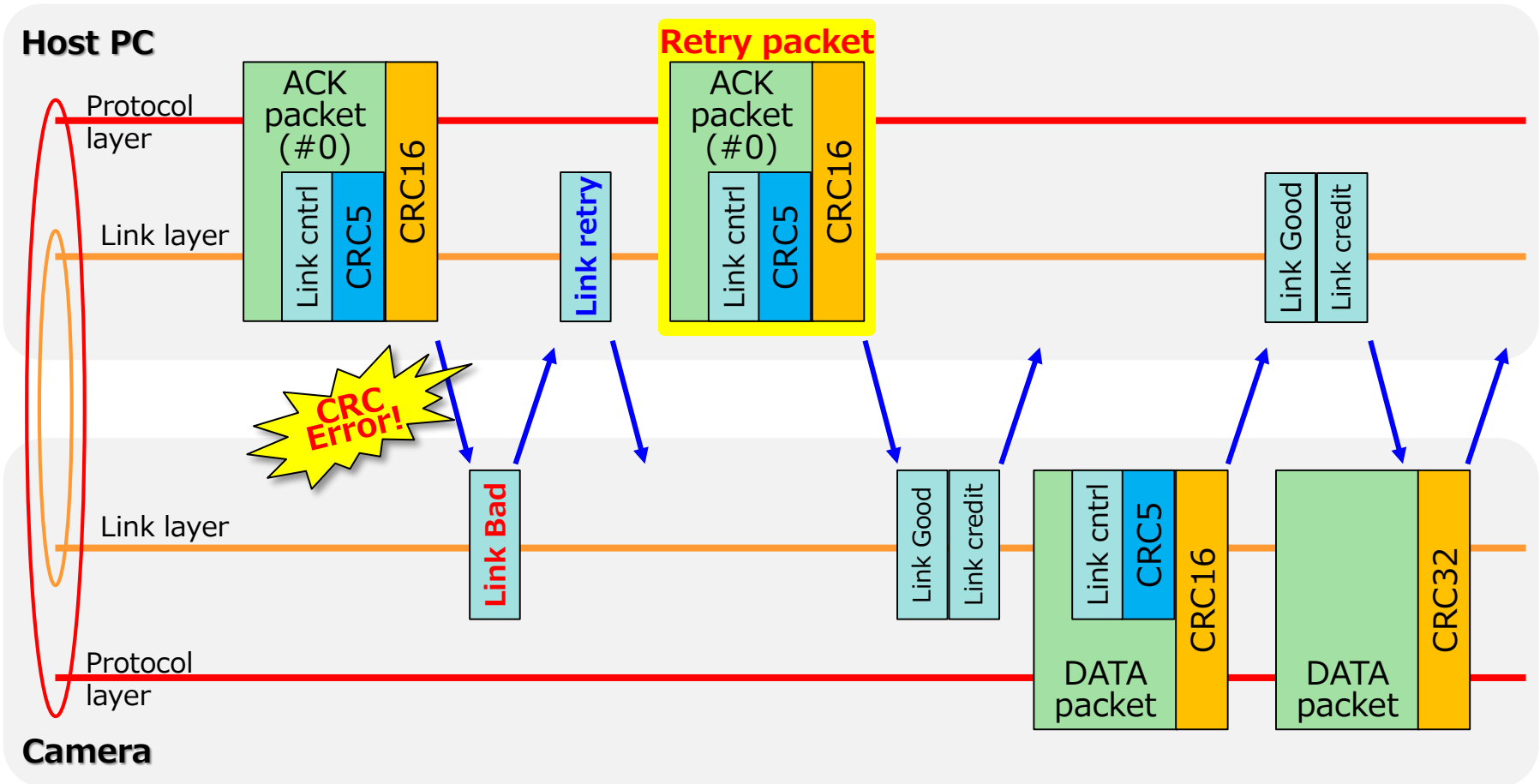


Expanded data reliability by USB3.0 (Link Layer)

■ Mechanism of USB3.0 re-try

USB3.0

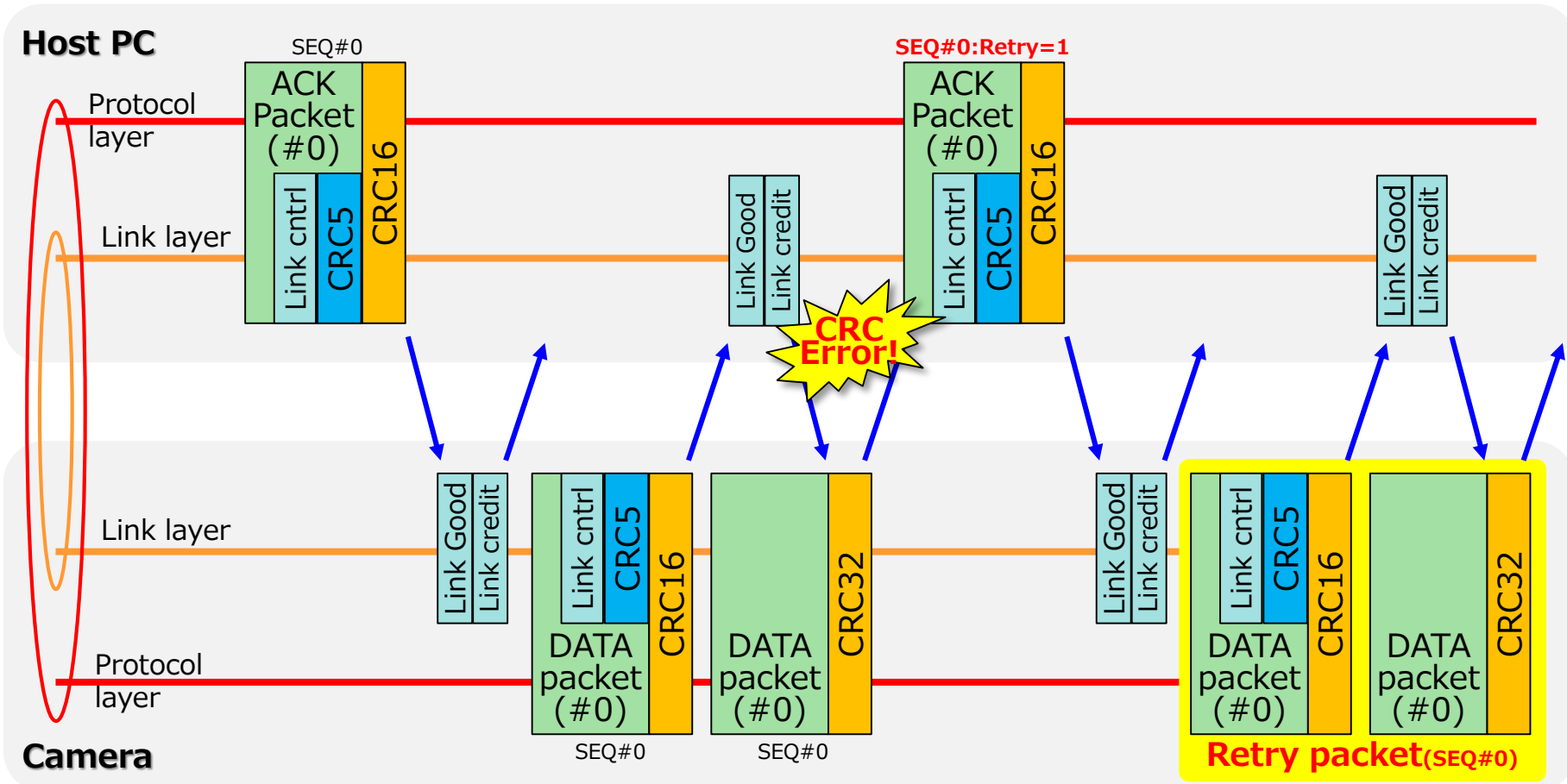
(example of retransmission in link layer level)



Expanded data reliability by USB3.0 (Protocol Layer)

■ Retry mechanism of USB3.0 (example in protocol layer)

USB3.0



Expanded reliability by USB3.0

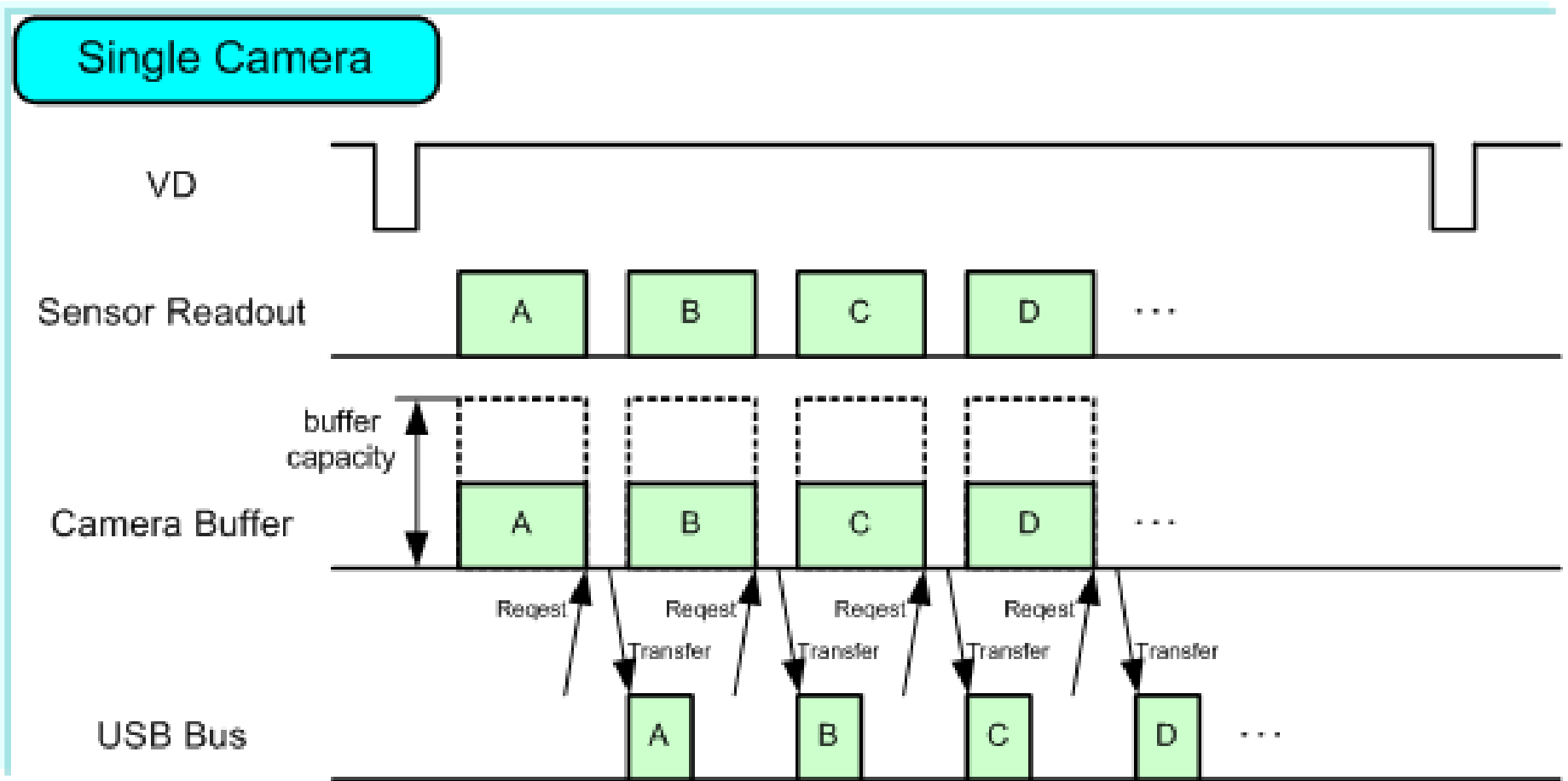
- Support for packet retransmission

	Retry layer	Remarks
CameraLink	None	-
IEEE1394.b	None	Isochronous
Gig-E(1000Base-T)	Application	Gig-E Vision
USB2.0	Protocol	Bulk
USB3.0	Link/Protocol	Bulk

Advantage of our USB3 Vision camera BU/DU series

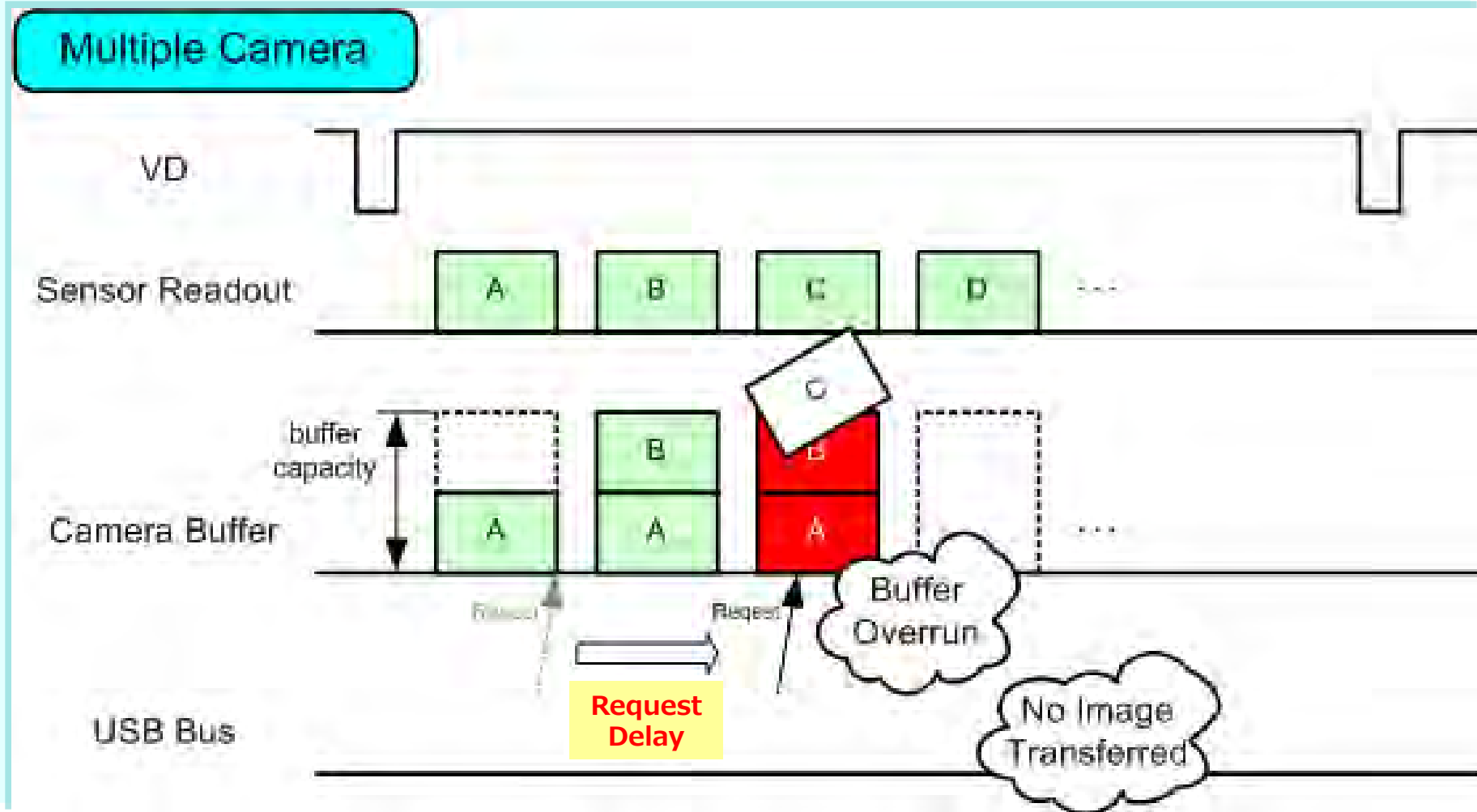
Flow control of image data

■ Getting image from a camera :



Flow control of image data

- Example of delayed transmission request from PC with multiple cameras :



Flow control of image data

- Buffer over run protection on our USB3 Vision camera CCD model :
- Solution :

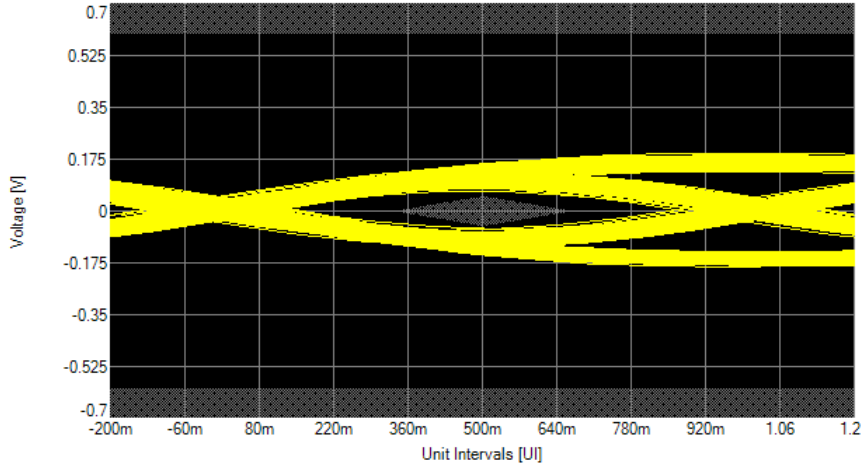
Buffer over run protection realizes a unique control by our design.

Error recovery

■ Cause of communication instability

Good quality cable: eyes are opened

Eye Diagram

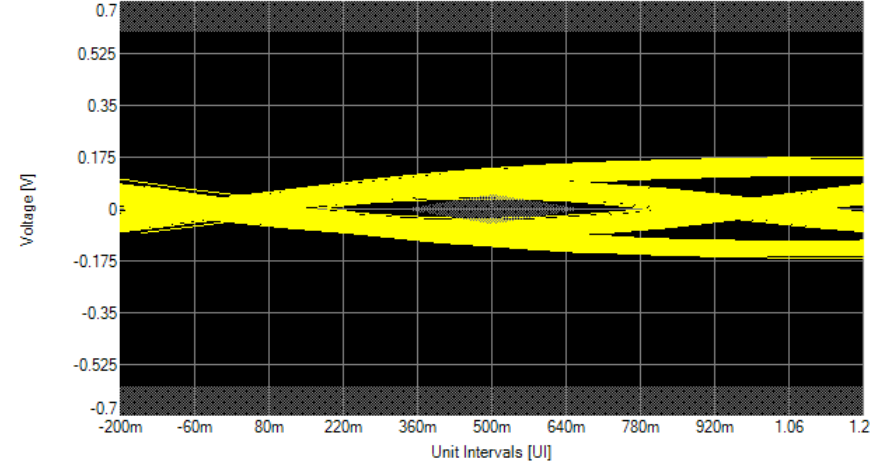


Legend:

■ Waveform

Poor quality cable: eyes are closed

Eye Diagram

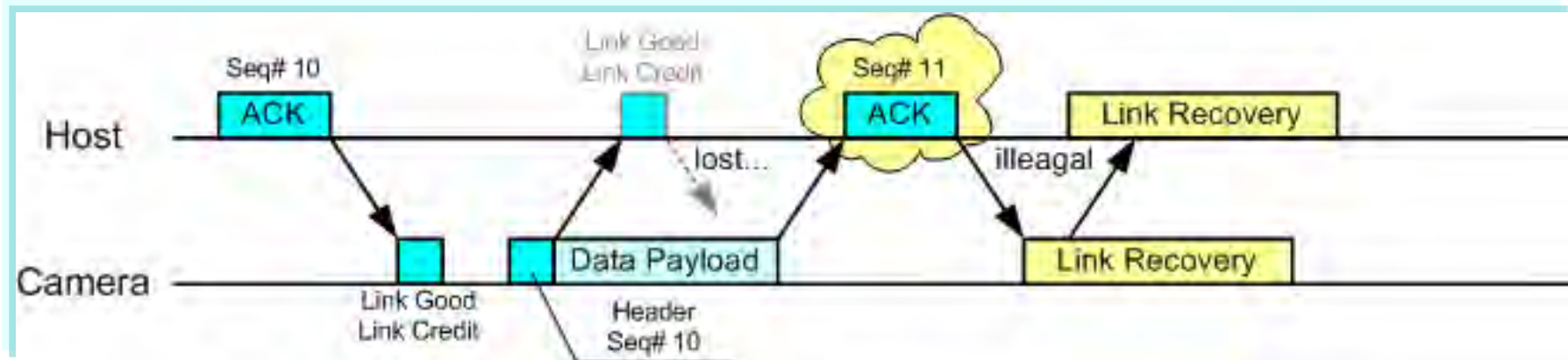


Legend:

■ Waveform

Error recovery

Case 1: Lost of packet from host

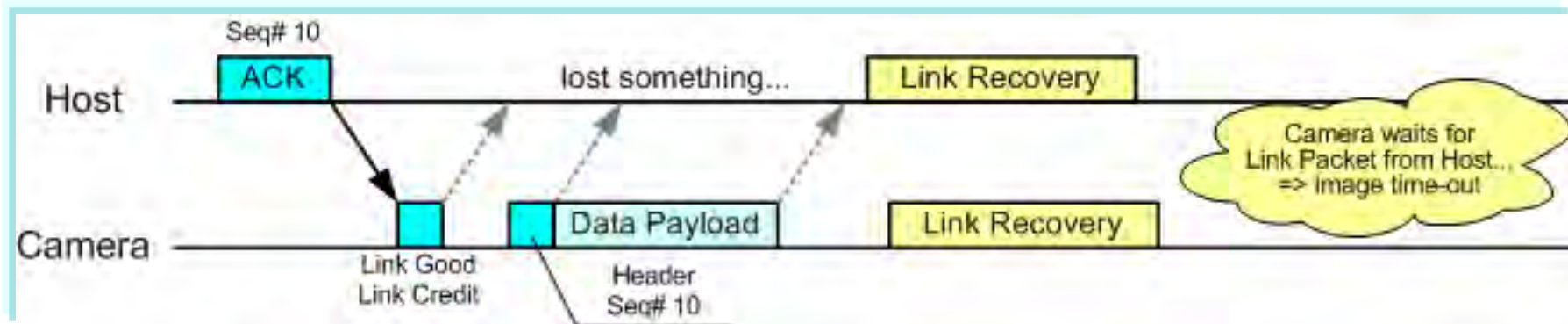


Solution :

BU/DU camera realizes a unique error recoveries by our USB IP.

Error recovery

■ Case 2: Lost of packet from camera



■ Solution:

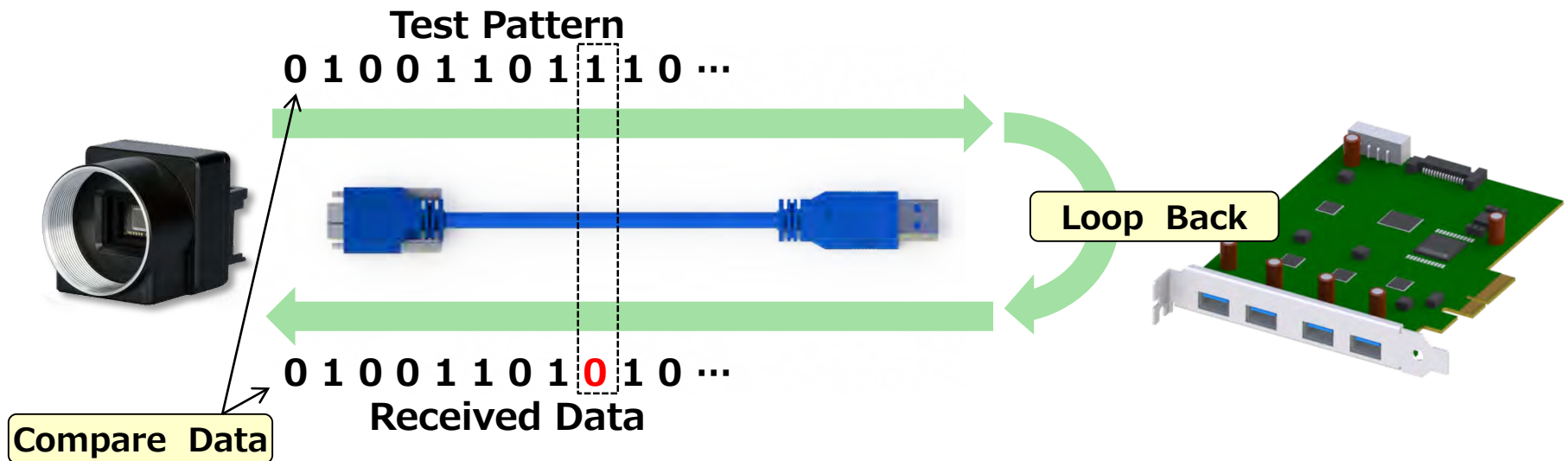
BU/DU camera realizes a unique error recoveries by our USB IP.

Reset function

- Camera reset
- Host controller reset

BERT function

- BERT (Bit Error Rate Test) = CMOS model



Challenge to reliability and quality

Challenge to each development status

Wide band width oscilloscope

Bus analyzer

Optical axis auto adjustment

Thermal analysis



Plan

Design

Evaluation

**Mass
production**

SI analysis

3D analysis

Reliability evaluation

*Camera auto
adjustment*

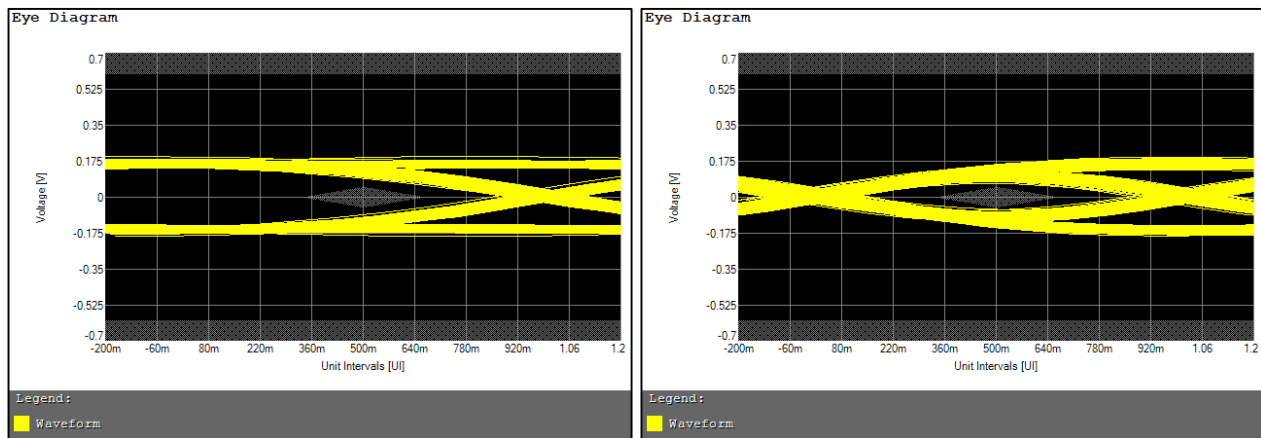
Ensure signal quality on the board by SI analysis

3D analysis

Ideal pattern layout by prior board pattern simulation of impedance, attenuation, delay etc.

Demonstrated signal quality

- Clearing standard by actual measuring verification based on USB compliance test.



Test Name	Pass	Spec Range
LFPS Peak-Peak Differential Output Voltage	✓	800.0 mV <= VALUE <= 1.2000 V
LFPS Period (tPeriod)	✓	20.0000 ns <= VALUE <= 100.0000 ns
LFPS Burst Width (tBurst)	✓	600.0 ns <= VALUE <= 1.4000 μs
LFPS Repeat Time Interval (tRepeat)	✓	6.0000 μs <= VALUE <= 14.0000 μs
LFPS Rise Time	✓	VALUE <= 4.0000 ns
LFPS Fall Time	✓	VALUE <= 4.0000 ns
LFPS Duty cycle	✓	40.0000 % <= VALUE <= 60.0000 %
LFPS AC Common Mode Voltage	✓	VALUE <= 100.0 mV
TSSC-Freq-Dev-Min	✓	TSSCMin ppm <= VALUE <= TSSCMax ppm
TSSC-Freq-Dev-Max	✓	-300.000 ppm <= VALUE <= 300.000 ppm
SSC Modulation Rate	✓	30.000000 kHz <= VALUE <= 33.000000 kHz
SSC Slew Rate	✓	VALUE <= 10.000 ms
Far End Random Jitter (CTLE ON)	✓	VALUE <= 230 mUI
Far End Maximum Deterministic Jitter (CTLE ON)	✓	VALUE <= 430 mUI
Far End Total Jitter at BER-12 (CTLE ON)	✓	VALUE <= 660 mUI
Far End Template Test (CTLE ON)	✓	VALUE = 0.000
Far End Differential Output Voltage (CTLE ON)	✓	100.0 mV <= VALUE <= 1.2000 V



Cable quality

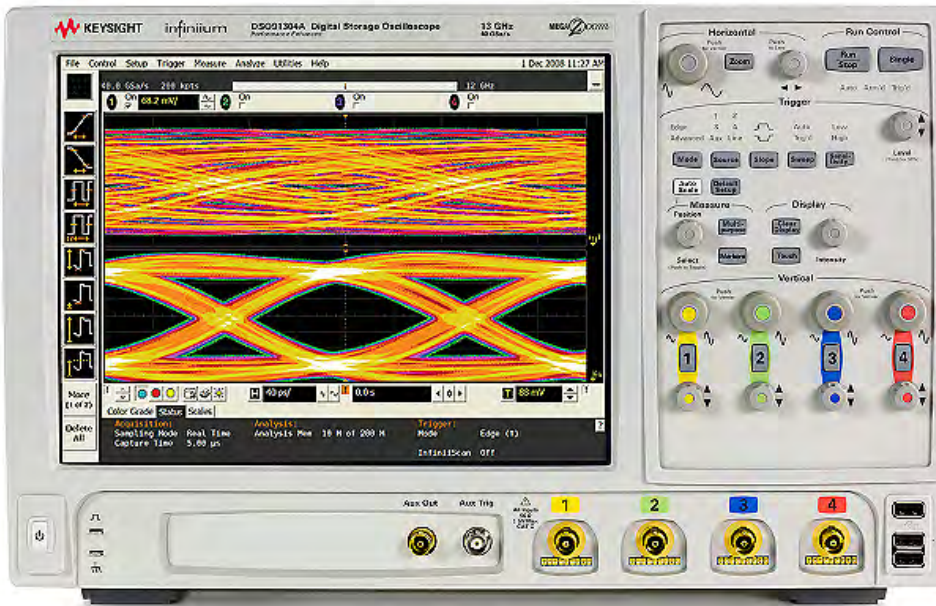


Reliability test on USB3 cable

Combinational evaluation result of USB3 Vision board and cables										
			Board							
			Company X		Company Y				company Z	
			4port		4port		2port		2port	
Cable			BERT	Continuous Test	BERT	Continuous Test	BERT	Continuous Test	BERT	Continuous Test
Company A	Norm	8m	OK	OK	OK	OK	OK	-	NG	NG
	Norm	9m	NG	OK	OK	OK	OK	-	NG	-
	Robot	5m	OK	OK	OK	OK	-	-	OK	OK
	Robot	8m	OK	OK	OK	OK	OK	-	NG	NG
Company B	Norm	5m	OK	OK	OK	OK	-	-	-	-
	Norm	6m	OK	OK	OK	OK	OK	-	OK	-
	Norm	7m	OK	OK	OK	OK	OK	-	OK	OK
Company C	Norm	3m	OK	-	OK	OK	-	-	OK	-
Company D	Norm	5m	OK	OK	OK	-	-	-	-	-
	Active	5m	NG	NG	OK	-	OK	-	OK	OK
	Active	10m	NG	NG	OK	OK	OK	-	OK	OK
Company E	AOC	20m	OK	OK	OK	OK	OK	-	OK	OK

◆BERT : Evaluation result of BERT
 ◆Continuous Test : Evaluation result of 72 hour continuous operation
 ◆“-” : Unadministered test

Evaluation facilities

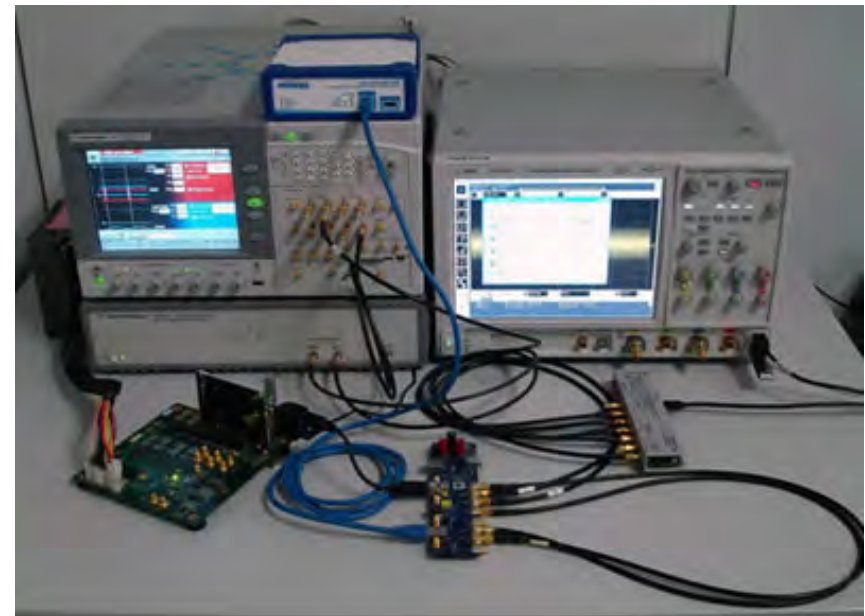


Keysight Technologies
DSO91304A Infiniium High Performance Oscilloscope

Wide band range oscilloscope

- Compliance test
- Bus analyzer

USB bus analyzer



Advanced features of BU/DU series camera

Advanced features

■ Sequential shutter mode

Bulk trigger setting:
3 shots (example)



Trigger input
(3 times)

Data output
(3 frames)

1st shot



Gain: 0.5dB
Exposure time: 0.7msec

2nd shot



Gain: 3dB
Exposure time: 0.7msec

3rd shot



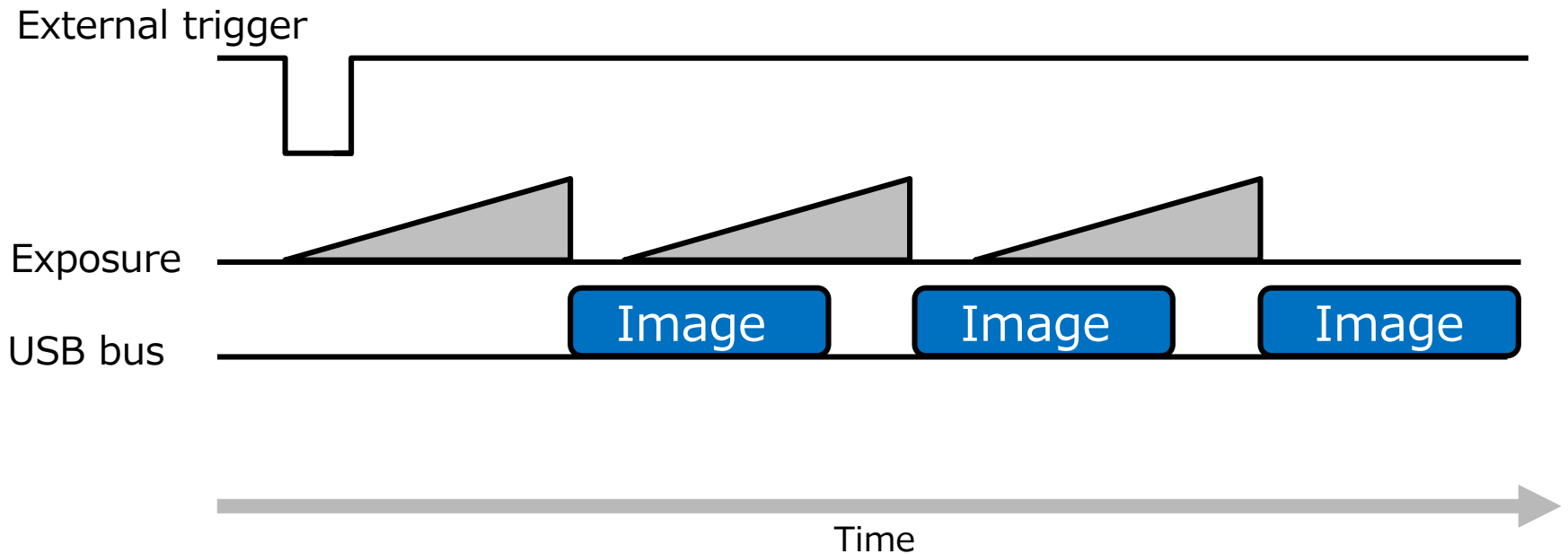
Gain: 8dB
Exposure time: 0.3msec



➤ Toshiba Teli is the patent holder of Sequential Shutter.

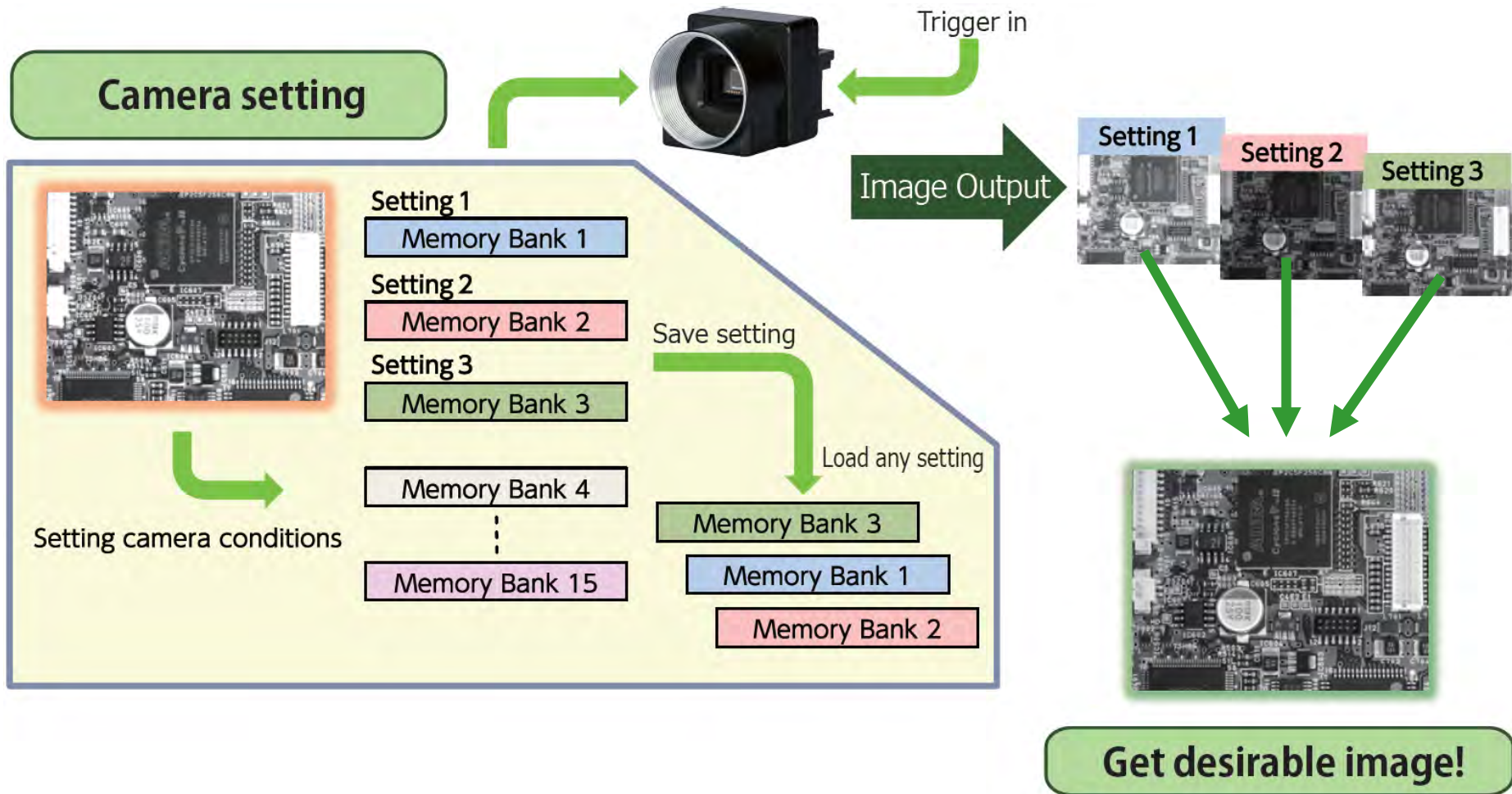
Advanced features

■ Bulk trigger mode



Advanced features

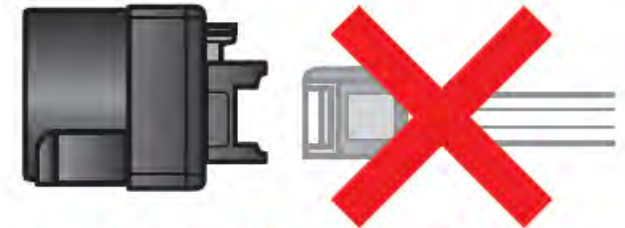
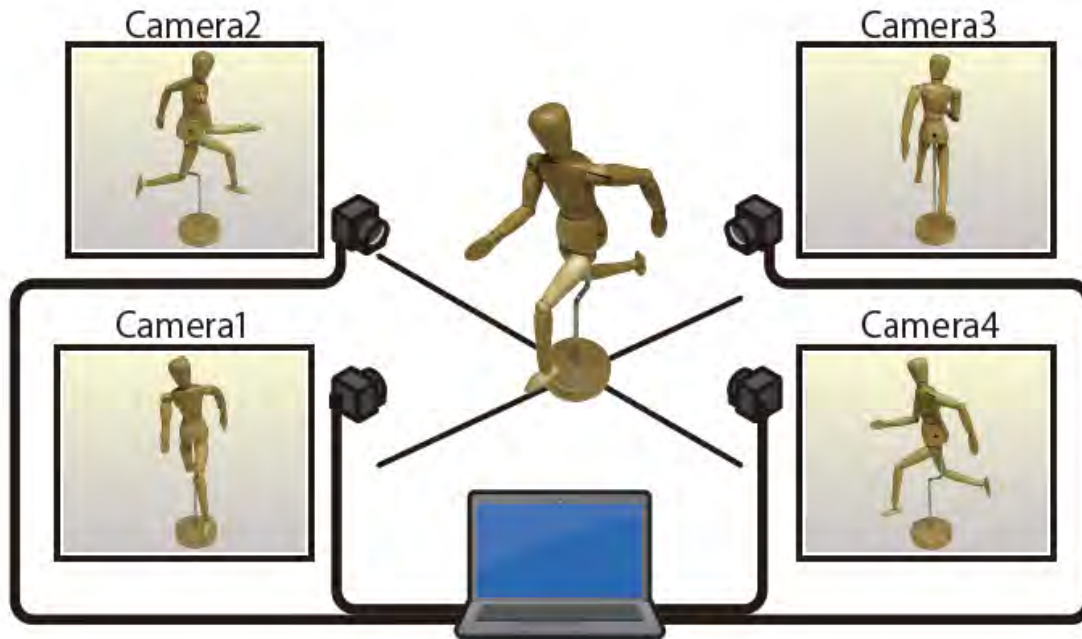
■ Sequential shutter+ Bulk trigger mode



➤ Toshiba Teli is the patent holder of Sequential Shutter.

Advanced features

■ Bus synchronization



**No cable needed for
'Trigger in'!**

Applications:
Stereo camera
Motion capture

➤ Toshiba Teli is the patent holder of Bus Synchronization.

Advanced features

■ Event notification

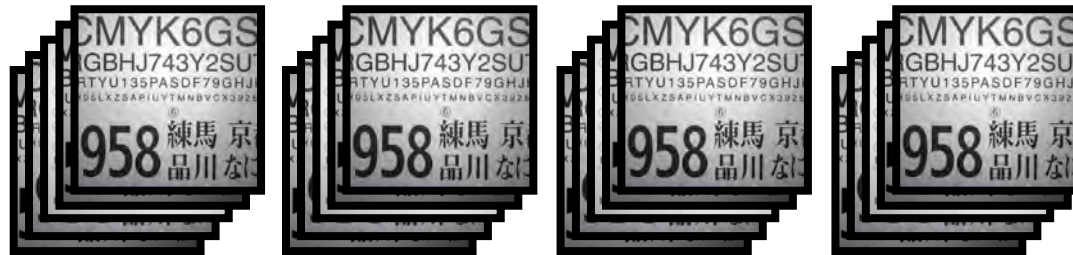


Example of triaxial robot

- 1 FrameTrigger : Reception of Frame Start Trigger
- 2 FrameTriggerError : Rejection of Frame Start Trigger
- 3 FrameTriggerWait : Start of waiting for Frame Start Trigger
- 4 FrameTransferStart : Start of transferring Streaming Data
- 5 FrameTransferEnd : End of transferring Streaming Data
- 6 ExposureStart : Start of Exposure
- 7 ExposureEnd : End of Exposure
- 8 Timer0Start : Start of Timer "0"
- 9 Timer0End : End of Timer "0"

Advanced features

■ Image buffer

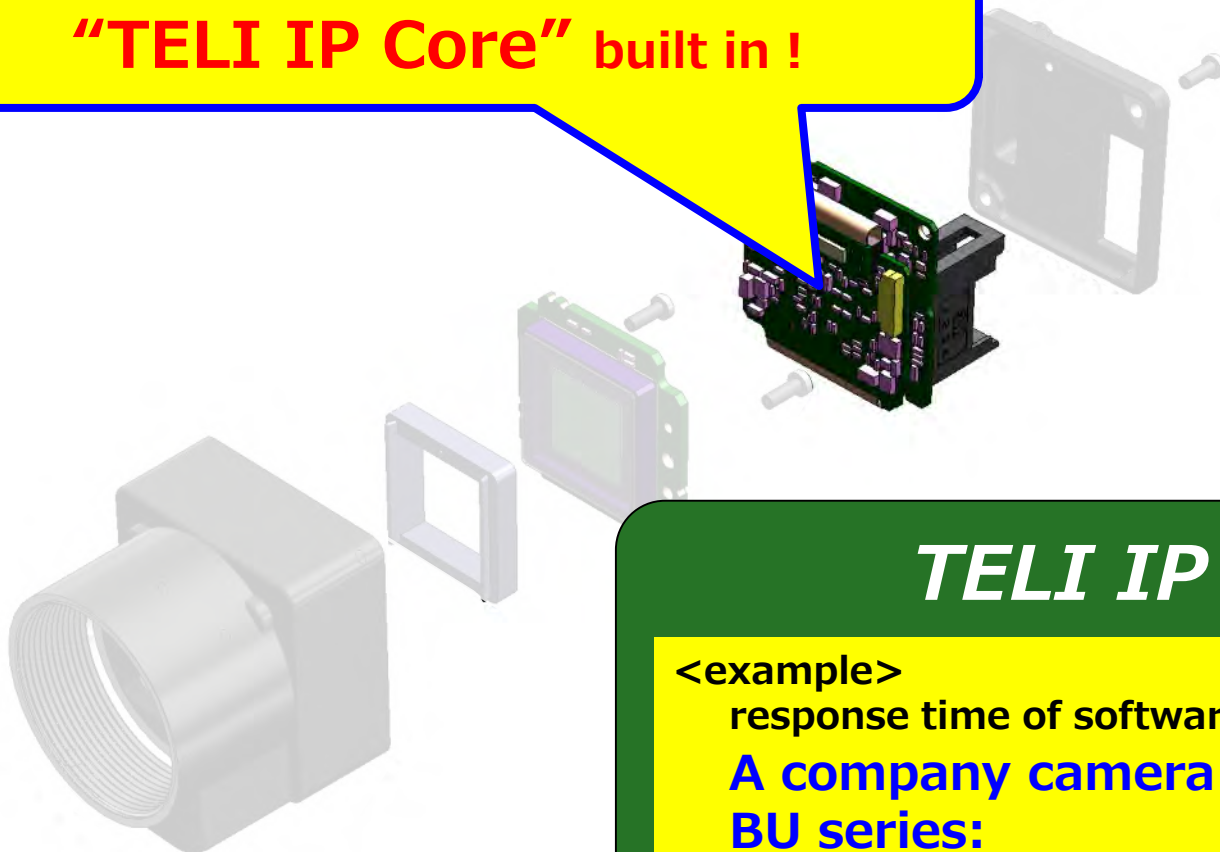


Multiple frames can be read and recorded

IP core of BU/DU series

- Extremely quick response by original IP core

Newly developed TELI original IP core
"TELI IP Core" built in !



TELI IP Core

<example>

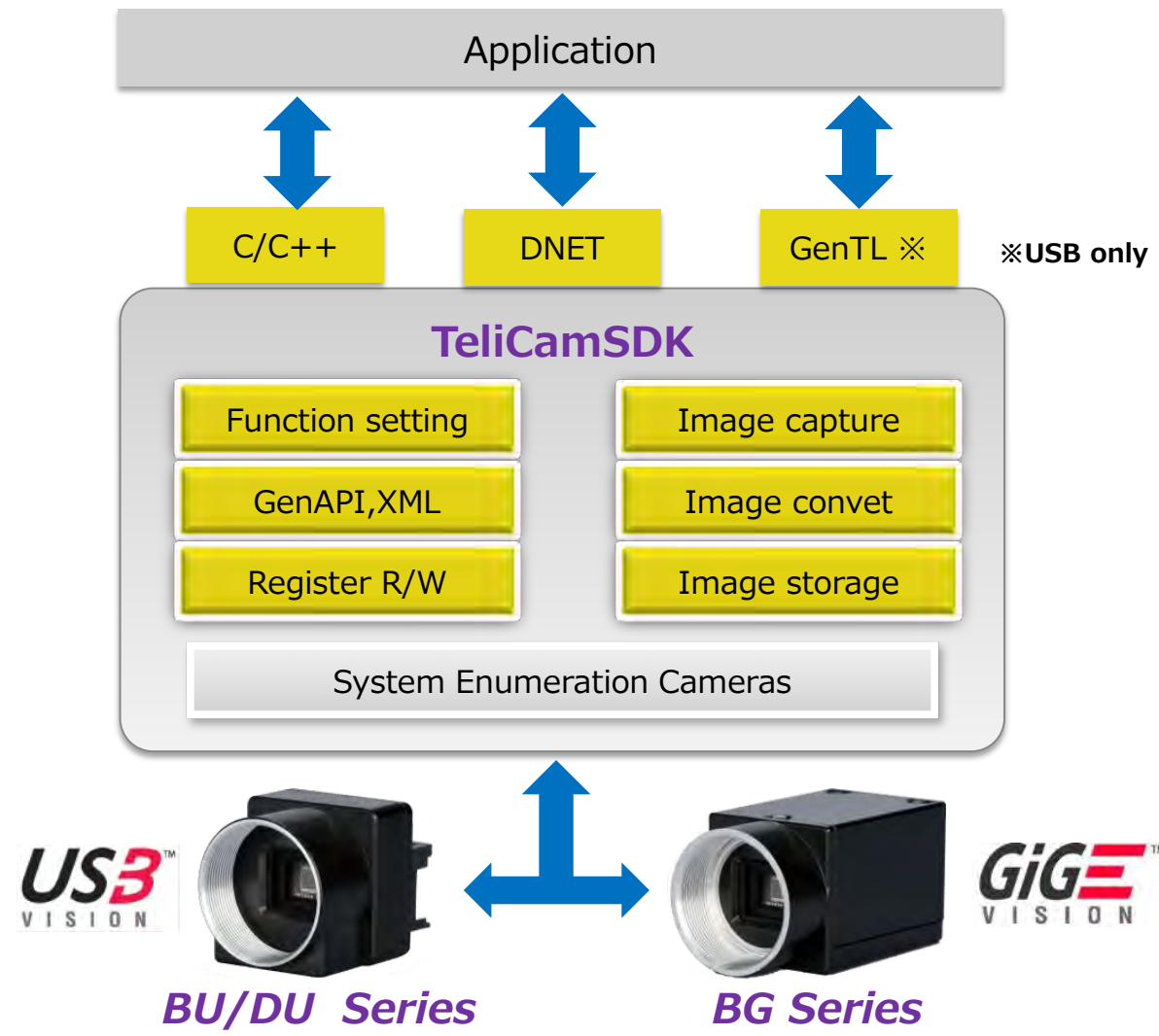
response time of software trigger

A company camera: 4msec

BU series: 5μsec (average)


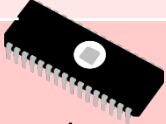




TeliCamSDK

TeliCamSDK, integration of USB3.0 and Gig-E



Application case

Application case

Market	AOI, SPI	Making panel	Fruit sorting	Medical
Use	<ul style="list-style-type: none"> •soldering check, •solder paste inspection 	<ul style="list-style-type: none"> •Alignment 	<ul style="list-style-type: none"> •scratch, shape, •ripe degree(color) 	<ul style="list-style-type: none"> •Image diagnosis
First camera	<ul style="list-style-type: none"> •Gig-E camera •CL camera 	<ul style="list-style-type: none"> •Gig-E camera 	<ul style="list-style-type: none"> •Gig-E camera 	<ul style="list-style-type: none"> •Analogue camera
Customer's challenge	<ul style="list-style-type: none"> •FGB, cable cost down 	<ul style="list-style-type: none"> •Cost down •reliability improvement 	<ul style="list-style-type: none"> •Speed up •Cost down •Image quality improvement •Color reproducibility 	<ul style="list-style-type: none"> •Replace CCD camera with CMOS camera •Higher sensitivity with less lighting •60fps recording
Point of adoption	<ul style="list-style-type: none"> •TELI original sensor •Quick response (TELI original IP core) •High image quality •Advantage of own equipment with new camera 	<ul style="list-style-type: none"> •Quick response (TELI original IP core) •Resolution •Cost benefits •Software support •Most compact overall dimensions in the industry 	<ul style="list-style-type: none"> •Quick response (TELI original IP core) •System cost benefits •High image quality •High frame rate •Most compact in the industry 	<ul style="list-style-type: none"> •High sensitivity •High S/N •High speed CMOS sensor
Choice of camera	<ul style="list-style-type: none"> •DU657MC •BU238MCF •BU406MC 	<ul style="list-style-type: none"> •BU1203MC 	<ul style="list-style-type: none"> •BU238MCF 	<ul style="list-style-type: none"> •BU238M 
Needs/ann.	2,000~3,000 sets	1,000~1,500 sets	300~500 sets	100 sets

Standard product range

Toshiba Teli USB3 Vision camera BU/DU series



Sony IMX174 Pregius
 BU238M BU238MC/MCF
 Sony CCD
 BU030 BU030C/CF
 BU031 BU080
 BU130 BU130C/CF

2.3M
 ~1.3M

Sony IMX252 Pregius
 BU302M BU302MC/MCF
 e2v EV76C560

NEW
 3M
 NEW
 1.3M

BU132M

Sony IMX250 Pregius
 BU505M BU505MC/MCF
 CMOSIS CMV2000

NEW
 5M
 2M

BU205M

Sony IMX178 STARVIS
 BU602M BU602MC/MCF
 Sony IMX255 Pregius
 DU806M DU806MC/MCF

UP COMING
 6M
 UP COMING
 8M

Sony IMX226 STARVIS
 BU1203MC/MCF

NEW
 12M

Sony IMX253 Pregius
 DU1207M DU1207MC/MCF

UP COMING
 12M

TELI Original 6.5M
 DU657M DU657MC

NEW
 6.5M

Pregius logo and STARVIS logo are trademarks of Sony Corporation.

New proposal from Toshiba Teli



USB3.0 Board Level Camera (concept model)

◆ Concept

- Flexible camera for use in various fields
- Smaller size than USB3 Vision camera "BU series"

◆ Advanced feature

➤ Easy operation

- Open frame structure in ultra-thin, compact and light weight
- Flexible optical system
- VGA~12M

➤ Various features

- Super quick response by new IP core
- Event notification
- Bus synchronizing mode
- Bulk trigger *1
- Sequential shutter *2
- Image buffer *3
- Scalable mode & binning mode *4
- BERT function *5

note : *1~5 are available in CMOS type only

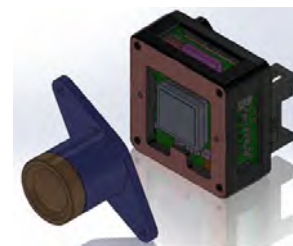
BU series



CCD type : 29×29×13mm
(without connector)

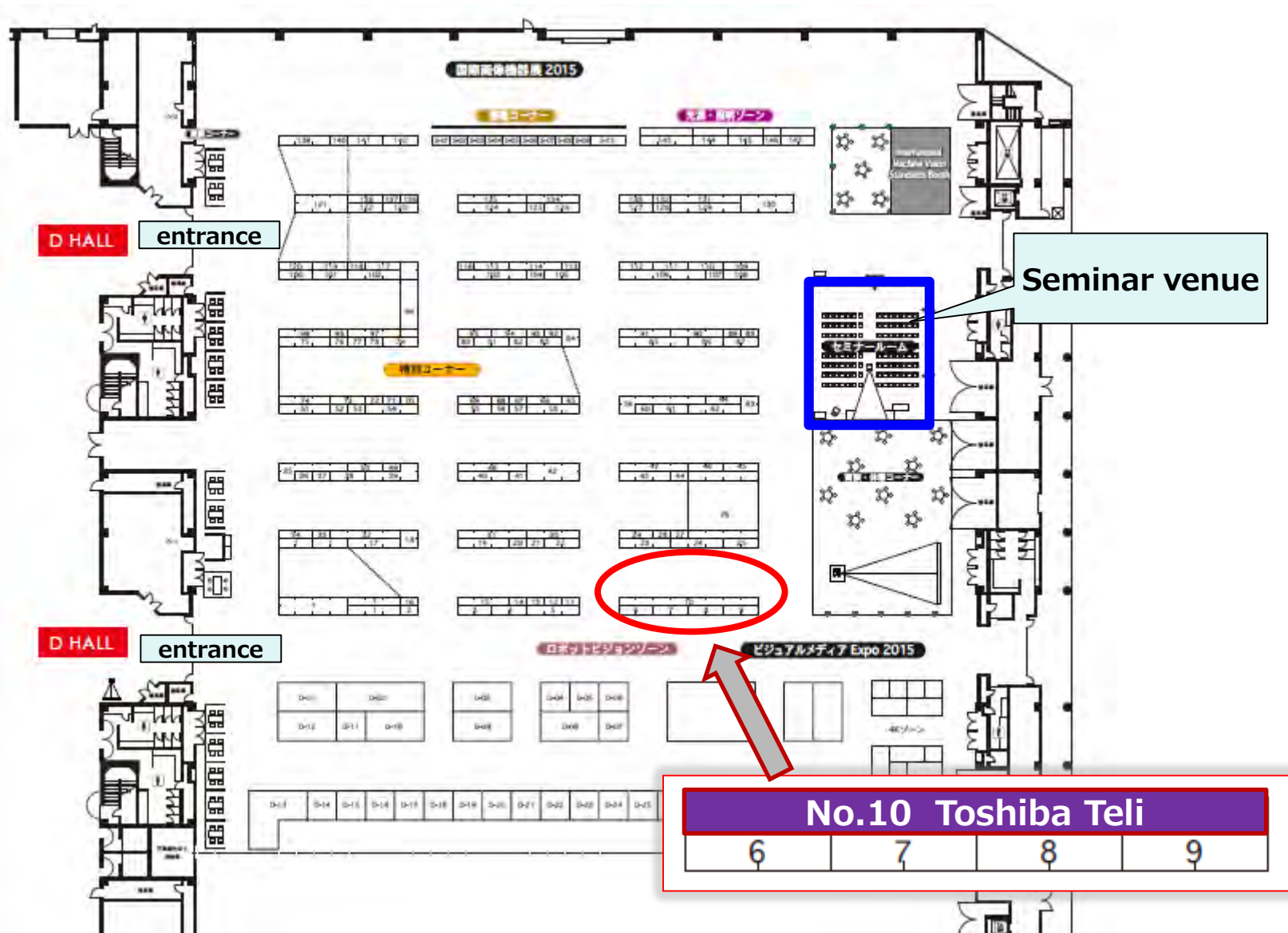


CMOS type : 29×29×16mm
(without connector)



S mount lens
(example)

Toshiba Teli booth



Contents of exhibition

■ New products

12MP USB3 Vision CMOS Camera

Featuring Sony IMX226 CMOS

BU1203MCF (color)
actual size=29(H)×29(W)×16(D)mm **32g**

[Advanced features]

- 1 With Sony's back side irradiation 12M CMOS sensor
- 2 Pixels number : 4,000(H)×3,000(V)
- 3 Pixel size : 1.85(H)×1.85(V) μm
- 4 Rolling shutter / Global reset type
- 5 Super high speed response : with TELI IP core
- 6 Various functions : Event notification, Image buffer

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5MP/3MP USB3 Vision CMOS Camera

Featuring Sony IMX250(5M)/IMX252(3M) CMOS

BU505M/MC/MCF (5M mono/color)
actual size=29(H)×29(W)×16(D)mm **32g**

[Advanced features]

- 1 With Sony's ultrahigh image quality CMOS sensor
- 2 5M : max. 75fps / 2,448(H)×2,048(V) pixels
- 3 3M : max. 120fps / 2,048(H)×1,536(V) pixels
- 4 Global shutter type
- 5 Super high speed response : with TELI IP Core
- 6 Various function : Event notification, Sequential shutter, Bus synchronising, Image buffer

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USB3 Vision System Solution

LONG CABLE & I/F CARD
Peripherals such as long cable and USB board are evaluated with Toshiba TeLi's original method

BERT(Bit Error Rate Test)
Communication of our camera and cable can be evaluated before building in system

[What's BERT]

- 1 A function to see communication status with comparison of test pattern signal by camera and receiving signal
- 2 Data transfer related issues of USB3.0 including cable and board can be evaluated before hand

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Multi Camera System for Machine Vision

Demonstration of multi camera system with utmost USB3 Vision performance

[Spec.]

- 1 Camera I/F max. width : 400MByte/unit
- 2 USB3.0 I/F card : PCIe Gen2 x4(2GB/s)
- 3 Data volume, 6 sets : 2.26GB/s

[Advantage]

Cost Camera Link (Medium Configuration equiv.)
6 cameras with 2 cards, 6 cables

Speed High speed command processing by USB3 Vision camera with max. performance of USB3.0

Stable Stable USB3 Vision system with our original technology of camera and SDK

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■ Robustness

■ Integration of FA & Monitoring solution

FA & Monitoring Solution

Solution by fusion of FA camera and surveillance camera

Fixed dome camera, PTZ camera, 360° camera, FA camera

Image processing system: LabVIEW

- Image analysis with FA camera
- Pattern matching
- Detecting strange object → Notification

Video server: ENTERPRISE

- Enterprise recording all time
- Play back desired scene
- Video analysis

Relieving notice →

- Zooming in strange object
- List up Influxions for later inspection

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IoT Solution

Argoculus

- 1 Detecting object by SPS → Notification of OK/NG to the server in cloud
- 2 Receiving notification → Getting object image, stored in designated directory depends on OK/NG judge
- 3 Image can be seen by tablet and PC through internet or mobile phone line

Image can be gained and stored to the server in the cloud at the time of detection by sensor in remote area. Stored data can be accessed all over the world through internet. The system is programmable corresponding to its size.

Argoculus SSIL
Argoculus, IoT platform of SSIL is used for this display

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Thank you very much for your attention to the last.
USB3.0 cameras are displayed in our booth.
Please don't miss.



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※ Some of the names and logos of company, organization, standard might be registered trade mark of each.

TOSHIBA

Leading Innovation >>>