

## Mixed Signal Oscilloscopes DLM2000 Series

# Serial Bus Analysis Application Note

## 1. Introduction

Embedded systems are being built into information and industrial devices used in various sectors, with focus on digital household appliances, such as game consoles, car navigation systems, mobile phones, copiers, and automatic teller machines. (Diagram 1) The automobile industry, under the key words of safety and environment, is also increasing man-hours in automotive development as engine control has become a more complex electronically-operated firmware in the engine control unit. (Diagram 2) The communication bus used inside the embedded devices are starting to use not only parallel bus but serial bus as well to reduce costs in the number of wiring, lower power supply, and standard parts.

Developers must expand software, create black boxes, and are given shorter development periods at the development bench for embedded devices. Under these circumstances, it is vital to have a measurement instrument with dedicated analysis functions catered to user application as developers are required to verify and troubleshoot product performances.

As it is possible to embed serial bus analysis functions, Yokogawa's digital oscilloscopes can trigger, analyze, and search data under the communication data conditions between the devices in the embedded equipment. Development efficiency can be improved by restricting the analysis conditions such as conducting signal observations and debugging by setting serial bus ID/Data/Error conditions.

Here we will introduce an overview of various serial buses and the serial bus analysis functions of the DLM2000 Series.

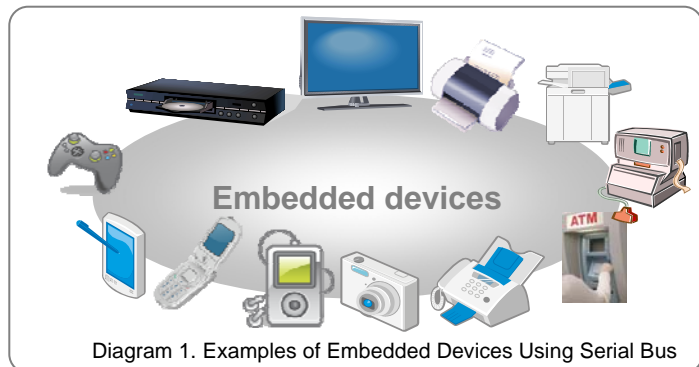


Diagram 1. Examples of Embedded Devices Using Serial Bus

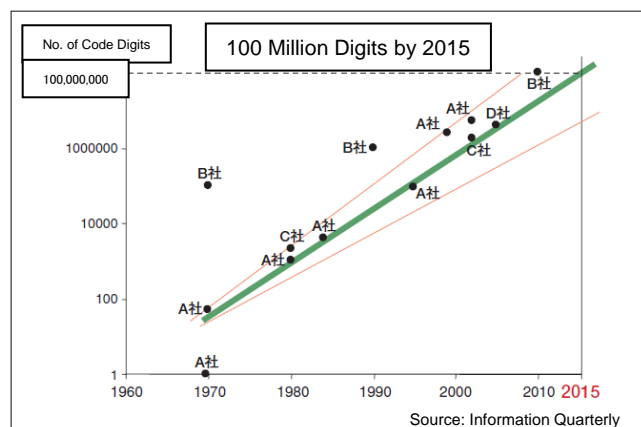


Diagram 2. Transition in the Number of Software in In-Vehicle Electronic Systems

## 2. Yokogawa's Serial Bus Analysis

Depending on the model, Yokogawa's digital oscilloscope can have a maximum of six different types of triggers and analysis functions for in-vehicle bus and multipurpose serial bus. (Please refer to Chart 1.)



|                  | DLM2000 | SB5000 | DL9710L | DL7400 | DL1600 | DL1700 |
|------------------|---------|--------|---------|--------|--------|--------|
| I <sup>2</sup> C | ○       | ○      | ○       | ○      | ○      | ○      |
| SPI              | ○       | ○      | ○       | ○      | ×      | ○      |
| CAN              | ○       | ○      | ○       | ○      | ○      | ×      |
| LIN              | ○       | ○      | ○       | ×      | ×      | ×      |
| UART             | ○       | ○      | ○       | ×      | ×      | ×      |
| FlexRay          | ×       | ○      | ×       | ○      | ×      | ×      |

Chart 1. Chart of Yokogawa's Digital Oscilloscopes Serial Bus Analysis Functions

### • Features of Serial Bus Analysis for DL9700/SB5000/DLM2000 Series

- Simultaneous analysis of two types of buses
  - Can display individually by changing the time scale on the two zoom displays
- Auto set up function for serial bus setting
- Logic input by serial bus analysis (Please refer to Chart 2)
- High-speed real time display update
- Trigger under two serial bus complex conditions
- Supports CAN database files (SB5000/DLM2000)

|              | I <sup>2</sup> C | SPI | UART | LIN | CAN |
|--------------|------------------|-----|------|-----|-----|
| Analog Input | ○                | ○   | ○    | ○   | ○   |
| Logic Input  | ○                | ○   | ○    | —   | —   |

Chart 2. Support for Serial Bus Analysis Input (DL9700/SB5000/DLM2000)

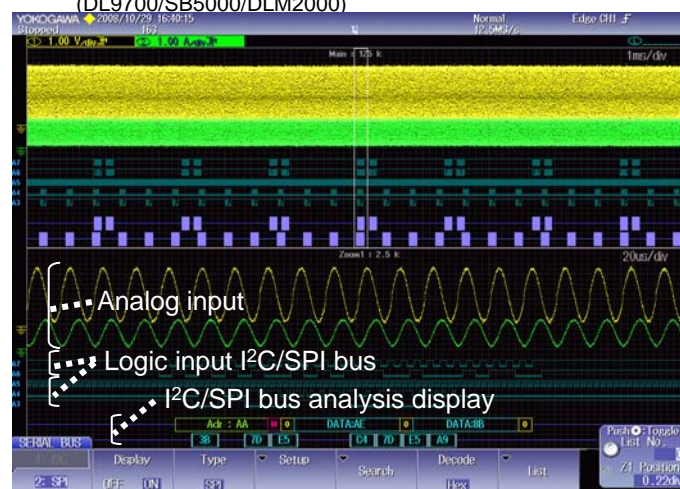


Diagram 3. Example of Simultaneous I<sup>2</sup>C & SPI Logic Input

# Application Note

| $t^2C$ | 19.6 times/sec (51ms)<br>(including 10ms capture period) | 5.6 times/sec (178ms)<br>(including 100ms capture period) | 0.7 times/sec (1.43s)<br>(including 1s capture period) |
|--------|--|---|--|
| CAN    | 16 times/sec (62ms)<br>(including 10ms capture period)   | 4.5 times/sec (220ms)<br>(including 100ms capture period) | 0.6 times/sec (1.6s)<br>(including 1s capture period)  |

Sample rate: 12.5MS/s

Ref: Number of analysis data at 12.5M point

(measures at 1°C data: approx. 3,000 byte, CAN data: approx. 1,900 frames)

Chart 3. Measurement Cycle of DLM2000 Serial Bus Analysis (Reference Data)

## 3. CAN Bus Signal and Analysis of Superimposed Noise Signal

### ● CAN Bus

CAN, an acronym for Controlled Area Network, was developed in 1985 by Bosch as an in-vehicle network. Now a standard network, the automobile industry is actively adopting CAN, which was registered as ISO11898 in 1993 as an international standard. Since 1994 several upper protocols in CAN such as CAN open and Device Net have been standardized.

CAN is now a network that has attracted widespread recognition for its reliability and refined fault detection functions in markets other than the automobile industry.

<Examples of CAN Applications>

- Automobiles, trucks, buses, off-road vehicles
- Medical equipment
- Fault analysis, sensors, machine control, switch gear, control gear
- Ship control, navigation system
- Agricultural equipment, forestry equipment

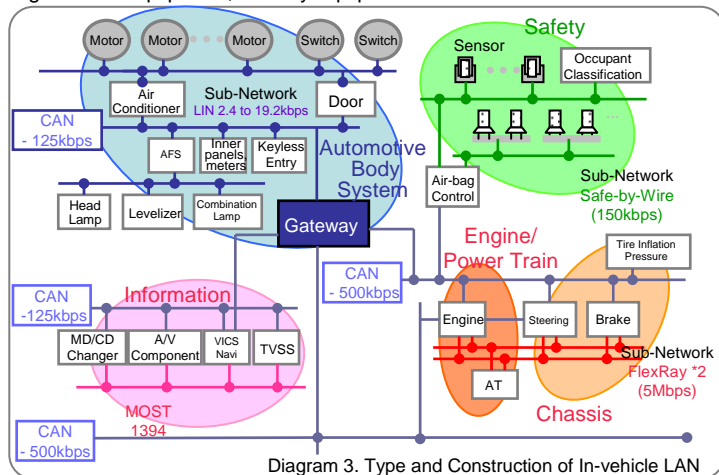


Diagram 3. Type and Construction of In-vehicle LAN

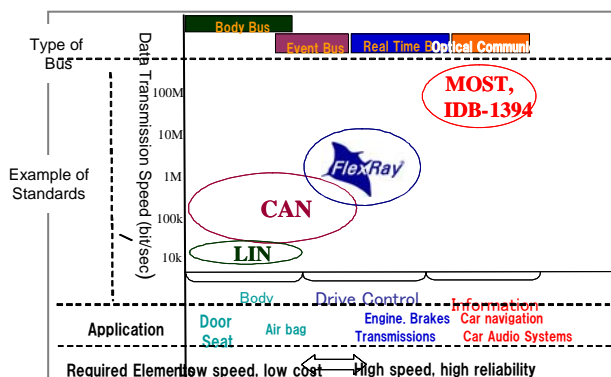


Diagram 4. Category and Standards for In-Vehicle LAN

## • High speed/Low speed CAN

CAN physical layer standards are High speed CAN (ISO 11898) and Low speed CAN (ISO 11519-2).

The bus level for both High speed/Low speed CAN, as in Diagram 5 and 6, are determined by the potential differences in the two buses (CAN High and CAN Low). Both High speed/Low speed CAN have differences in signal levels, however, both make judgment with differential signals "0" and "1".

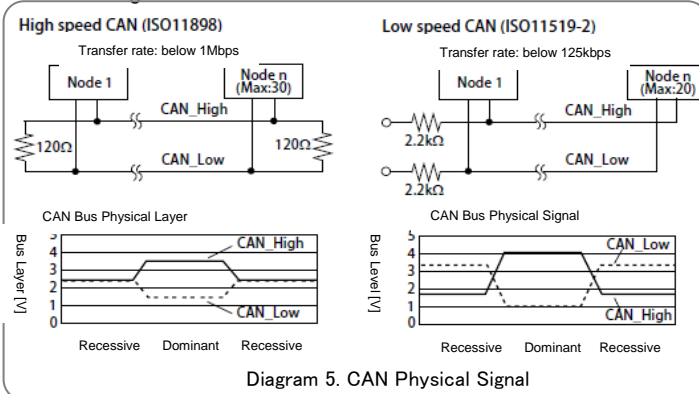


Diagram 5. CAN Physical Signal

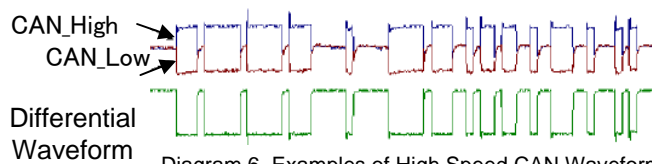


Diagram 6. Examples of High Speed CAN Waveform

## • Differential Signal Measurement

Differential probes make it easy to measure CAN differential signals. Bandwidths wider than the signal bandwidth must be entered for noise evaluation. Also, probes with higher input impedance is better as the signal level may decline if the probe input resistance is low.



Differential probe PBDH1000 (701924)  
1.0GHz bandwidth, 1MΩ input



Differential probe (701920)  
DC - 500MHz bandwidth, 100kΩ

## • Use of CAN Data Base File

DLM200/SB5000 Series can read in CAN DBC data base files (.dbc), set triggers for physical values (Message/Signal), and display analysis results (decode). It improves efficiency in CAN fault analysis and troubleshooting as it can directly read physical values from waveforms. The DBC database file is a text file that has definitions of CAN messages (frame ID/Data) and physical values (Message/Signal), and scaling information. Symbol Editor, a free computer dedicated software, converts the DBC data files into a format (\*.sbl) that can be read into measurement instruments and can create physical definition files (Message/Signal) for SB5000. Please use the following link to download Symbol Editor from Yokogawa's website.

<http://www.yokogawa.co.jp/tm/F-SOFT/DLsoft/symbol.htm>



# Application Note

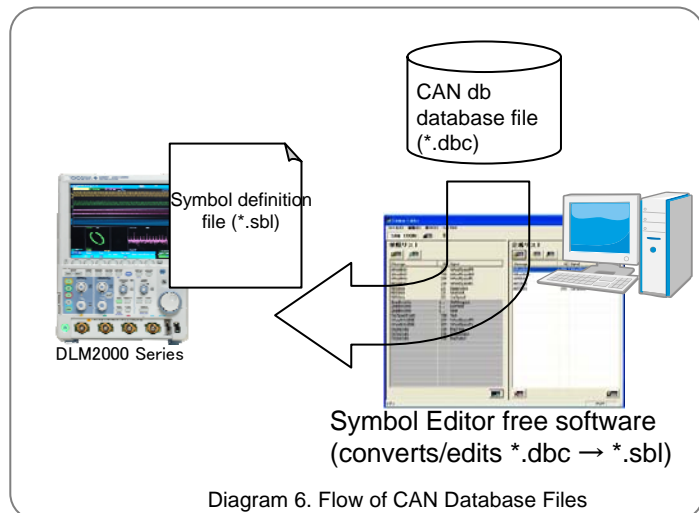


Diagram 8 Setting Dialogue for CAN Bus Trigger Conditions

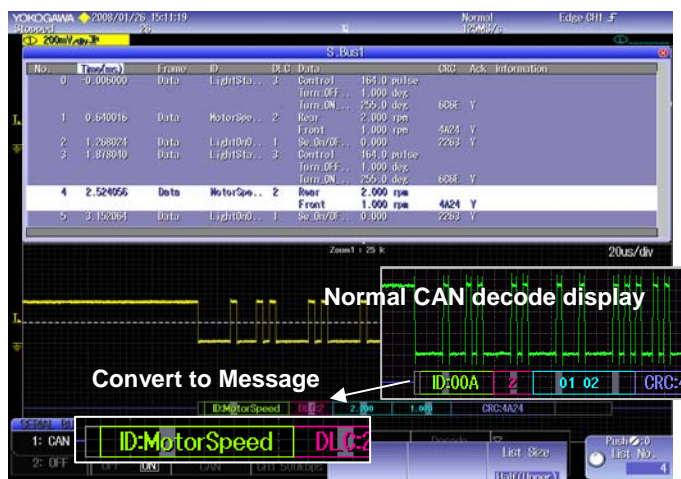


Diagram 7. Examples of Decode Results using CAN Database Files (Converted into Message)

## ● Trigger Function for CAN Bus

You can use the trigger function by setting the bit pattern, data link connector (DLC), data, and acknowledge (ACK) slot, and use the specific data/remote frame as the trigger conditions. You can set up to four types of ID/Data conditions and can trigger under OR conditions. In addition, Start of Frame (SOF) and error frames can be made into trigger conditions.

- Trigger mode
  - SOF : Trigger on SOF
  - Error Frame : Trigger on error frame
  - ID Std/Data : Trigger on data/remote frame with same setting conditions (ID: standard format)
  - ID Ext/Data : Trigger on data/remote frame with same setting conditions (ID: extension format)
  - ID/Data OR : Trigger on OR conditions of four data types of data/remote frames. Can set as standard or extension format for each ID.
  - Msg/Signal : Trigger on CAN Message (ID) and Signal (ID/Data).
- Bit Rate
  - 1Mbps, 500kbps, 250kbps, 125kbps, 83.8kbps, 33.3kbps, and User.
  - (Set on an optional value between 10k to 1Mbps when selecting User.)

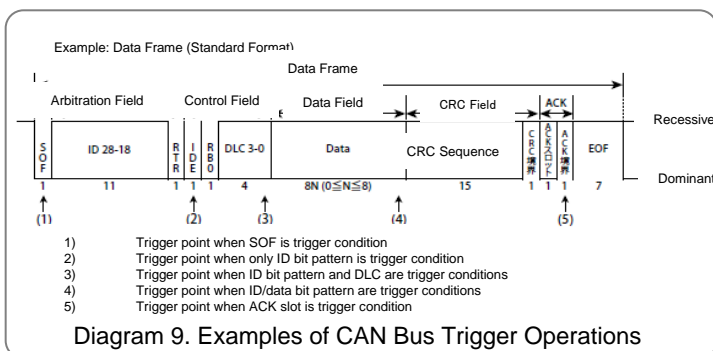


Diagram 9. Examples of CAN Bus Trigger Operations

## ● CAN Bus Analysis Function

This function analyzes CAN bus signals and lists up the analysis results. The list of the analysis results show the analysis number, the type of analysis frame, ID, data, ACK, slot status, time from trigger position, DLC, and cyclic redundancy check (CRC) sequence. In addition, it selects an optional frame from the analysis results and can automatically show the CAN bus signal supporting that frame (zoom link). It can also jump (field jump) and zoom into (the center of zoom box) to the top of the field of the selected frame.



Diagram 10. Example of Simultaneous Two CAN Bus Analysis (High/Low Speed)

# Application Note

## <Stuff Bit Display>

For CAN bus signals, when 5 bit and above are continuously on the same level, a supplementary reverse logic bit is inserted in that bit sequence (stuff bit). This is only carried out in specific areas. (SOF to CRC Seq) and due to bit stuffing, it can detect errors and resynchronize. It can detect and display stuff bit from CAN bus signals.

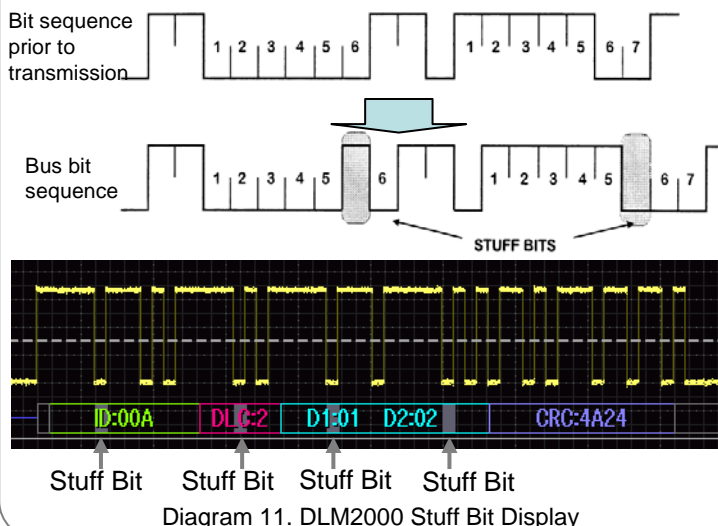


Diagram 11. DLM2000 Stuff Bit Display

## ● Search Function for CAN Bus

Similar to trigger conditions, this function can search CAN bus signal data under SOF, ID, and Data Frame conditions. After executing the search, data that coincides with the conditions are transferred into the zoom box and the data will be enlarged in Zoom or Zoom2.

Diagram 12 is an example of an error frame search. You can search CAN frames by selecting the following three error types; Error Frame, CRC Error and Stuff Error.

### • Error Frame

This notifies errors to other nodes. It outputs dominant sequences after detecting errors.

### • CRC ERROR

This notifies errors when there are inconsistencies after comparing transmitting and receiving data.

### • STUFF ERROR

This notifies errors when the stuff bit rules are not followed and receives over 6 bit data at the same level in sequence.



Diagram 12. Examples of Results for Error Frame Detection

## ● Extracting Noise Concealed in Bus Signals

Signals superimposed on bus signals are difficult to distinguish between noise and data pulse when the location of the overlapped signal cannot be specified. DLM2000 Series can detect isolated noise signals by using the filter calculation process from the data captured in the long memory. This long memory has up to 62.5 M points. The following example is noise superimposed on a 125kbps CAN bus signal, however, the lower waveform is an extract of a high-frequency noise using 500kHz high pass filters. The overview of digital filter functions are as follows:

### • Specifications of DLM2000 Digital Filter

Computable memory length: 62.5M points (with built-in /M2 memory extension option)

Filter type: IIR Highpass/ IIR Lowpass

Filter characteristics: Select from primary to secondary

Cut off frequencies: 0.01Hz to 500MHz

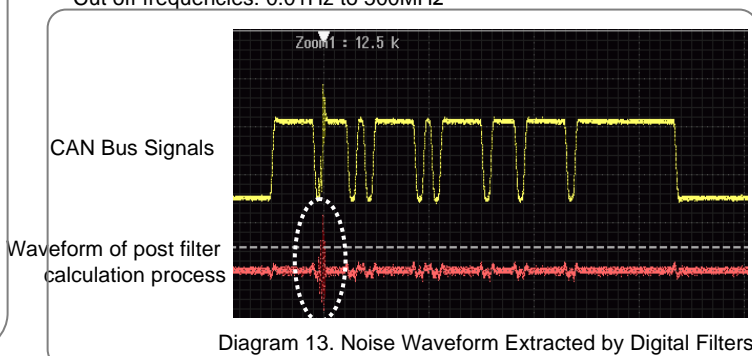


Diagram 13. Noise Waveform Extracted by Digital Filters



Diagram 14. Noise Waveform Extracted by Digital Filters

Diagram 14 depicts bus signal captured in long memory. You can see that the noise overlaps periodically at a 16ms interval. As computed waveforms can be subject to this waveform search function, you can search for waveforms from the noise waveforms extracted after the filtering process.

It is easy to troubleshoot as the bus waveform and decode analysis results are displayed at the same time as the noise waveform.

## 4. LIN Bus Signal and Analysis of Abnormal Levels of LIN Bus

### Signals

#### ● LIN Bus

LIN, an abbreviation for Local Interconnect Network, is a single master serial communications protocol aimed at reducing costs for in-vehicle LAN. It is widely used in vehicle-body sub-networks that do not need CAN in communication speed or in the amount of information. (Please refer to Diagram 15) In most cases CAN nodes are converted to LIN master nodes.

#### <Features of LIN>

1. Network configuration is made from a single master node and several slave nodes
2. The slave nodes can be synchronized without crystal oscillators (Master node to the reference clock within the communication data)
3. Uses widespread UART/SCI interface as the communication system
4. Signal transmission that can calculate the signal's transmission time (time trigger method)
5. Can operate with single wire (reduces costs)
6. The transmission speed is up to 20kbps
7. Interoperates between frame-based applications

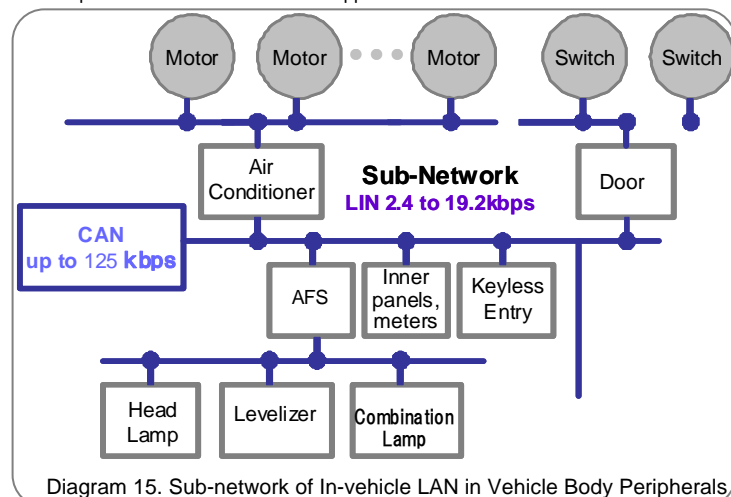


Diagram 15. Sub-network of In-vehicle LAN in Vehicle Body Peripherals

#### <LIN Communications>

LIN is made of one master task and several slave tasks (a single master system). The master task assigns when and what kind of frame should be transmitted to the bus, whereas the slave task prepares the data to be transmitted to each frame. The master node has a master task and slave task, whereas the slave node only has a slave task. (Please refer to Diagram 16.) In other words, the slave node will not transmit data unless the master node gives instructions.

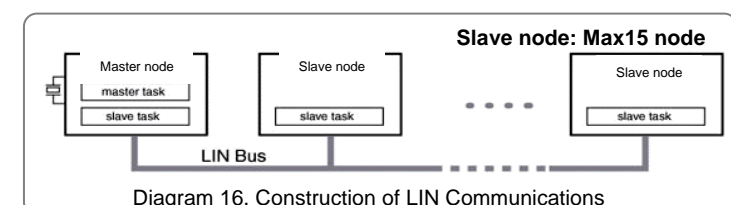


Diagram 16. Construction of LIN Communications

#### ● Trigger Functions for LIN Bus

The bit rate can be selected from 19200bps, 9600bps, 4800bps, 2400bps, 1200bps, or User. You can trigger by combining trigger conditions of LIN bus signals and trigger conditions of CAN bus signals, or combining trigger conditions of LIN bus signals with trigger conditions of analog signals.

#### • Trigger mode (Please refer to Diagram 17 and 18)

Break Synch : Trigger when detecting Synch field after Break field

ID/Data : Trigger on AND conditions of ID and Data settings

ID/Data OR : Trigger on OR conditions of several ID and Data settings

Error : Trigger after detecting errors

#### • Bit rate

19200bps, 9600bps, 4800bps, 2400bps, 1200bps, User

(When selecting User, set within the range of 1,000 to 20,000bps)

#### • Revision settings

Select LIN revisions from LIN2.0 or LIN1.3. LIN2.0 and LIN1.3 have different error definitions.

LIN2.0 : Detects Enhanced Checksum errors including secured ID

LIN1.3 : Detects Classic Checksum errors only of Data field

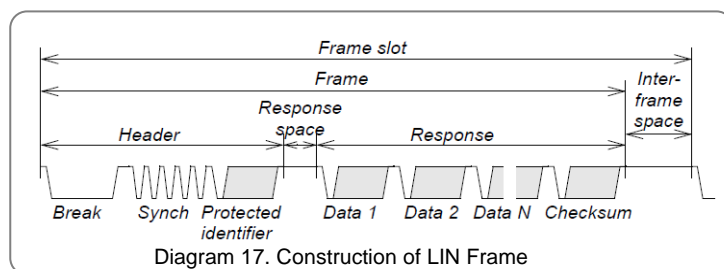


Diagram 17. Construction of LIN Frame



Diagram 18. Dialogue Display of LIN Bus ID/Data Condition Setup



# Application Note

## ● Analysis Function for LIN Bus

This analysis function analyzes data from LIN bus signals and lists up the analysis results. (Please refer to Diagram 19.) There are two types of displays in the analysis result list: the Simple and Detailed. Simple lists up the analysis number, ID, Data, and Checksum status. Detail lists up time from trigger position, ID Field, ID Parity error and Checksum error in addition to the Simple items. The data of the analysis results can be stored in CSV format in any storage media. Also, you can also select any field on the list of analysis results and display automatically to the corresponding LIN bus signal of that field (zoom link).



Diagram 19. LIN Bus Analysis Display

## ● Search Function for LIN Bus

This function can search specific fields of the LIN bus signal data. When the search is executed, the zoom box relocates to the data that coincides with the conditions and enlarges the data in the zoom waveform display area (Zoom1 or Zoom2).



Diagram 20 LIN Bus Search Condition Setup Display

## ● Capturing Abnormal Signals (Runt Pulse)

There are times when pulse (runt pulse) with not enough amplitude levels occur due to load in the connected node, noise, and data sequence. (Please refer to Diagram 21.) Runt pulse waveforms and other similar waveforms, at times, do not appear as errors from the decode results on the protocol and its cause is difficult to determine. DLM2000 Series can capture abnormal signals such as runt waveforms with its Window comparator and pulse width trigger.

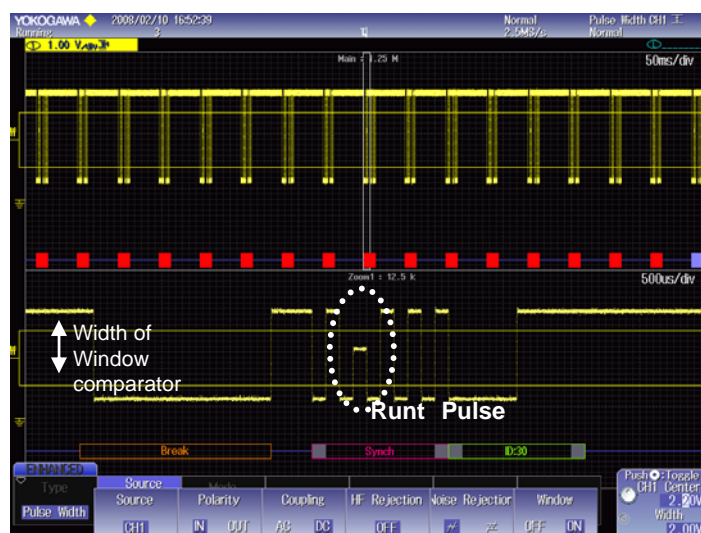


Diagram 21. Examples of Runt Pulse Capture

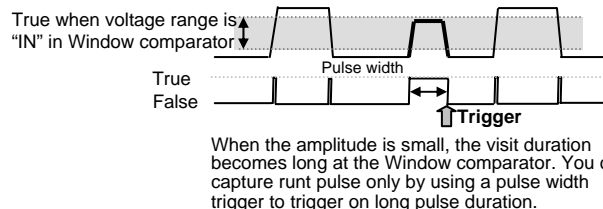


Diagram 22. Capture Runt Pulse Using Window Comparator

Diagram 22 describes how to capture runt pulse using a Window comparator. Only a thresh-hold level will be set under a normal trigger level setting. When setting a Window comparator, you can set the trigger from the timing entered into the set upper/lower limits and the time taken to pass from lower to upper limits. As shown in Diagram 22, when the comparator enters the "IN" voltage range, it is "True:1". When outside the range, it is "False:0." When the amplitude has a small pulse, the time spent in the "IN" period of the comparator becomes longer. The runt pulse can be triggered by triggering the pulse width using the True/False values.

This function can also be applied not only for LIN bus but for CAN bus and detecting abnormal waveforms for standard data communications.

# Application Note

## 5. UART Signals

### ● Overview of UART

UART, an abbreviation for Universal Asynchronous Receiver Transmitter, is a communication circuit that converts serial signals to parallel signals or vice versa. It is generally used as an interface with external equipment by combining with IC that converts signal levels that comply with a certain signal level (standard). RS-232 is a standard that represents this "certain signal level."

There are two data lines – the transmitting and receiving lines. Depending on the standard, the transmitting speed and the signal type (differential or single end) differs.

Eg.) RS-232 (single end) : bit rate : 115.2 kbps max

RS-422 (differential) : bit rate : 10Mbps max

RS-485 (differential) : bit rate : 10Mbps max

### <Examples of UART Applications>

The following are some UART applications:

#### ■ CPU communication (I/O) on ECU platform

(such as communication between ECU microcomputer and ROM and local communication between microcomputers)

#### ■ Communication with embedded microcomputer evaluation board and PC

■ Communication between in-vehicle sensors (such as millimeter wave image sensors, collision prevention sensors, preceding-vehicle detecting sensors) and Decision Support System (DSS)

#### ■ Communication between wireless lock signal receiver (tuner) and subjected ECU

#### ■ Control signals in agricultural equipment

Control signals of wide-range manufacturing facilities (production line) unrelated to automobiles

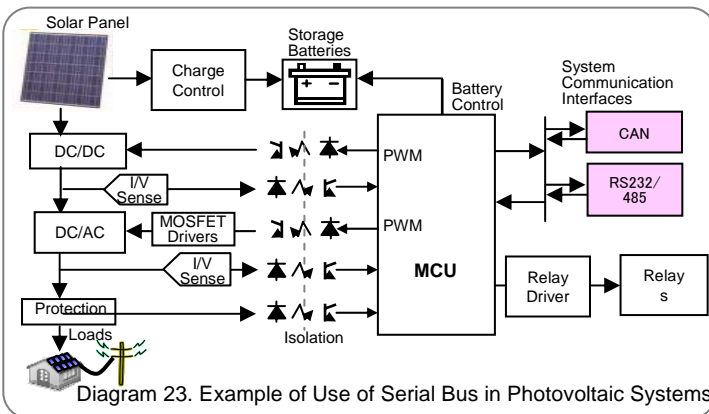


Diagram 23. Example of Use of Serial Bus in Photovoltaic Systems

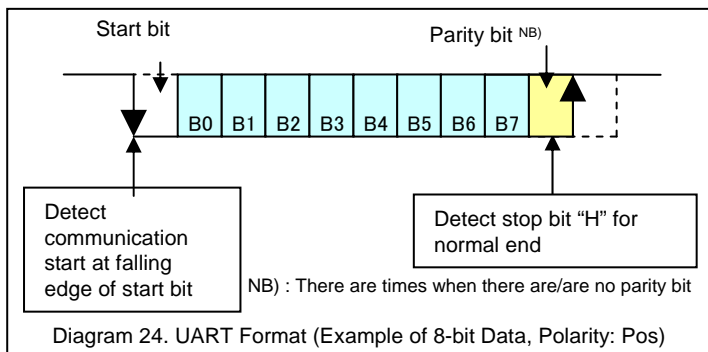


Diagram 24. UART Format (Example of 8-bit Data, Polarity: Pos)

### ● Trigger Function for UART

Triggers at all Stop bit data location. The bit rate is 115200bps, 57600bps, 38400bps, 19200bps, 9600bps, 4800bps, 2400bps, and 1200bps. You can also select from user settings. The data format can be selected from 8 bit (parity), 8 bit (no parity), 7 bit (parity).

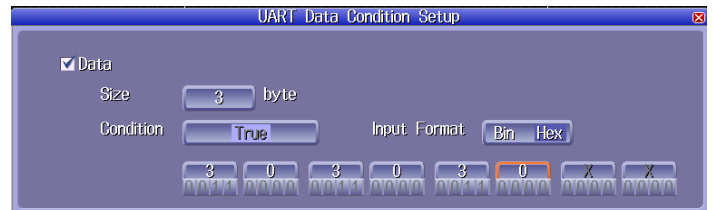


Diagram 25. Setting Dialogue of UART Trigger Condition

### ● Analysis Function for UART

This function analyzes UART signal data and lists up analysis results. The list consists of analysis number, time from trigger position, Data, and error (framing and parity). The data can be displayed not only in Hex/BIN but it can also be converted to comply with ASCII codes. The data of the analysis results can be stored in the built-in memory or in USB memory media devices in CSV formats. In addition, by selecting optional data from the analysis results list, a real UART signal waveform corresponding to that analysis data can be automatically shown on zoom display (zoom link).



Diagram 26. Example of UART Analysis Result Screen

### ● Search Function for UART

This function can search certain data patterns (max 4 byte) and errors from UART signal data. When the data corresponding to the conditions are found, it is transferred into the zoom box so that the data is displayed and enlarged.

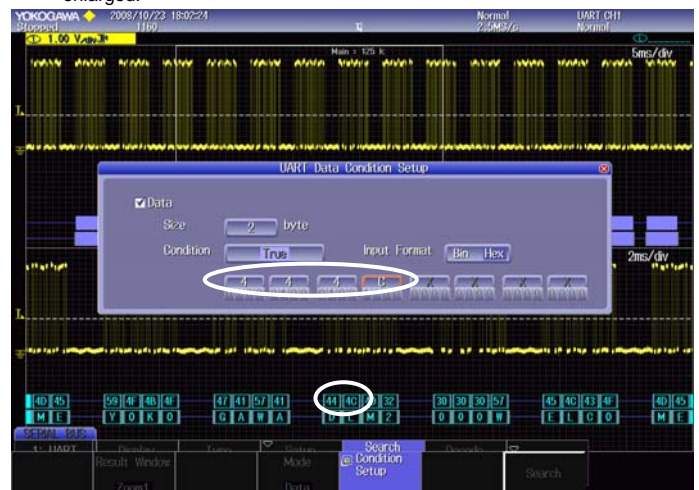


Diagram 27. Examples of a UART Data Research  
Serial Bus Analysis Application Note

# Application Note

## 6. I<sup>2</sup>C Bus Signals

### ● Overview of I<sup>2</sup>C Bus

I<sup>2</sup>C bus is a synchronized serial communication that transmits two signal lines (not including GND), serial clock (SCL) and bi-directional serial data (SDA). This bus can be connected to several slaves. The master appoints, selects, and communicates with the slave address that has been determined individually. The bit rate consists of standard mode, fast mode, and high-speed mode.

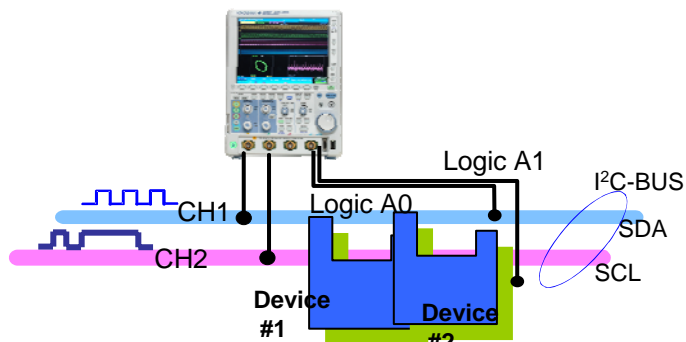


Diagram 28. Examples of a I<sup>2</sup>C Bus Configuration and Signal Observation



Diagram 29. Examples of I<sup>2</sup>C Bus Signal Observation

### ● Overview of I<sup>2</sup>C Bus Format

#### Start Condition

This is a start condition for new data transmission by master devices. This condition occurs when SCL is in "Hi" and the SDA data line transforms from "Hi" to "Lo".

#### Address (7Bit, 7Bit + Sub = 10Bit)

This is the slave device address that the master sends data to.

#### R/W (1bit)

Transmission direction (Read/Write) that is issued from the master. It continues after the address block. (H:Read L:Write)

#### Acknowledge (ACK) : 1bit

The receiver end sends an acknowledgement reply after each address and data bit. An ACK bit is not issued when it is reading the last byte data.

#### Data (8bit)

Data can be sent continuously as there are no restrictions to the number of data bytes.

#### Stop

When the data transfer ends, the master device opens the bus by sending a stop condition. While the SCL clock is on "Hi", the SDA data line transforms from "Hi" to "Lo".

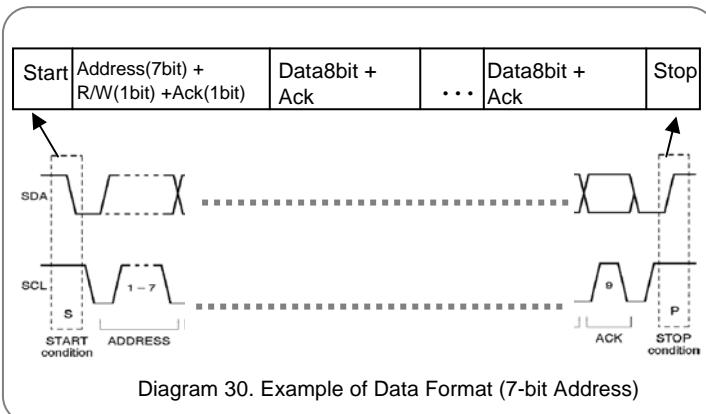


Diagram 30. Example of Data Format (7-bit Address)

### ● I<sup>2</sup>C Bus Trigger Function by DLM2000 Series

You can trigger on the following conditions:

- ◇ Every-Start Trigger : Trigger on all start conditions
- ◇ Address Data Trigger : Trigger on set address or data
- ◇ Non-ACK Trigger : Trigger when there is no acknowledgement
- ◇ General Call Trigger : Trigger when issuing general call
- ◇ Start Byte : Trigger at start byte
- ◇ HS Mode Trigger : Trigger at HS mode

#### <Trigger Setting at Address and Data>

- 1) Set IC address + R/W bit
- 2) Can designate 7 Bit Address, 7 bit + Sub Address, and 10 Bit Address 3) Can select True/False for data specification
- 4) Trigger is valid after byte set on byte count

#### Combination of Address, Data, and byte-count

Address : A4  
Data 1 : 27  
Byte Count : 3

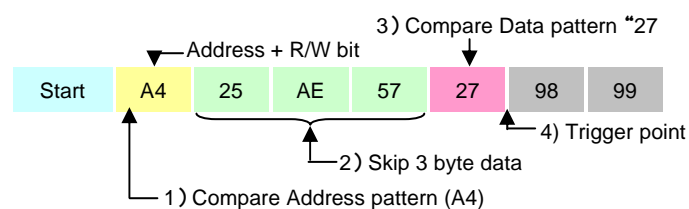


Diagram 31. Example of I<sup>2</sup>C Bus Trigger Setting



# Application Note

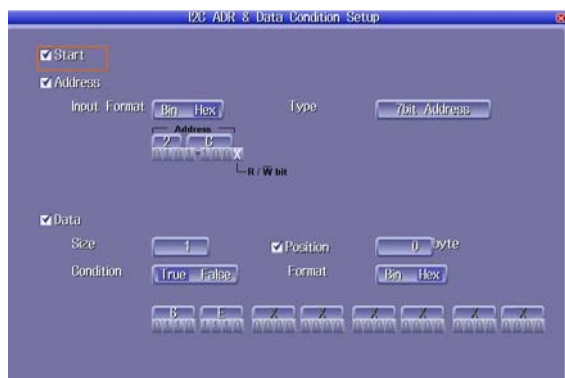


Diagram 32. Setting Dialogue for I<sup>2</sup>C Bus Address/Data Condition

## ● Analysis Function for I<sup>2</sup>C Bus

This function can show the decode results simultaneously under the waveforms. The list displays the analysis number, time from the trigger position, first byte, second byte, Read/Write, data, Acknowledge Yes/No, and Information (7bit/10bit address). The zoom position shifts with the selection within the list.

The decode results can be stored in a CSV formatted file.

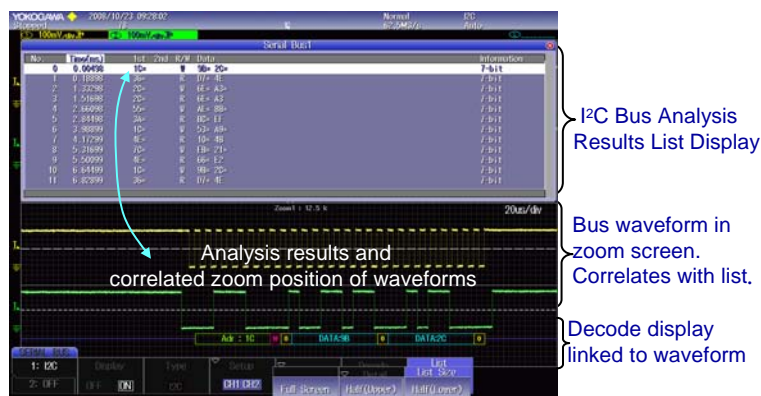


Diagram 33. Example of I<sup>2</sup>C Bus Analysis  
(Upper part displays list)

## ● Waveform Search Function for I<sup>2</sup>C Bus

This function can search for data that coincides with the dedicated address pattern, data, data pattern, acknowledge bit conditions with the I<sup>2</sup>C bus signal data. When carrying out the search, the corresponding data is transferred to the zoom box and the data is enlarged in either Zoom1 or Zoom2.

### • Data Search Conditions

- ◇ Every-Start : Searches every start condition
  - ◇ Address Data : Searches the set address or data
  - ◇ Non-Ack : Searches when there is no acknowledgement
  - ◇ General Call : Searches general calls
- Select from Don't care, 00000100/00000110/master address (voluntary setting)
- ◇ Start Byte : Searches start byte
  - ◇ HS Mode : Searches HS mode

## 7. SPI Bus Signals

### ● Overview of SPI Bus

SPI bus, an abbreviation for Serial Peripheral Interface, is a synchronous serial communication that communicates with serial clock (SCK) and a one-way SDI, and three SDO signal lines. The bus can connect with several slave modes, however, the master mode must select the slave with a chip select (CS) signal to specify the slaves. Although the number of signal lines may increase, the communication is as fast as the data format and the principles are simple.

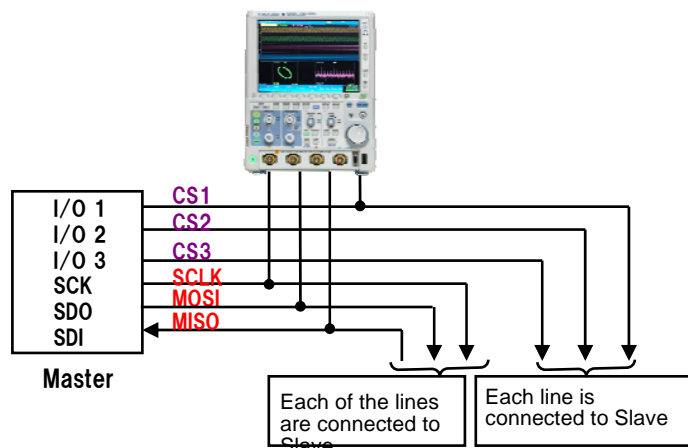


Diagram 34. Example of SPI Bus Configuration

### ● Trigger Function for SPI Bus

The trigger can be set at a data pattern up to 4 bytes. The data location can be triggered after the chip select (CS) is asserted and skipping the specified bytes.

- ◇ Can select either three wire or four wire serial
- ◇ Can trigger at the specified data size (1 to 4 bytes)
- ◇ Can select True or False
- ◇ Can select most significant byte (MSB) or least significant byte (LSB) for data specification
- ◇ Can skip bytes

### Example of SPI Data Trigger (Complex Trigger)

#### • Combination of Data and byte-count

- CS : Active at Low
- Data 1 Condition: True
- Data Size: 3
- Pattern: 3B D7 FF
- Data Position: 4
- Data2 Condition: True
- Data Size: 4
- Pattern: FF FF 00 00
- Data Position: 10

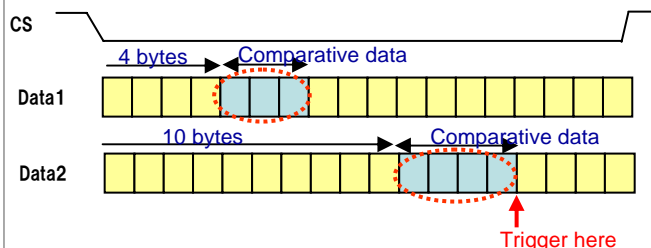


Diagram 35. Example of SPI Bus Trigger Condition

# Application Note

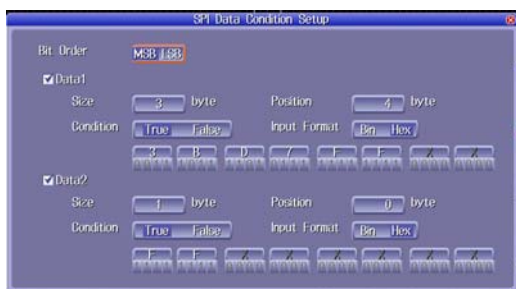


Diagram 36. Example of SPI Bus Trigger Setting Screen (For Four Wire)

## ● Analysis Function for SPI Bus

- Displays SPI bus signal waveforms and decode analysis results simultaneously in real time
- Displays time from trigger point, Data1 and Data2 from analysis results
- High-speed analysis and waveform display
- Can store analysis results (list) in CSV text files



Diagram 37. Examples of SPI Bus Analysis Results (List on Upper Screen)

## ● Search Function for SPI Bus

Can pick out the needed data under the SPI bus conditions from the large number of captured data.

- Conditions of Selection
  - ◇ Can search from the specified data size (1 to 4 Bytes)
  - ◇ Can select from True or False
  - ◇ Can select from MSB or LSB for data specification
  - ◇ Can skip bytes



Diagram 38. Example of SPI Bus Search Screen

## ● Examples of SPI Bus Application

SPI is used for IC data communication that are built in digital cameras. The DLM2000 bus analysis function can check if the IC data communication is normal while observing waveforms and can check the data at the same time.

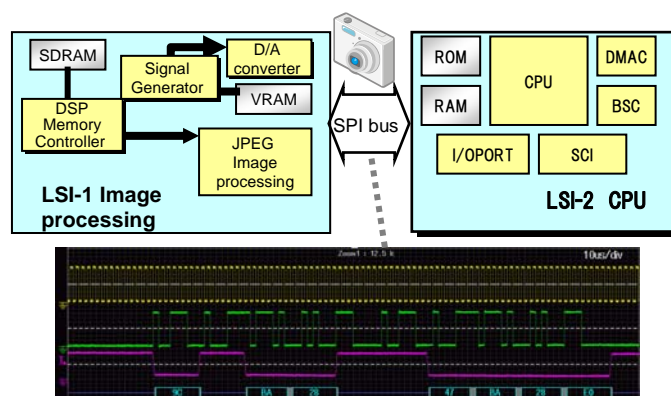


Diagram 39. Example of SPI Bus Application for Digital Cameras

## 8. Conclusion

It is extremely effective to observe waveforms for serial bus events regarding embedded systems in in-vehicle LAN and digital household appliances. Yokogawa's DLM2000 Series supports a number of buses such as CAN, LIN, UART, I<sup>2</sup>C, and SPI, and has trigger, analysis, and data search functions. As an oscilloscope that can measure and analyze physical layer signals and has a protocol analysis function, it can promptly and easily evaluate the system. Please link to the following websites for further information on the serial bus analysis functions in Yokogawa's oscilloscopes.

<http://www.yokogawa.co.jp/tm/Bu/serial/>

<http://www.yokogawa.co.jp/tm/Bu/SB5000/>

<http://www.yokogawa.co.jp/tm/Bu/dl7400fr/>