SpaceWire network and communication technology in the MMX system

Akira Chiba, Isao Odagi, Shinya Hirakuri, Takahiro Owaki,
Shimpei Ogino, Kazuhiro Nishikawa (MELCO)
Masanobu Ozaki (JAXA)

9th International SpaceWire and SpaceFibre Conference 2022

Outline

1. Introduction
2. MMX mission
3. SpaceWire Network
4. Specific Technology
5. Lessons Learned
6. Summary

MMX: **M**artian **M**oons e**X**ploration

1. Introduction

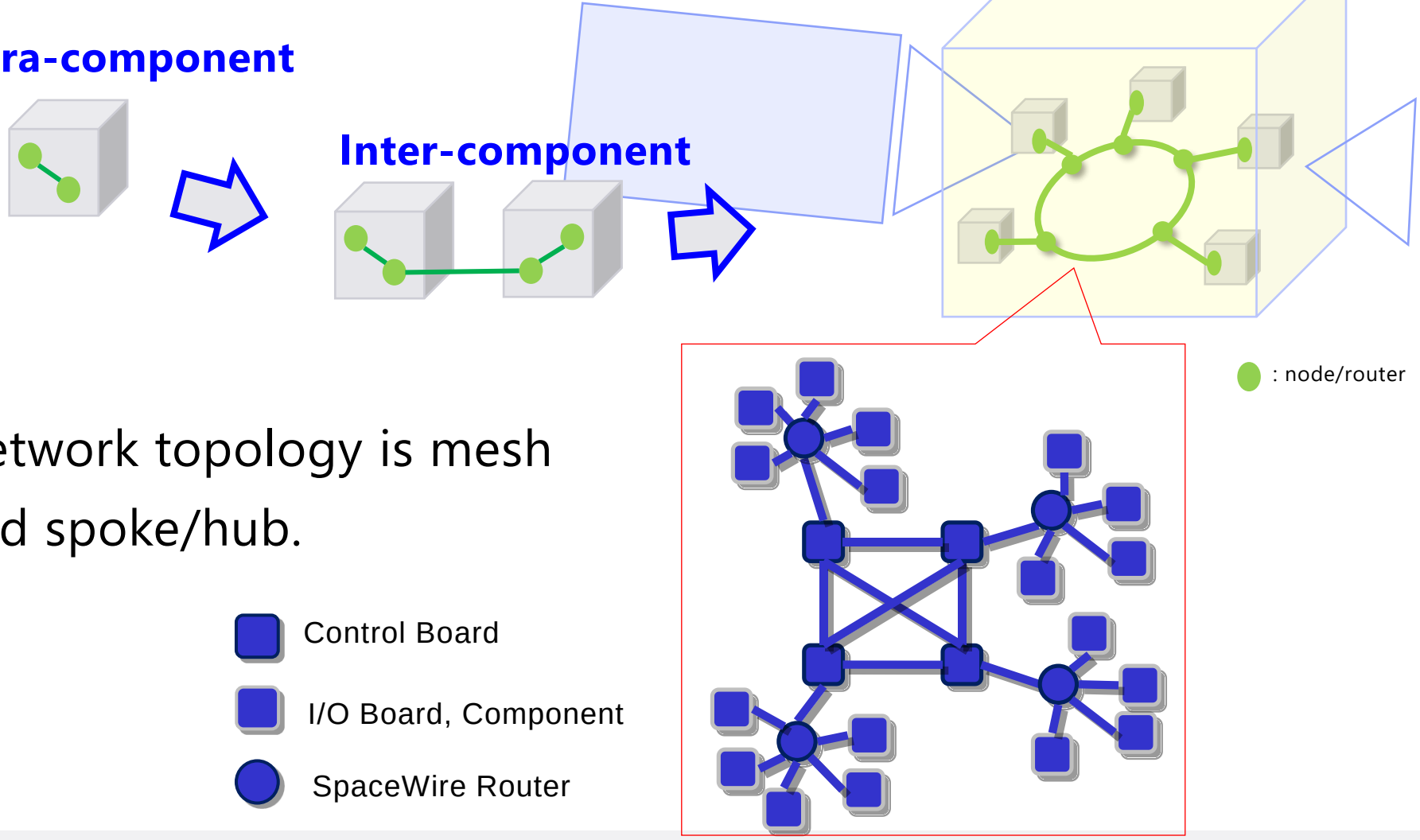
Our SpaceWire development:

NOW

Intra-component

Inter-component

Spacecraft system



Network topology is mesh and spoke/hub.

Control Board

I/O Board, Component

SpaceWire Router

2. MMX mission

MMX

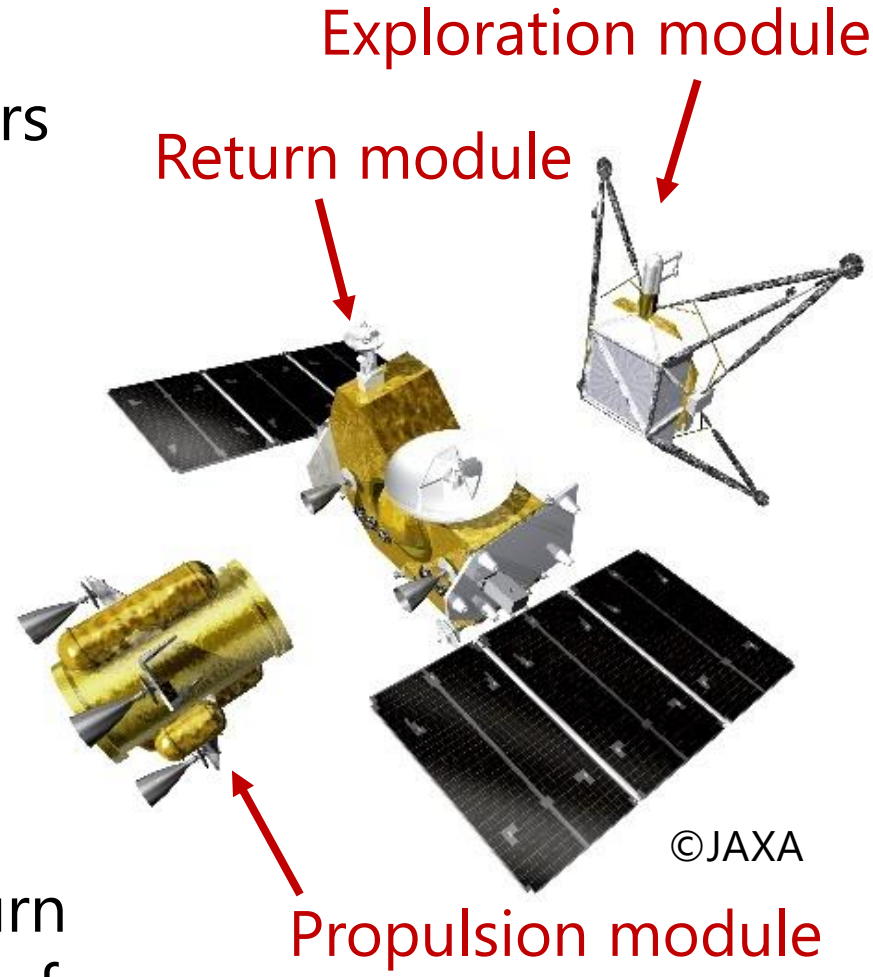
- Launched in the mid-2020s
- Explore the two moons of Mars

Engineering Objectives

- Advanced sampling
- Return trip
- Deep space communication

Modules

- Consists of three modules
- SRC/RDR separated from Return module to go back to Earth surface



2. MMX mission

Part of instruments in Return module

No.	Name	Description	SpaceWire	Host
1	IREM	Interplanetary Radiation Environment Monitor	X	JAXA
2	CMDM	Circum-Martian Dust Monitor	X	JAXA
3	SRC	Sampling Return Capsule		JAXA
4	RDR	Retrievable Data Recorder	X (*1)	JAXA
5	SHV	Super Hi-Vision camera	X	JAXA
6	DST	Deep Space Transponder		ESA

(*1) Strobe-less communication

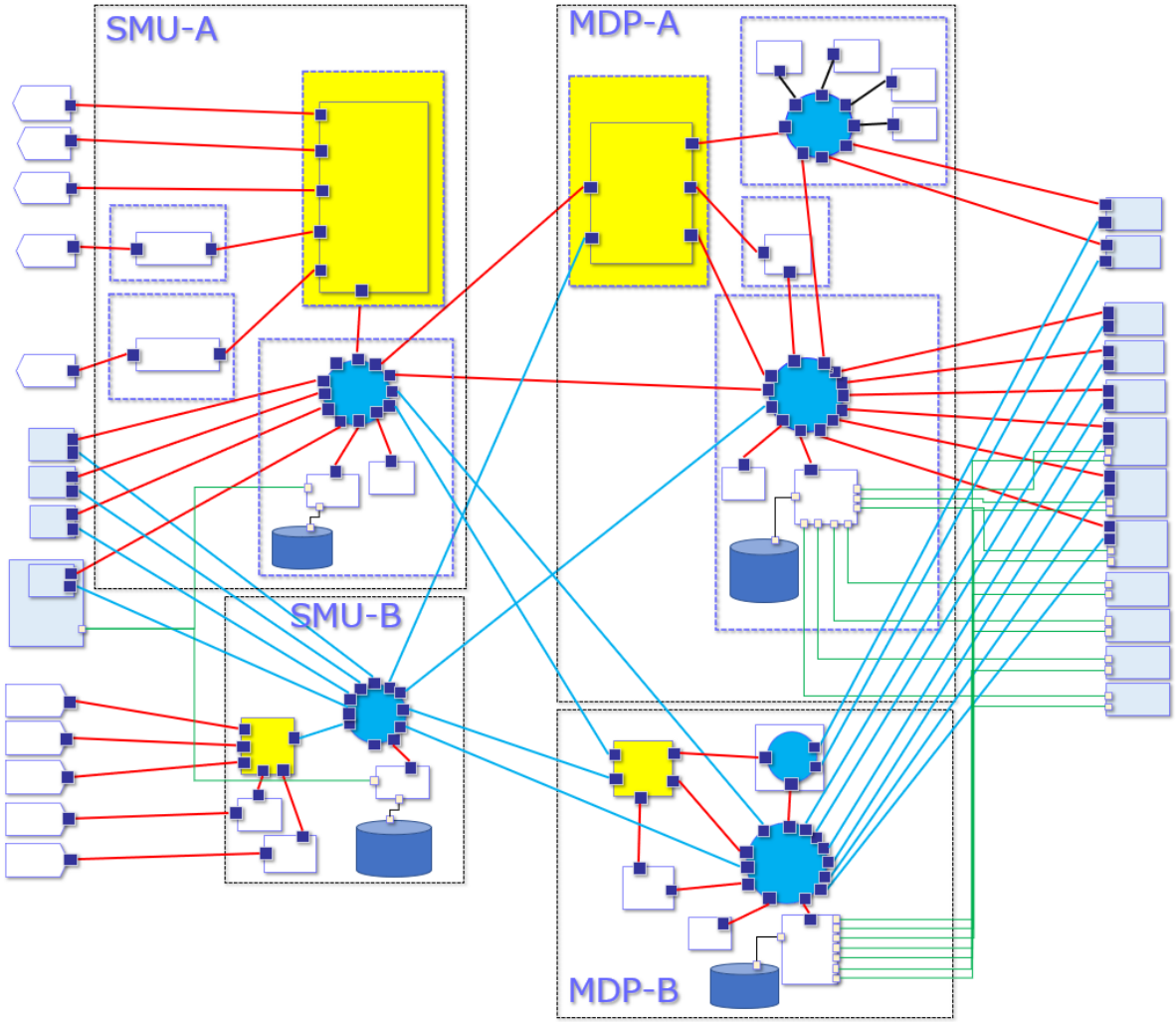
2. MMX mission

Part of instruments in Exploration module

No.	Name	Description	SpaceWire	Host
1	CSMP	C-SaMPler	X	JAXA
2	MSA	Mass Spectrum Analyzer	X	JAXA
3	TENGOO	TElescopic Nadir imager for GeOmOrphology	X	JAXA
4	OROCHI	Optical RadiOmeter composed of CHromatic Imagers	X	JAXA
5	CAM-T	CAMera (Telescope)	X	JAXA
6	CAM-W	CAMera (Wide angle)	X	JAXA
7	MIRS	MMX InfraRed Spectrometer	X	CNES
8	LND	LaNDing sensor		JAXA
9	MEGANE	Mars-moon Exploration with GAmma rays and NEutrons		NASA
10	Rover	Rover		CNES/DLR
11	LIDAR	Light Detection And Ranging		JAXA
12	ALT	ALTimator		JAXA
13	PSMP	P-SaMPler		NASA

3. MMX SpaceWire Network

(1) Topology



Internal Connection

Main SpaceWire

Redundant SpaceWire

NOT SpaceWire

Node (Internal)

Node (Other)

Node (Payload)

Board

Router

Data Recorder

3. MMX SpaceWire Network

(2) Data Handing Components

・We have developed DH components: SMU, MDP and RDR.

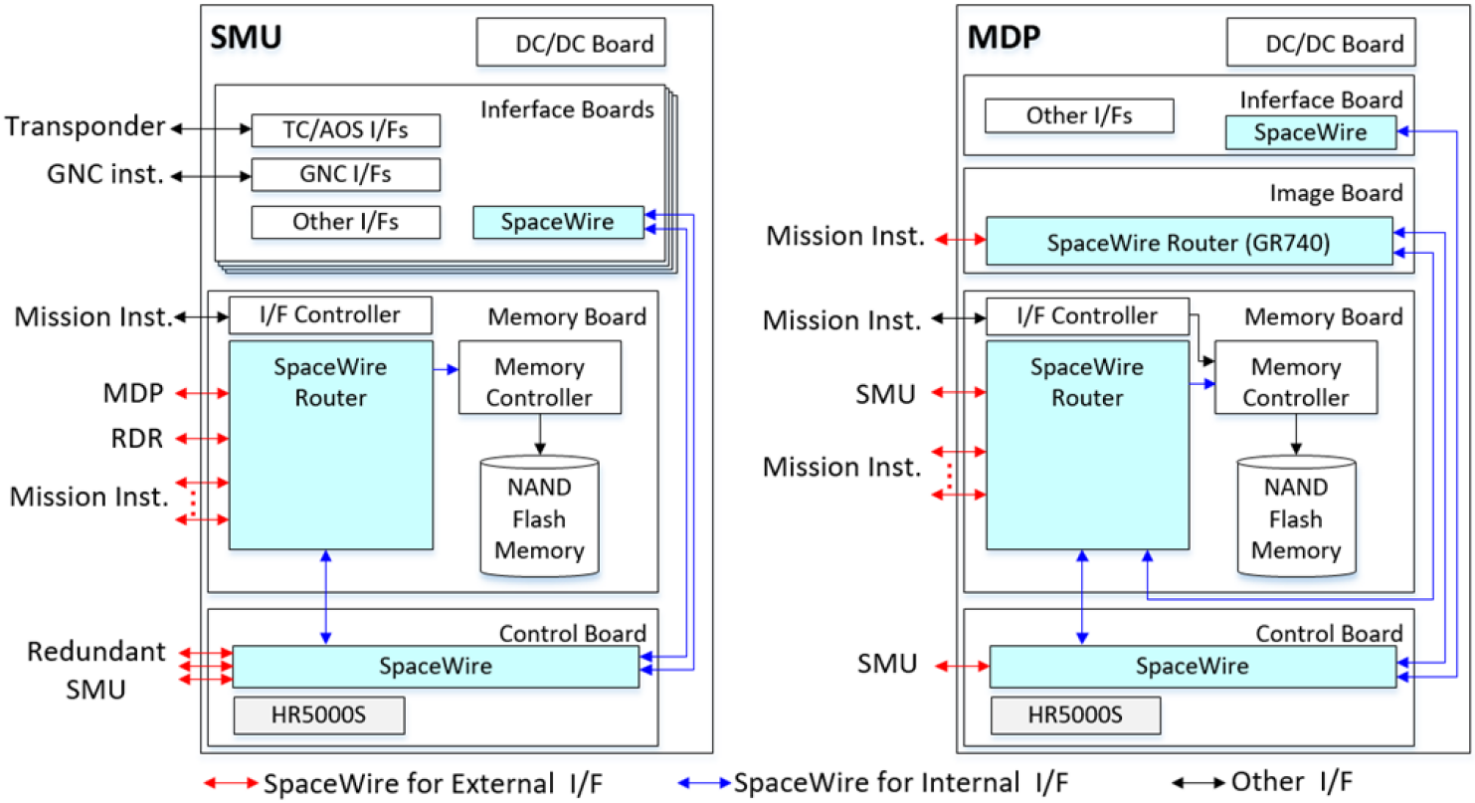
Specification of DH components

	SMU	MDP	RDR
CPU	HR5000S	HR5000S, GR740	None
Size (Typ.)	231 x 315 x 223 mm	171 x 315 x 223 mm	110 x 110x 25 mm
Mass (Typ.)	10.5 kg	7.4 kg	301 g
Power (Max.)	67 W	74 W	6.5 W
Recording Capacity	32 GByte	32 GByte	1 TByte
H/W redundancy	yes	yes	no

3. MMX SpaceWire Network

(3) SMU and MDP

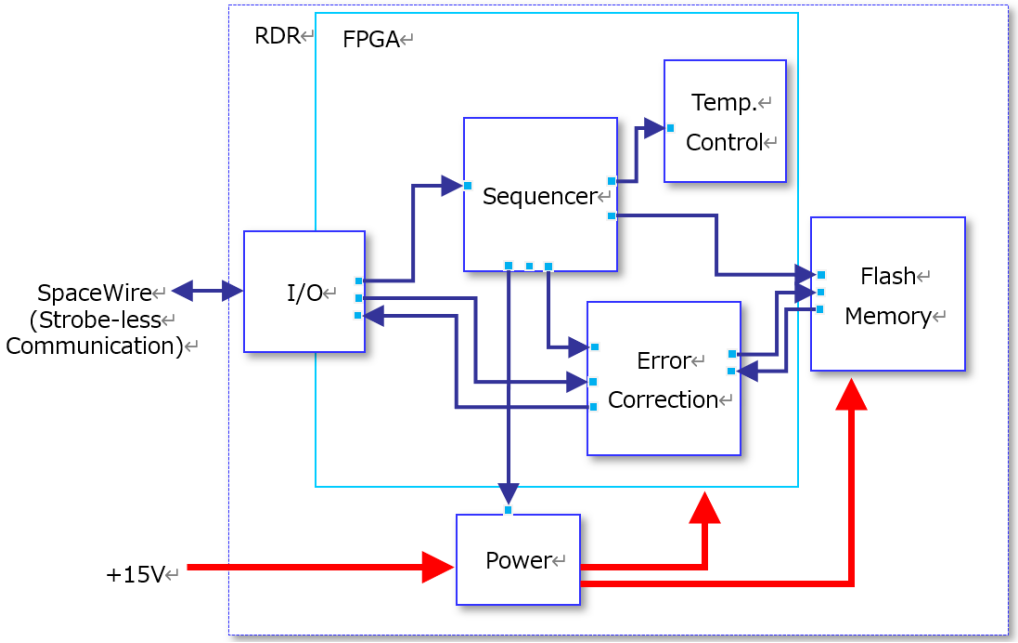
- HR5000S controls all SpaceWire nodes and routers.
- 10 to 180 MHz internal SpaceWire link using Backplane.

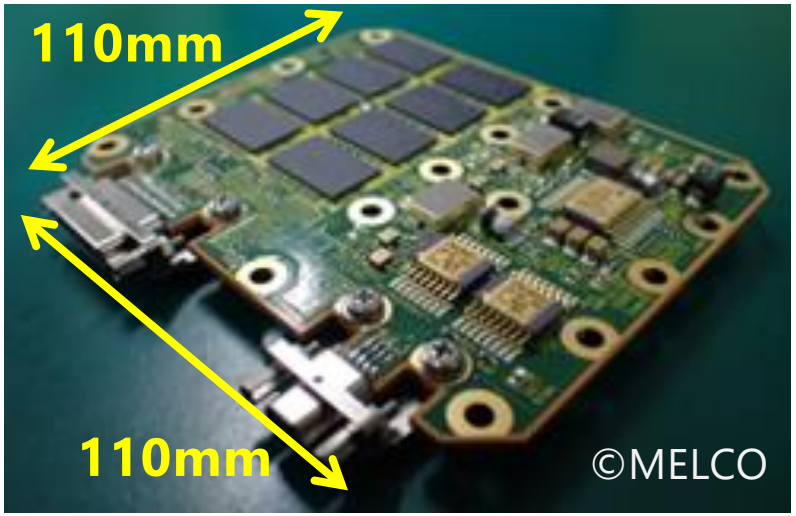


3. MMX SpaceWire Network

(4) RDR

- Very large storage (1TB).
- Flash memory controller is in FPGA.
- Strobe-less communication is applied at SMU I/F.





3. MMX SpaceWire Network

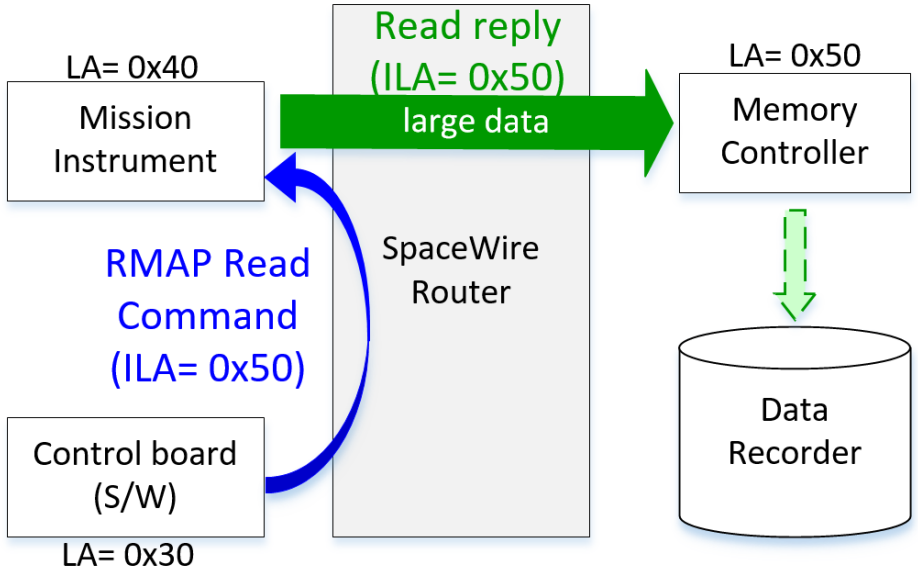
(5)Timing Scheduling

・To achieve synchronization and high reliability, time-slot management with 64Hz time-code is applied.

(6) Direct Reply Input

・Setting ILA of RMAP header to memory controller value

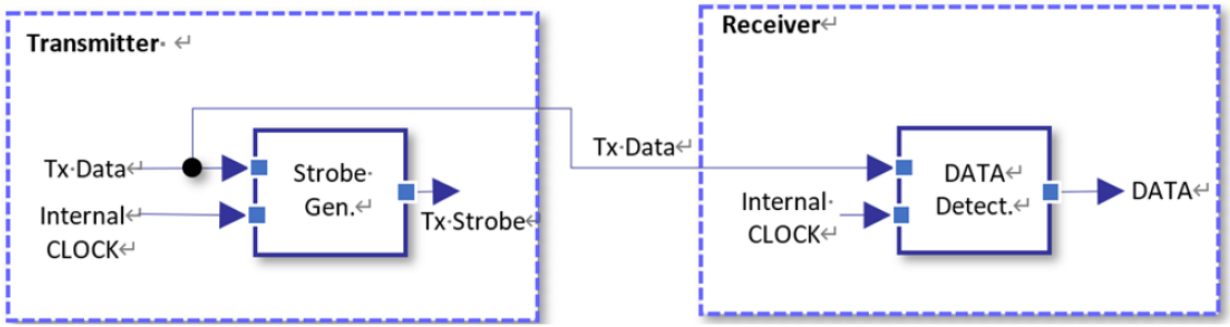
⇒Large data can be input to Data Recorder without going through S/W.



4. Specific Technology

(1) Strobe-less Communication

- The number of signals between SMU and RDR must be eight or less.
- We successfully implemented Strobe-less communication.
- Using Data only to realize asynchronous communication.

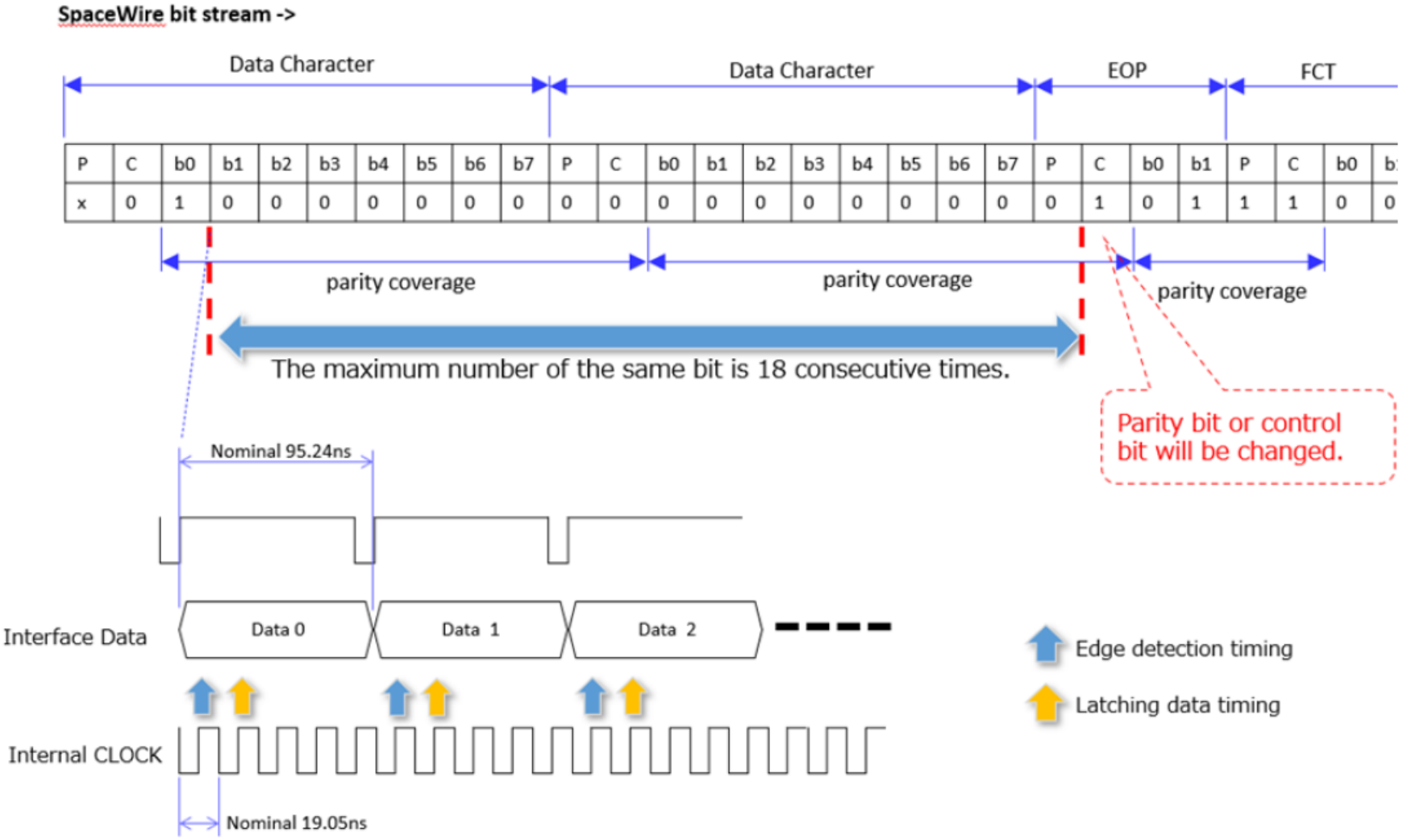


RDR pin assignment

Pin #	Signal
1	Power Hot
2	Power Return
3	NC
4	Data RX-
5	Data RX+
6	Power Hot
7	Power Return
8	Data TX-
9	Data TX+

4. Specific Technology

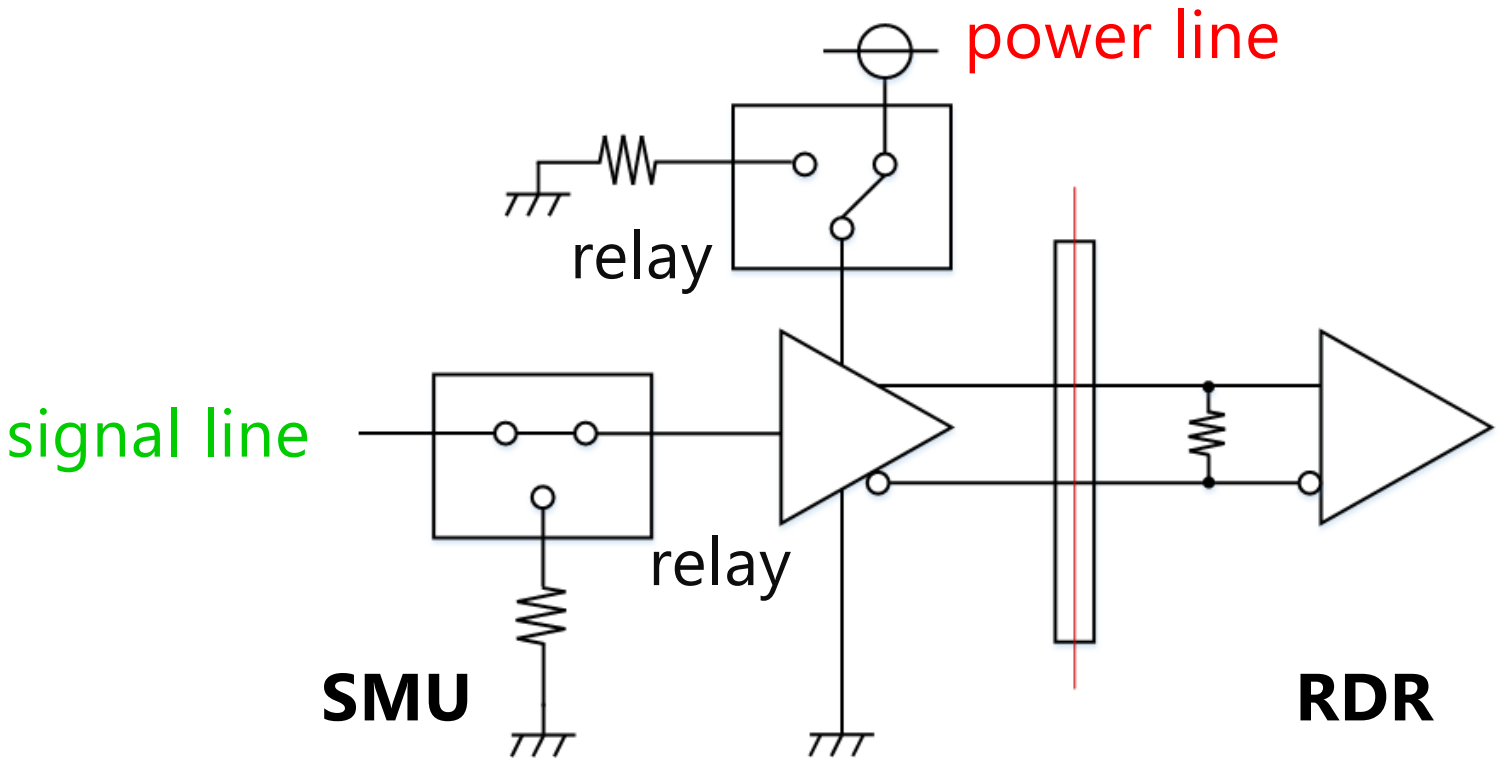
(1) Strobe-less Communication



4. Specific Technology

(2) Protection for after Separation

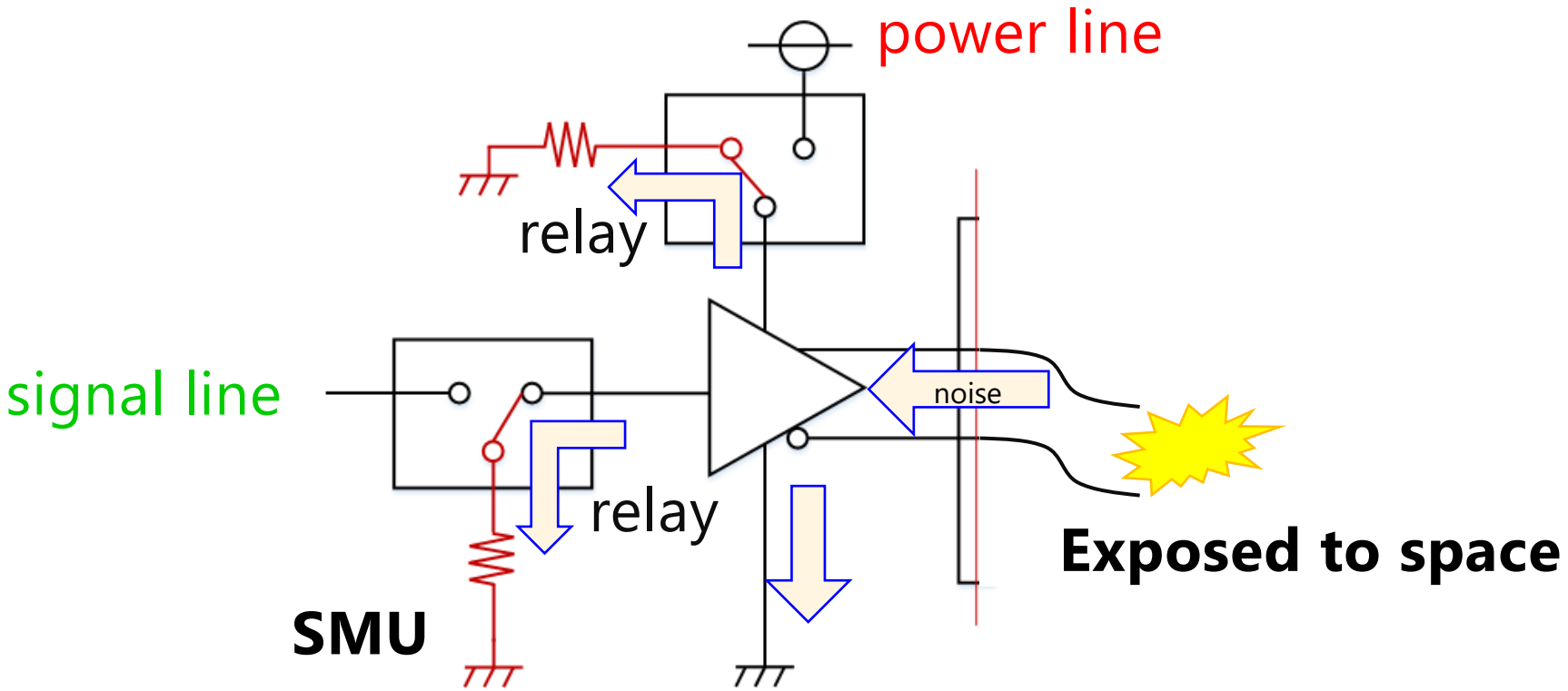
- There will be separation events in SpaceWire I/Fs.
- Before separation, IC is connected power and signal line.



4. Specific Technology

(2) Protection for after Separation

- There will be separation events in SpaceWire I/Fs.
- After separation, IC is connected GND through resistor.



5. Lessons Learned

(1) Constraints of Existing Design

- Using many existing HW/SW frameworks.
  - ! It caused network complex.
  - ✓ Choosing a new design if there is total benefit instead of using the existing design is important

(2) Interface Specification Adjustment

- How to use upper layer than SpaceWire varies from instruments to instruments (how to identify dummy data etc.) .
  - ! It took a lot if time to develop some components.
  - ✓ To determine quickly or standardize upper layer than SpaceWire is important.

5. Lessons Learned

(3) Interface Verification

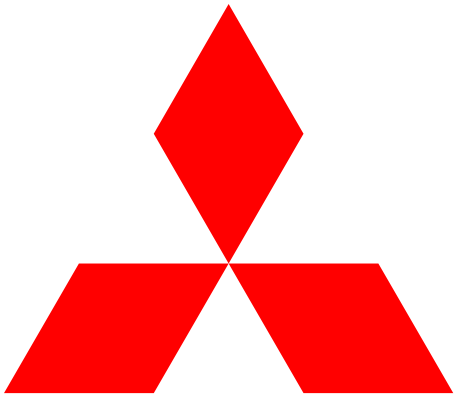
- We distributed simulators to instruments manufacturers at early phase when not interfaces finalized.

! It took a lot of time to verify at combinational tests.

✓ Determining interface specification at early phase and updating simulator can shorten combinational test term.

6. Summary

- We have developed MMX SpaceWire network.
- MMX consists of Three modules and have separation events at three times.
- We successfully implemented specific technologies;
  - Strobe-less communication
  - Protection circuits
- We have gotten some lessons learned during development.



MITSUBISHI
ELECTRIC

Changes for the Better