Keynote 3: Research Trends and Hot Issues

Part 1:
Topics of Industry Application in Japan

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Outline

- Present circumstances of PLC, especially PLC modems for home, in Japan
- Japanese regulation
- Some topics of industry application

  (1) to non-power line mediums

  (2) to electric vehicles, and other transportations

  (3) Our activity: a research of PLC in cargo ships

  – Common-mode transmission will be proposed as the suitable scheme for the ships.

Present Circumstances of PLC in Japan

- Japanese regulation was relaxed in October, 2006.
  - Before: allowed band was from 10k to 450kHz
  - Now: HF band of 2M to 30MHz
- PLC modem for home has gradually but steadily been popularized.
  - ✓ The EMC issue is not completely solved, so that the allowed area is limited indoors.
  - ✓ Compatibility with the existing products (1st generation) with the next (2^{nd}) gen. based on the standard

➢ To solve these problems and advance the PLC technology further, it is necessary to develop new application fields, especially industry applications,.

Weekly ranking of popular products for home

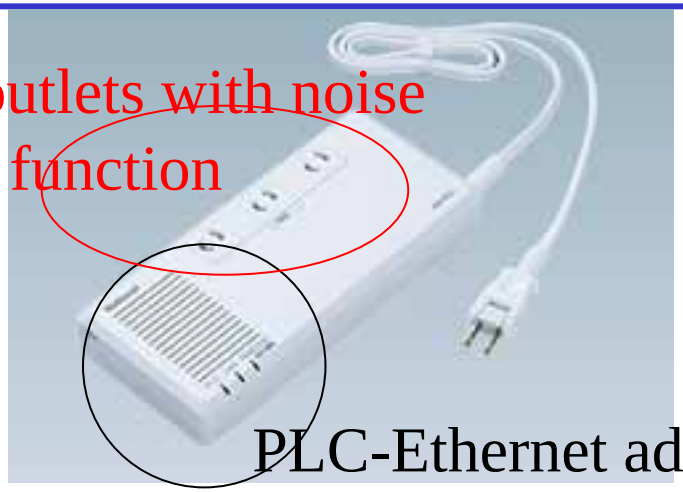
Ranking	Vendor / Product number	Average price [JPY] (2008/03/20)	Release date	compliant system
1	Panasonic / start pack BL-PA100KT	15,762	2006/12	HD-PLC
2	BUFFALO/ set model PL-UPA-L1/S	12,560	2007/08	UPA
3	Panasonic / start pack 4ports type BL-PA204KT	16,704	2007/12	HD-PLC
4	NEC / router set PA-CR2500P/A	21,202	2007/07	HD-PLC
5	Panasonic / power strip type LN3710	19,482	2007/05	HD-PLC
6	BUFFALO / set model PL-HDP-L1/S	12,845	2007/04	HD-PLC
7	SHARP / pair model	10,603	2007/08	HomePlug AV

•Average price of a pair of PLC adapters is around 160USD.

2008 http://www.coneco.net/masterranking/01302020.html, 2008/03/16 to 2008/03/23

Unique PLC products for home

- Panasonic / power strip type LN3710 (HD-PLC)



http://biz.national.jp/Ebox/plc/siyou.html,

- Pioneer Co. / PLC speaker XW-PSS01 (Dynamic Multi Carriers Reconfiguration (DMCR) –PLC: proprietary)

Music can also be played automatically using a motion sensor which detects people's existence.(e.g. at kitchen or toilet).

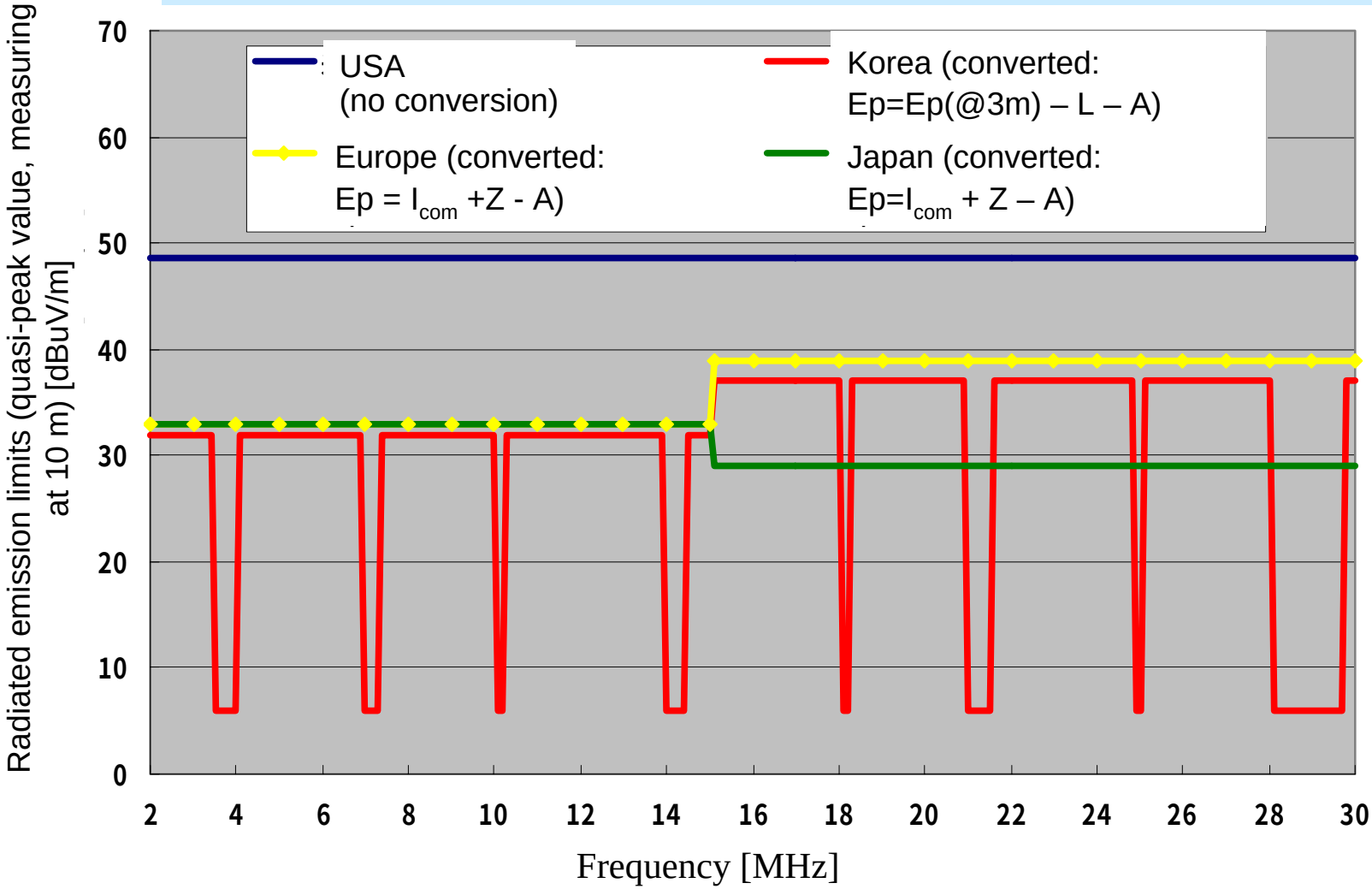
http://pioneer.jp/press/release568-j.html

Comparison of regulations

Ref. “All of the high speed PLC”, p.36, Nikkei Business Publications, Inc., July 2006.

- Att. by a wall, A=12dB(2 to 15MHz), 7dB(15 to30MHz)
- Att. by the distance, $L=20\log_{10}(10m/3m)=10$ [dB]
- Conversion factor, Z=15dBΩ/m(2 to 15MHz), 16dBΩ/m(15 to 30MHz)

← Field strength, Ep [dBμV/m] = current I_{com}[dBμA] + Z [dBΩ/m] (from CISPR 15)



Radiated emission limits (quasi-peak value)

USA

frequency	Limit (field strength)	
1.705 to 30MHz	48.5μV/m	Measuring at 10m beyond a wall, 16 directions
30 to 80MHz	39μV/m	

Europe (EN55022, comm.port)

frequency	Limit (common-mode current)
0.5 to 30MHz	30dBμA (LCL of ISN = 30dB)

Korea

frequency	Limit (field strength)
0.45 to 30MHz	54dBμV/m (without a wall/shield, 3 m from aerial cable)

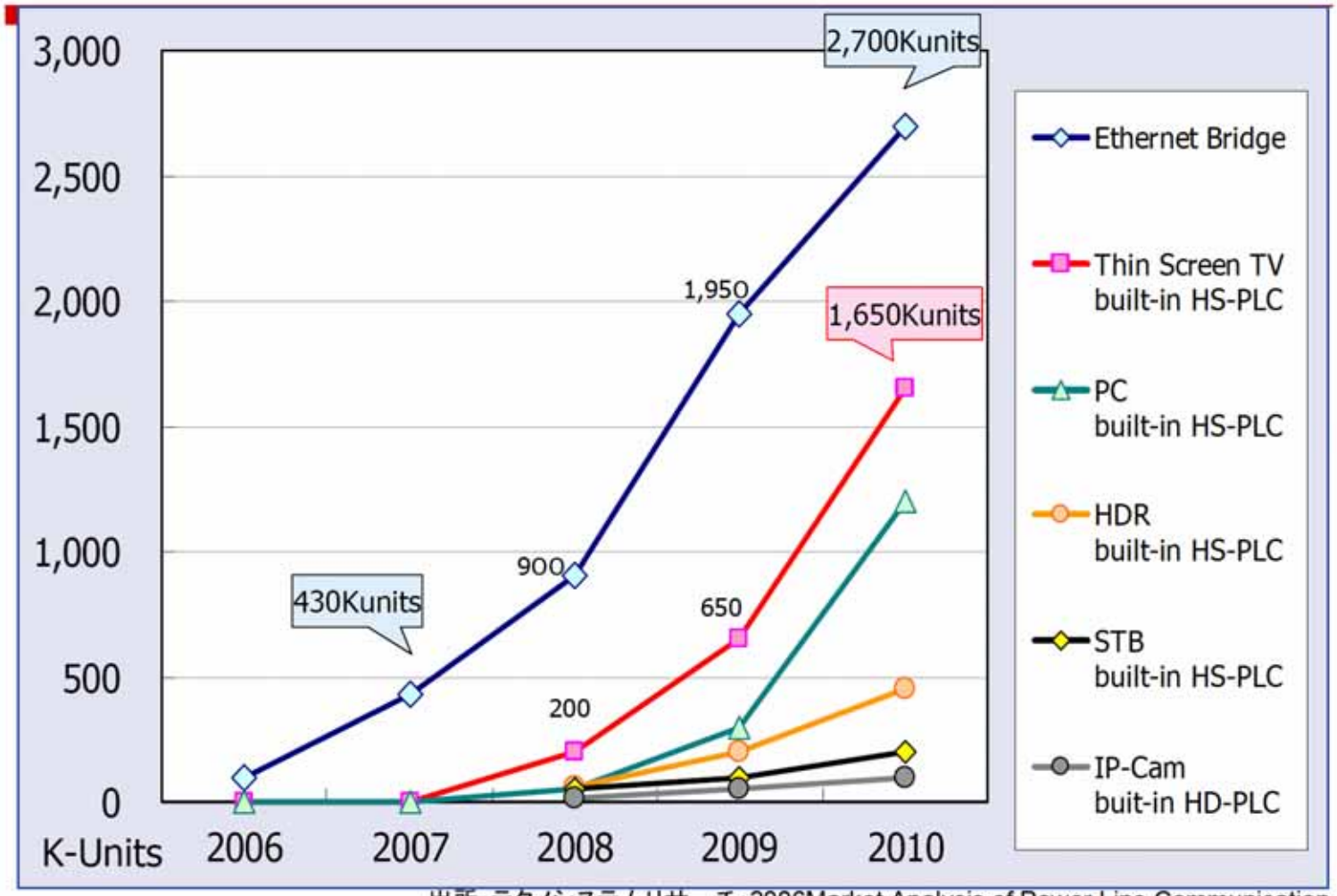
Japan

frequency	Limit (common-mode current)	
2 to 15MHz	30dBμA	(LCL of ISN = 16dB)
15 to 30MHz	20dBμA	

- Japanese limits are severest.
- Only indoor use is allowed in Japan.

2007/03/07

PLC market of Japan



出所：テクノシステムリサーチ：2006Market Analysis of Power Line Communication

SHARP

http://net.intap.or.jp/INTAP/information/seminar/18-20070307_ipsj/03_kitaguchi.pdf

Present Circumstances in Japan (Summary)

- Japanese regulation was partly relaxed in October, 2006.
- PLC modems for home have gradually but steadily been popularized.
  - ✓EMC issue is not completely solved, so that the allowed area is limited indoors.
  - – The embedded PLC is waiting.
    - ← Standardization issue

➢ To solve these problems and advance the PLC technology further, it is also necessary to develop new application fields, especially industry applications.

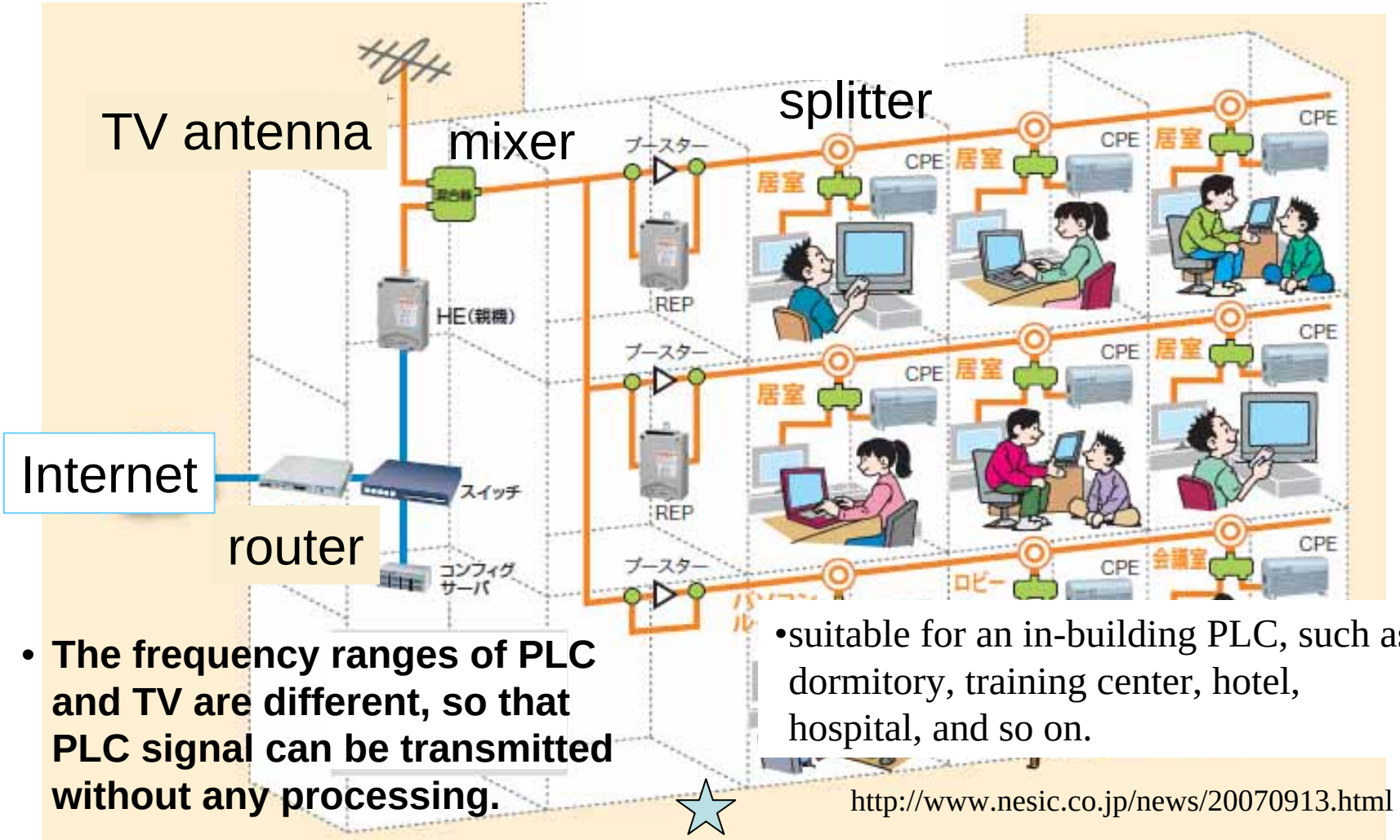
Some topics of industry application
(1) applied to a non-power line medium

- Advantage : When metal lines, such as coaxial cables and twisted pair wires, are used, the performance, quality, and distance are improved without any severe regulation.
  - ➢ Seamless network (e.g., power-line for access, metal line for distribution backbone)

(1.1) Example of product: Ethernet bridge using existing coaxial cables for a TV antenna

- DS2 chip based: max. 200Mbps
  - •Sumitomo Electric Industry (ACLC series), NEC (TOYONETz CX series). Since Sep., 2007.
- Mitsubishi Elect. (proprietary) chip based: max. 300Mbps
  - •IEEE-P1901 proposed. Embedded software is possible. (LVC-BD10 and CPE-BD10). Since 2009

(1.1) Ethernet bridge using existing coaxial cables for a TV antenna



- **The frequency ranges of PLC and TV are different, so that PLC signal can be transmitted without any processing.**

•suitable for an in-building PLC, such as dormitory, training center, hotel, hospital, and so on.

http://www.nesic.co.jp/news/20070913.html

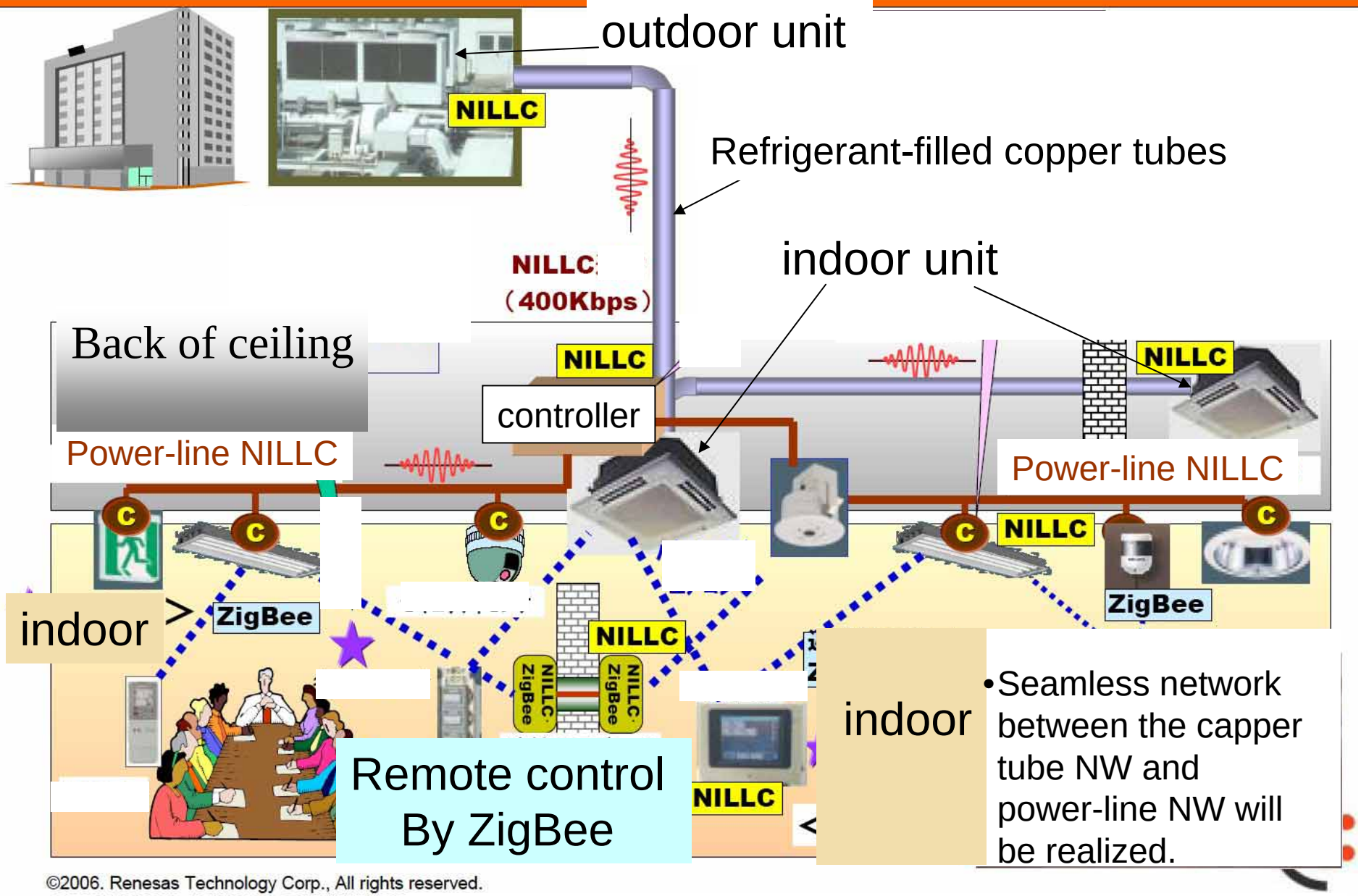
(1.2) to copper tubes for air-conditioner

- When a ferrite is attached as a impedance upper, a pair of tubes become a pair of communication line.
- use a chip of NILLC* by Renesas Technology Corp.
  - Multi-carrier (5 tones) modulation using a freq. band of 2 to9MHz
  - Max. 400kbps
- Patent: Mitsubishi Electric Co.

NILLC: Non Interference Legacy Line Communication
http://journal.mycom.co.jp/articles/2005/02/20/mitsubishi/001.html

CEPCA 技術セミナー

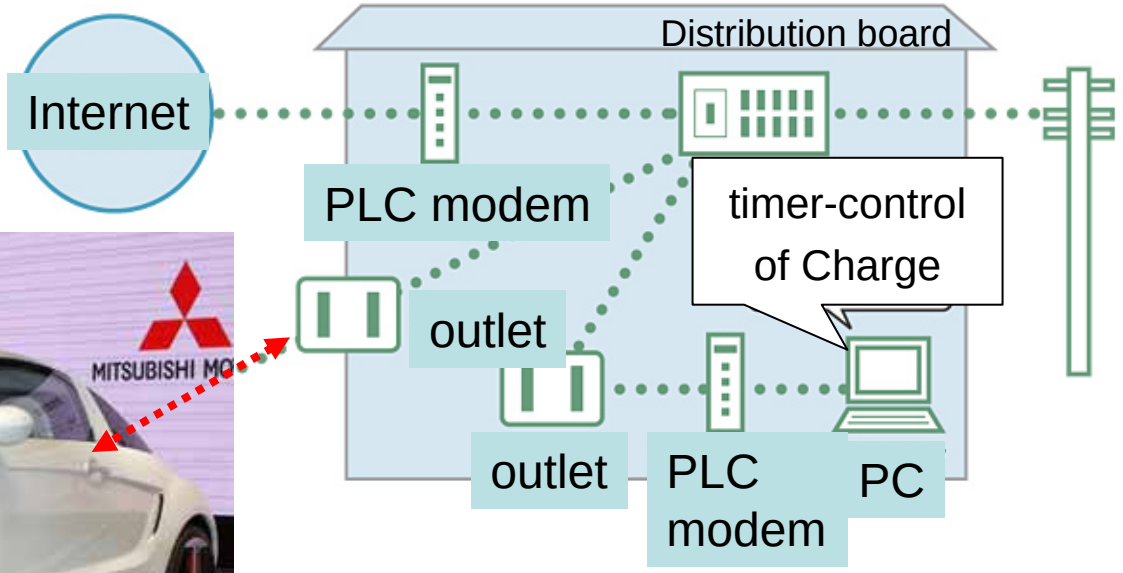
Application to air-conditioning and lighting system in a building



http://www.cepca.org/about_us/Events/past_events/japan_seminar/CEPCA_Seminar_Renesas.pdf

(2) Application to Electric vehicles By Mitsubishi Motors, “MiEV communication system”

http://bb.watch.impress.co.jp/cda/event/19853.html, Oct., 2007



When an electric vehicle (EV) is charged at home, the LV power-line is used.

- Timer-control of charging, air-conditioning of the car, and so on, can be remotely controlled from a PC in the house,
- Music contents and navigation information can be downloaded into the car.

(The schedule of commercialization is undecided.)

(3) Other transportation applications

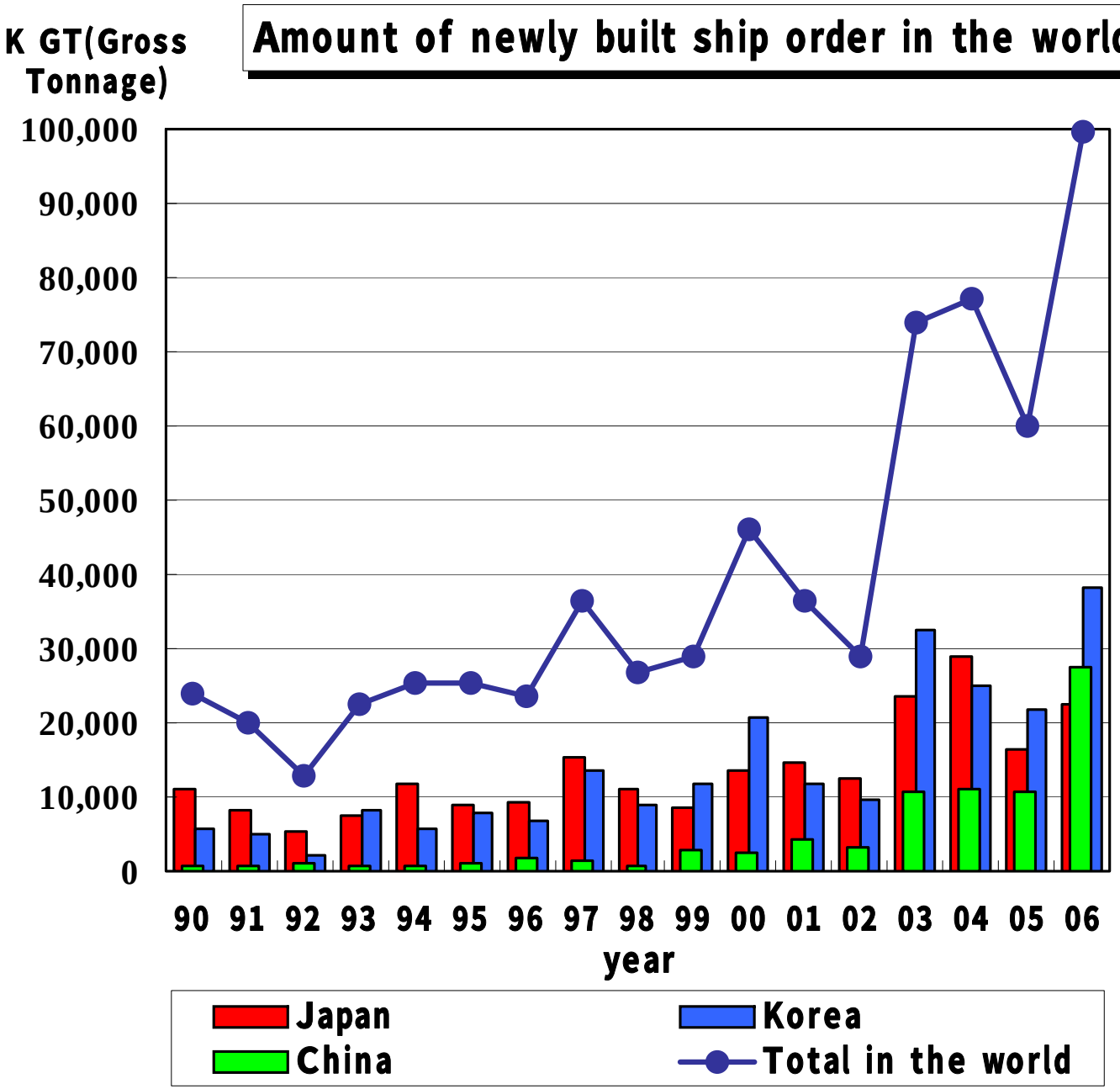
Are also not allowed, but …

- Train: e.g., Internet service in Shinkansen bullet train will be a promising service realized by PLC technology.
- Ship
  - Cruise ship
  - Cargo ship* : Technical issues:
    - ✓Compatibility with the existing radio services
      - ➢ Adaptive power-control to electromagnetic environment
    - ✓Repeating method for long distance communication

http://onkochishin.blog.so-net.ne.jp/2007-07-06

*This work was supported by the Strategic Information and Communications R&D Promotion Program (SCOPE) of the Ministry of Internal Affairs and Communications of Japan.

Amount of newly built ship order in the world



- As a position of Japan, the development of high-value added ships are required.

http://www.sajn.or.jp/data/neworder.htm

From the features of the distribution system in cargo ships, (1) Dual-mode trans. will be possible

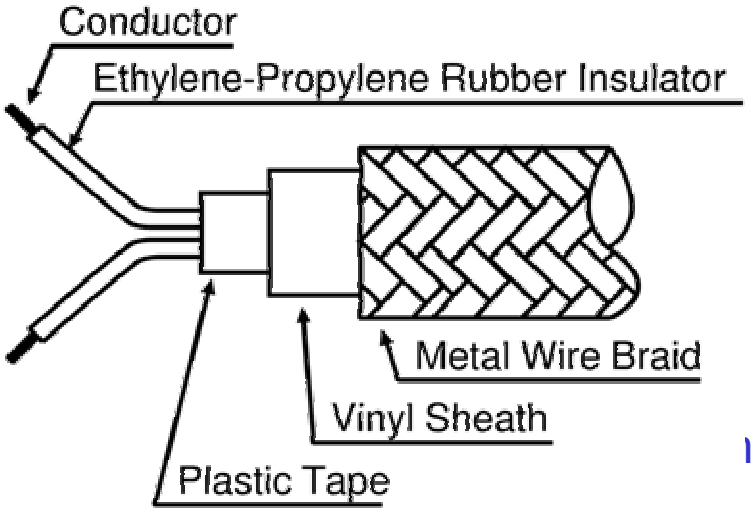
- Cargo ships are made of iron.
- Most power-line cables in the ships are armored.

➢ The hull and the wire braid shields the electromagnetic radiation.

- The hull provides the common ground level anywhere.

➢ The common-mode transmission in addition to the conventional differential-mode is possible to improve the channel capacity.

■Note: If unarmored cables are used partly, the radiation is easily occur.



Most power-line cables are shielded

- Most ships (87%) were built in Asia.
- 89% of cables used in Asian ships were armored.

➢At least 77% (=0.87 * 0.89) of shipboard cables were shielded.

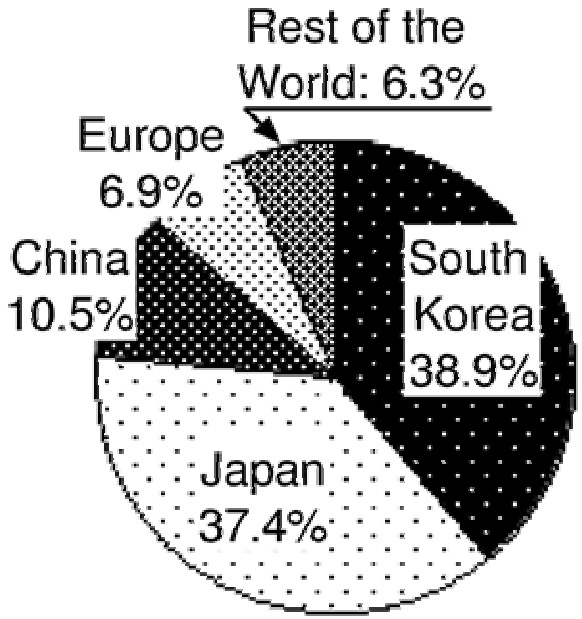


Fig.1. Ratio of amounts of newly built ship in 2004 by Gross Tonnage (GT). (For the ships of 100 GT or more.)

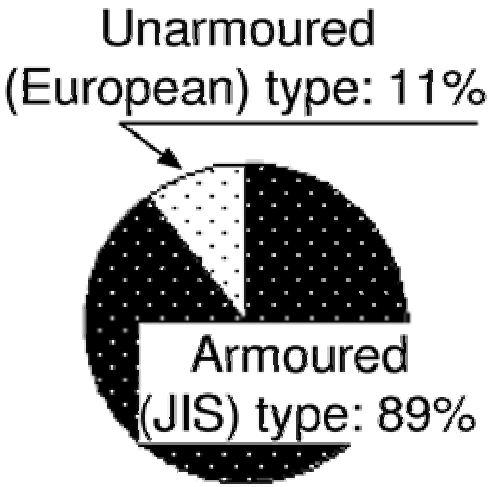


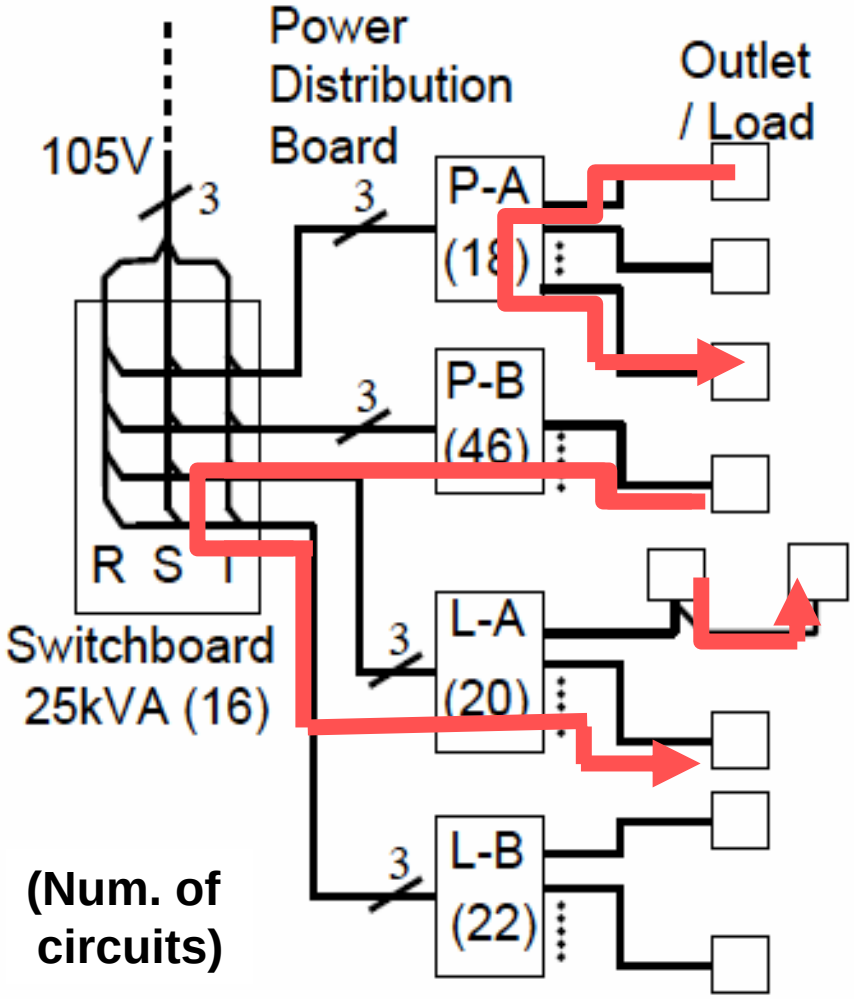
Fig.2. Ratio of maximum monthly shipping capability of the shipboard cables by five major companies in Asia in 2006.

[S.Tsuzuki, et.al., ISPLC2007]

Not only power cables, but all of communication cables are also armored.

Diagram of the distribution system of Ship-C

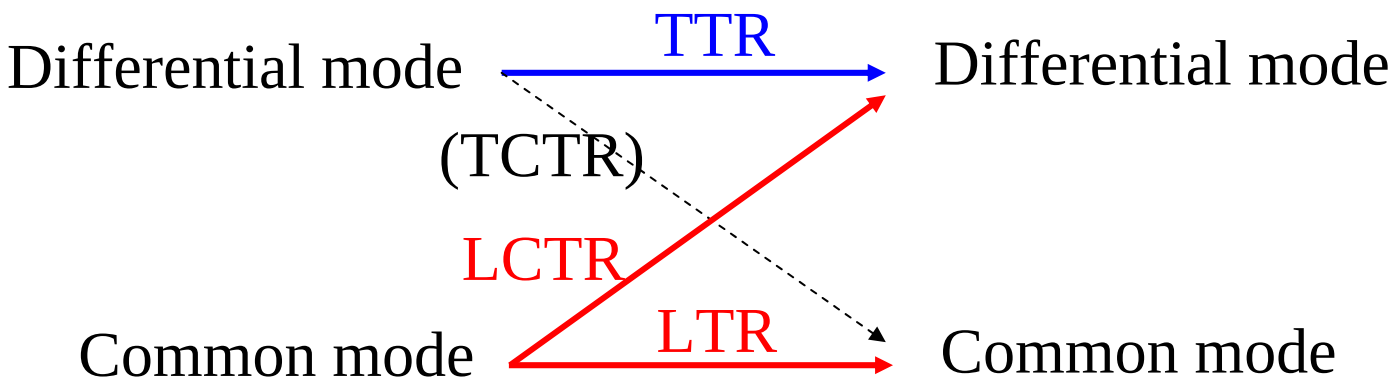
- In general, the LV distribution systems in ships are the three-phase configuration, whose phases are called R, S and T.
- ➢ The named P boards (P-A, P-B,…) are for power distribution.
- ➢ The L boards (L-A, L-B, . . .) are for lighting.
- The possible numbers of boards which the injected signal passes are 0, 1, and 3.
- ☐ This topology is the same as that of other ships.



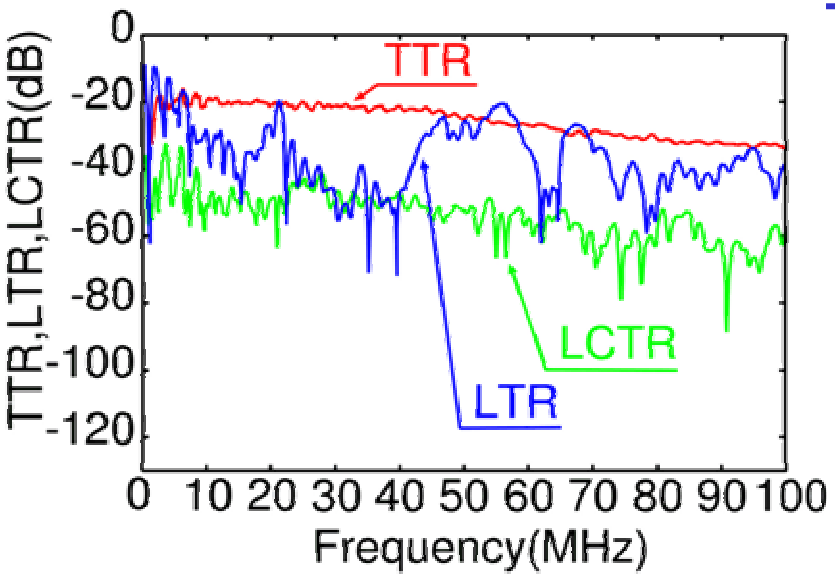
Measured transfer functions

- Transfer functions
  - TTR (Transverse Transfer Ratio) : conventional PLC
  - LTR (Longitudinal Transfer Ratio)
  - LCTR (Longitudinal Conversion Transfer Ratio)

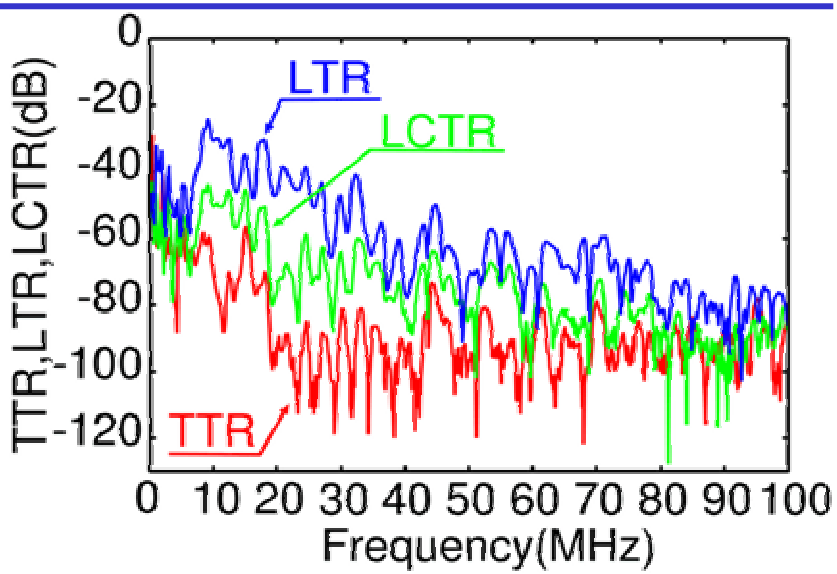
} proposing



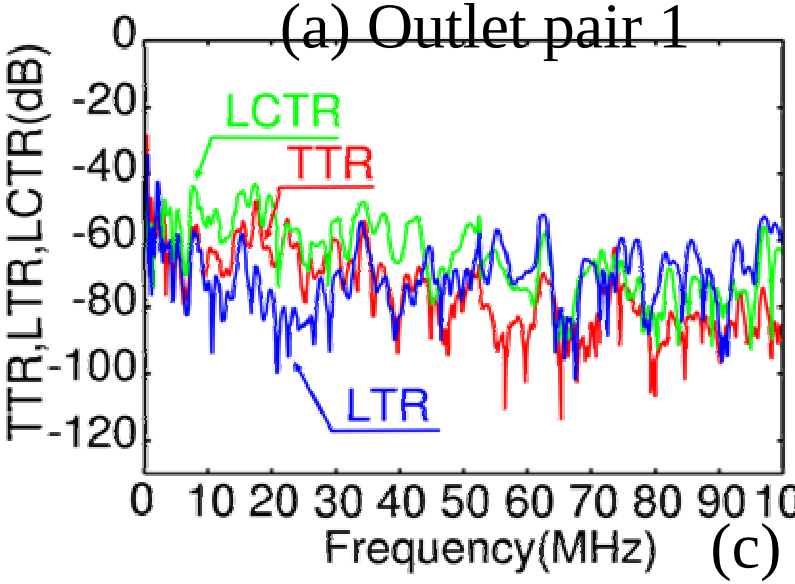
Typical examples when one of the transfer functions is superior to the others.



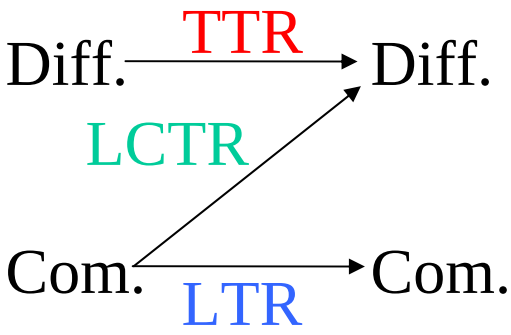
(a) Outlet pair 1



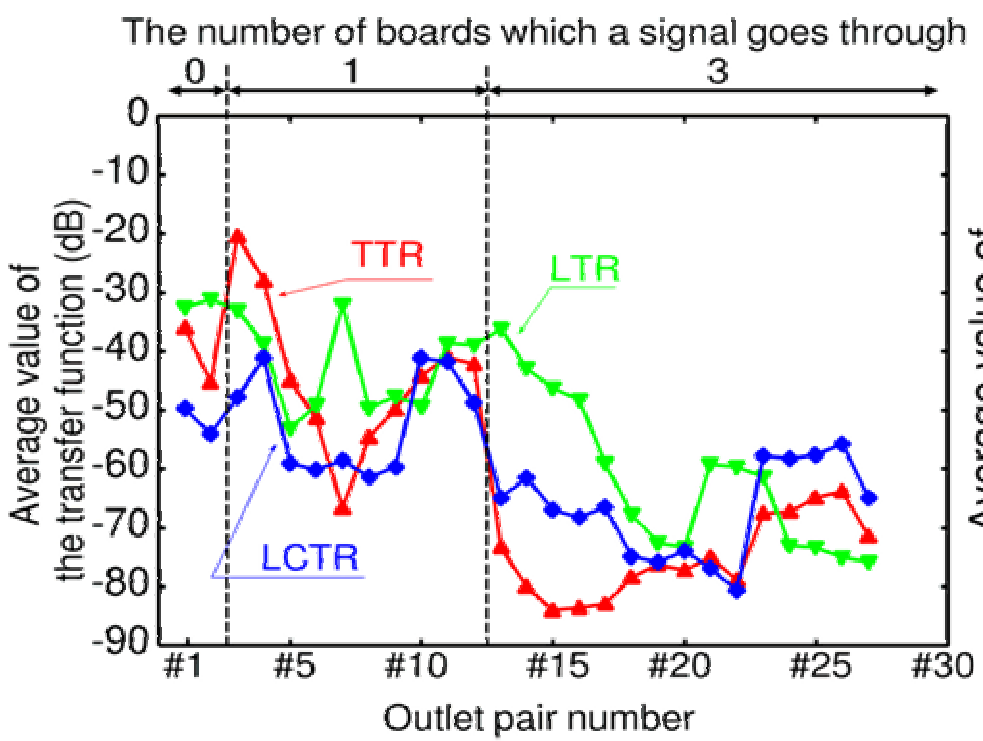
(b) Outlet pair 2



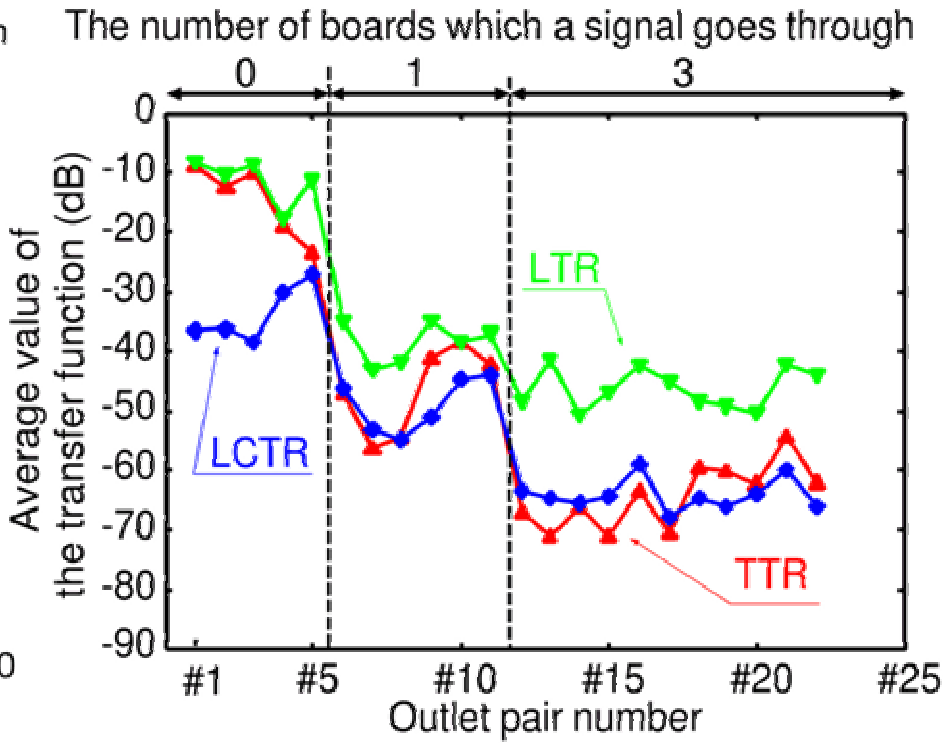
(c) Outlet pair 3



Average value (2M to 30MHz) of transfer functions

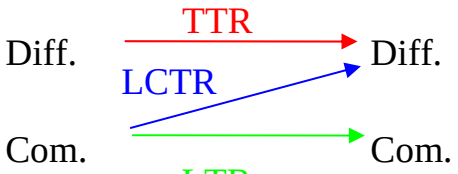


(a) Ship C (All cables were armored)



(b) Ship T (unarmored cables were used partly)

- The superiority of three functions depended on the examined outlet pair.
- Fully or partly are important.



Features of low-voltage distribution system in cargo ships (2)

- The number of circuits per board is more than that of home, and its loss is dominant.

The amount of attenuation per distribution board when the number of boards was three.

Transmission mode	Ship C (All cables were armored)	Ship T (unarmored cables were used partly)
Differential (TTR)	16.2 dB	8.9 dB
Common (LTR)	8.7 dB	4.0 dB

➢The place where the repeaters should be set is the board.

Comparison of radiation from Ship-T and a model house

Attenuation for Ship-T (unarmored cables were used partly)

Freq.band [MHz]	Att. by the distance, L: (10m / 30m) [dB]	Att. by a wall, A [dB]	Att. by the armored cable, C [dB]	L+A+C [dB]
5 to 30	17	11	0 (except Engine Room)	28
			16 (ER)	44

Partly armored

Fully armored

Attenuation for a model house [http://www.soumu.go.jp/s-news/2005/pdf/051021_1_1.pdf]

Freq.band [MHz]	L (dB)	A [dB]	L+A (dB)
2 to 30			

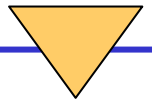
If unarmored cables are used partly, the radiation is easily occur. Although the ship was made of iron, the shield by the ship wall is not perfect.

Topics of industry application fields: Summary

(1) a non-power line medium, (2) Electric vehicles and other transportations → These availability studies are important to relax the Japanese regulation more.

(3) Channel characteristic of cargo ships is affected by

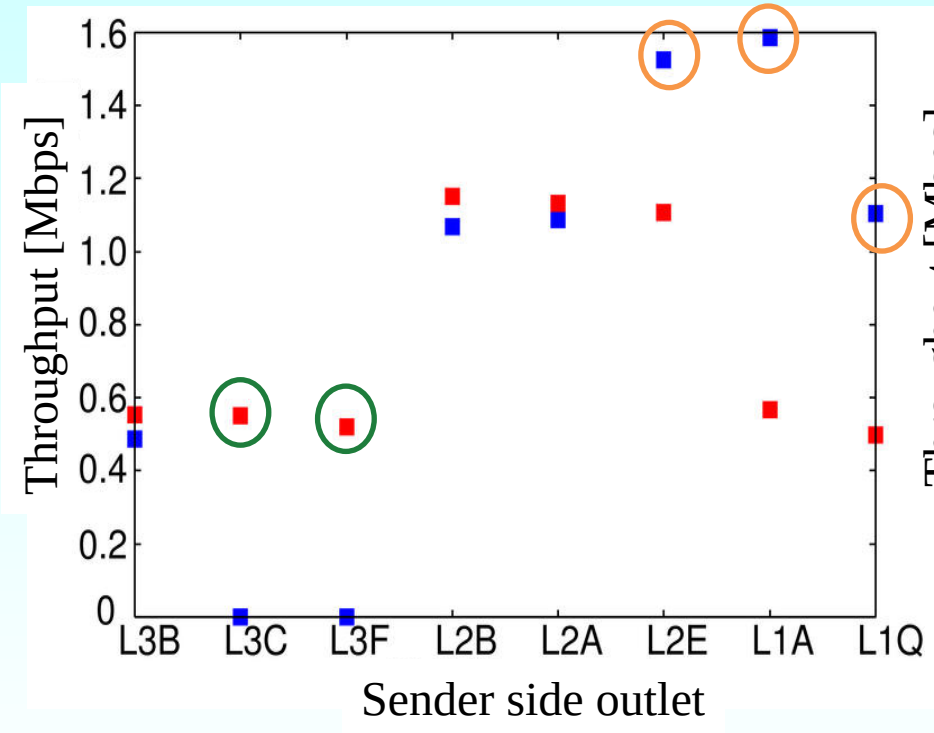
- the power-line cable structure (armored or not)
- the number of circuits at a board
  - The place where the repeaters should be set is the board.
- Common-mode and dual-mode transmission have been proposed.



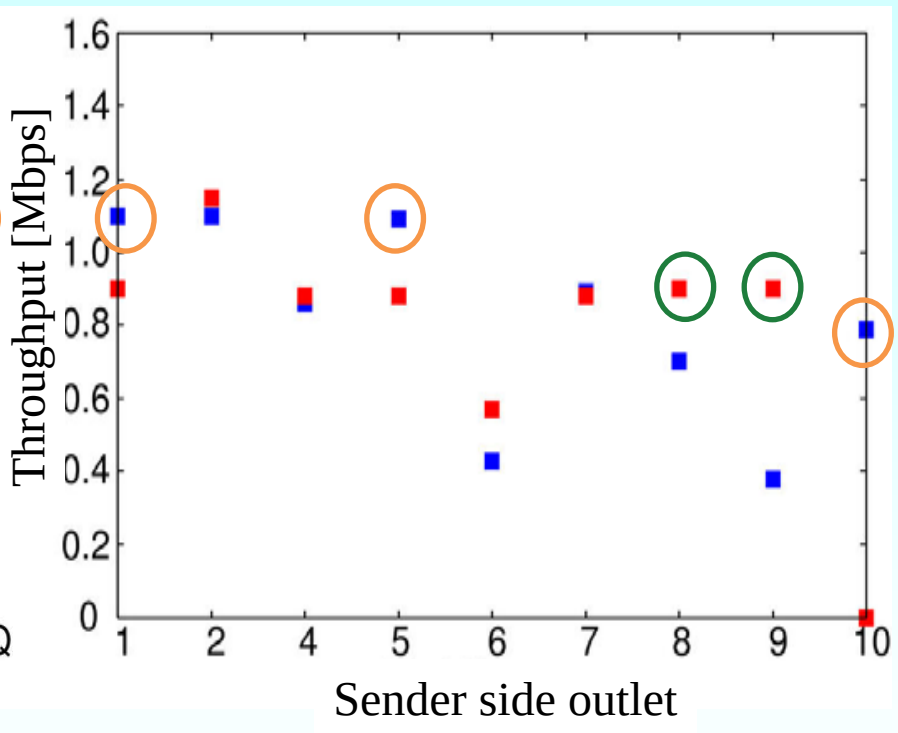
Throughput evaluation of both modes (UDP packet)

Differential mode
Common mode

Yitran Com. based modem: PLAM2500J



(a) Ship T
(Receiver side outlet: L2D,
Packet size: 1472byte)



(b) Our Laboratory
(Receiver side outlet: #3,
Packet size: 512byte)

→ Mode combining or selection seems to be effective.

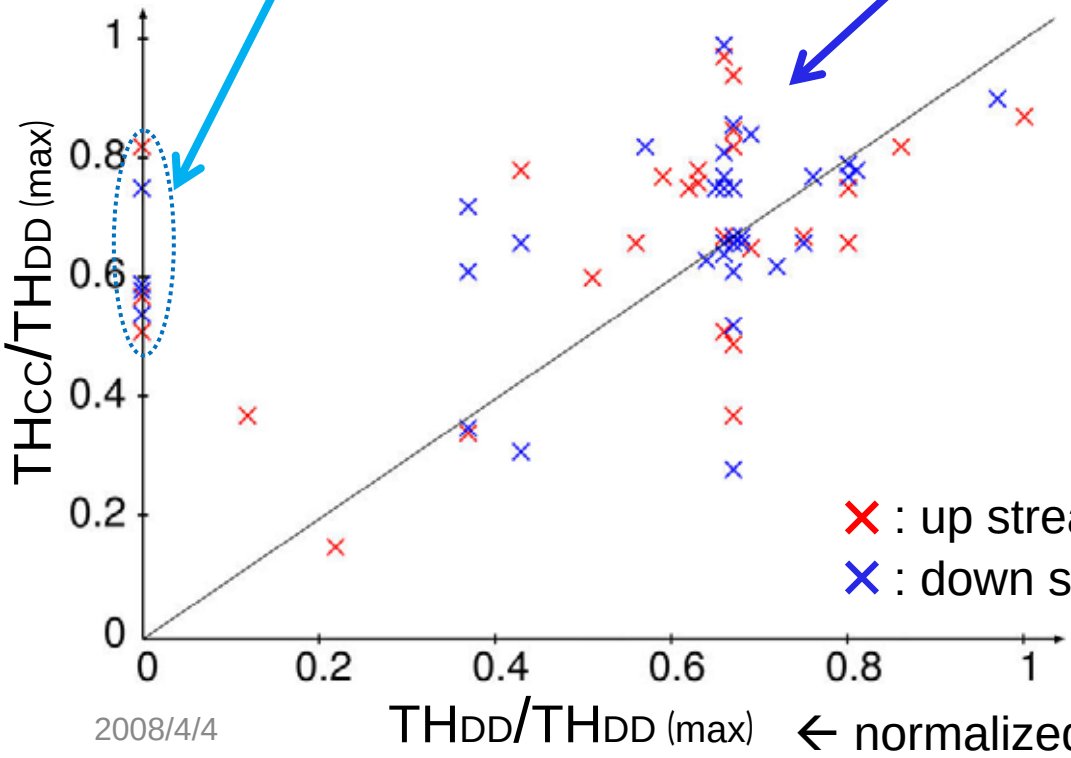
Mode selection approach in our Lab.

Diff → Diff :TH_{DD}
Com → Com:TH_{CC}

- Number of outlets: 10
- Measured outlet pairs: 40 (i.e., Number of routes: 80)
- Max. throughput, $TH_{DD(max)}$=1.34Mbps

Com → Com only : 8 routes (10%)

Com→Com is better : 44.4%, excluding 8 routes



$$\sum_{i=1}^{72} \frac{\max(TH^{i}_{DD}, TH^{i}_{CC})}{TH^{i}_{DD}} \Big/ 72 = 1.15$$

Another mode selection

- Typical routes of 28 were selected.
- $TH_{DD(max)}$=1.15Mbps

Diff → Diff :TH_{DD}
Com → Com:TH_{CC}

$$\sum_{i=1}^{28} \frac{\max(TH_{DD}^{i}, TH_{CC}^{i})}{TH_{DD}^{i}} \Big/ 28 = 1.29$$

Diff → Diff :TH_{DD}
Com → Com:TH_{DC}

$$\sum_{i=1}^{28} \frac{\max(TH_{DD}^{i}, TH_{DC}^{i})}{TH_{DD}^{i}} \Big/ 28 = 1.33$$

$$\sum_{i=1}^{28} \frac{\max(TH_{DD}^{i}, TH_{CC}^{i}, TH_{DC}^{i})}{TH_{DD}^{i}} \Big/ 28 = 1.42$$

Application to cargo ships: Conclusion

- Common-mode transmission have been proposed.
  - ○ Throughput improvement due to the mode-selection diversity was about 40 % in our laboratory.
  - ✖ Usage of common-mode trans. has a risk of radiation, especially for the ship using unarmored cables.

Future Work

  - ○ Throughput improvement due to the mode-selection or combining diversity will be examined in the ships.
  - ✖ Adaptive power-control method to the radiation should be developed.
    - ➢ Applications to the non-power line medium will also be accelerated.
    - ➢ Japanese regulation will be relaxed more ?