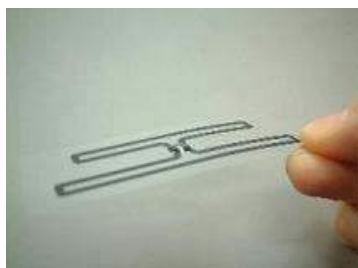


Antenna Design for RFID Tag

AMPLET Communication Laboratory



Dr. Nebiya's RFID Books

1. History of RFID
2. How does RFID work ?
3. How to determine Antenna Impedance at RFID Tag ?
4. Antenna Design for RFID Tag

Hideyuki Nebiya
AMPLET Communication Lab.

Feb. 23, 2017

Private & Confidential

1

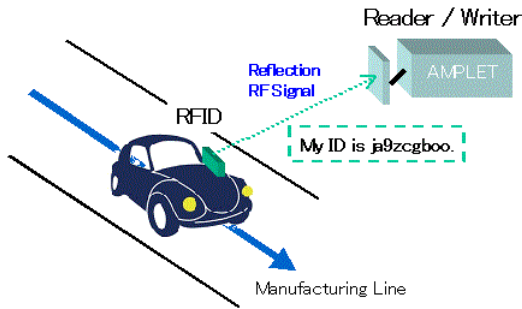
1. How does RFID work ?

Feb. 23, 2017

Private & Confidential

2

RFID using Radar Technology



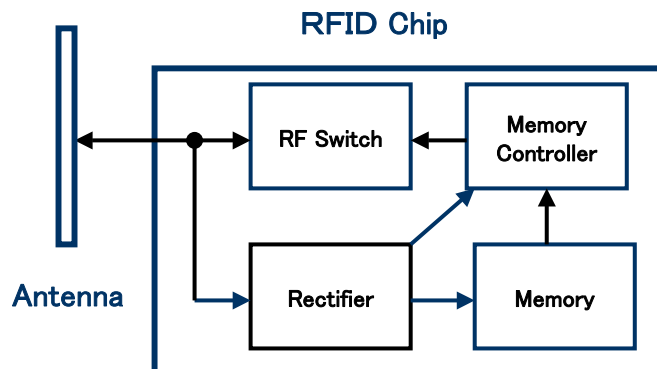
Reader



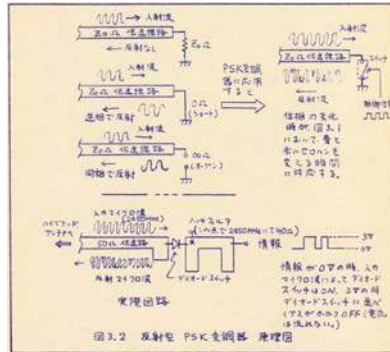
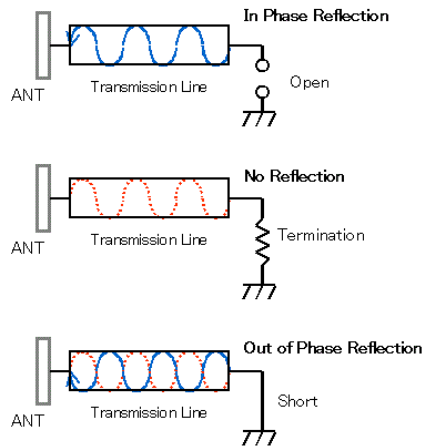
RFID Tag

When I moved to Hitachi from Nissan, I considered efficiency of Manufacturing Lines using Radar Technology. Then I invented RFID in 1984.

Typical Block Diagram of RFID Tag



Reflection on Transmission Line

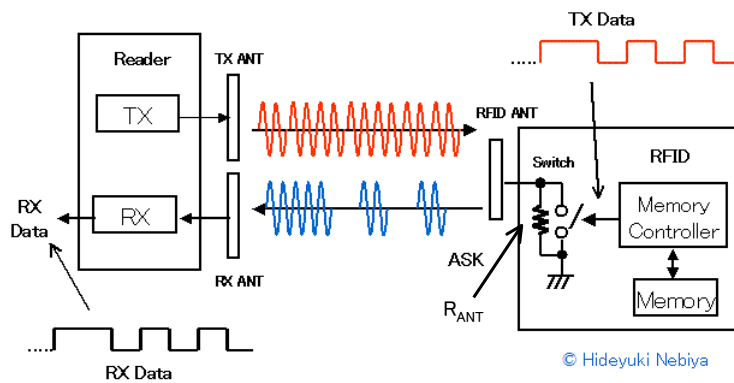


Feb. 23, 2017

Private & Confidential

5

Passive ASK RFID

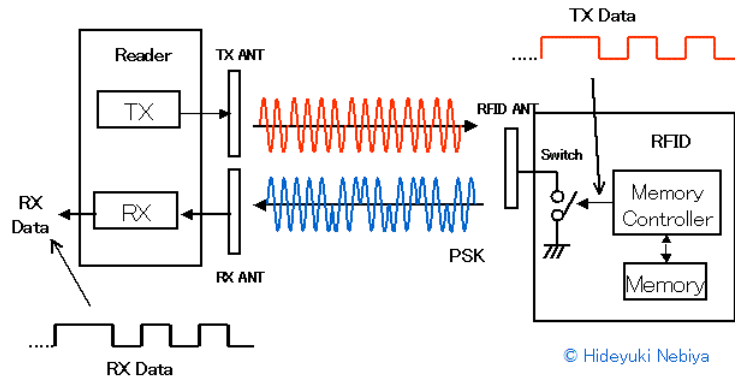


Feb. 23, 2017

Private & Confidential

6

Passive PSK RFID

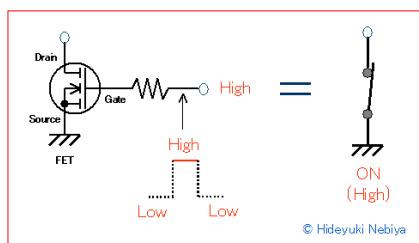


Feb. 23, 2017

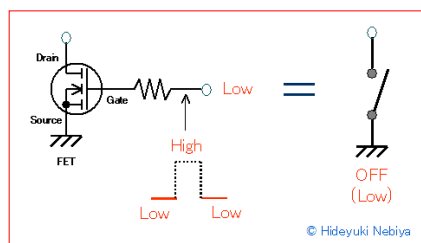
Private & Confidential

7

RF Switch



Switch ON



Switch OFF

Feb. 23, 2017

Private & Confidential

8

2. How to determine Antenna Impedance at RFID Tag ?

Feb. 23, 2017

Private & Confidential

9

In Case of ASK-RFID Tag

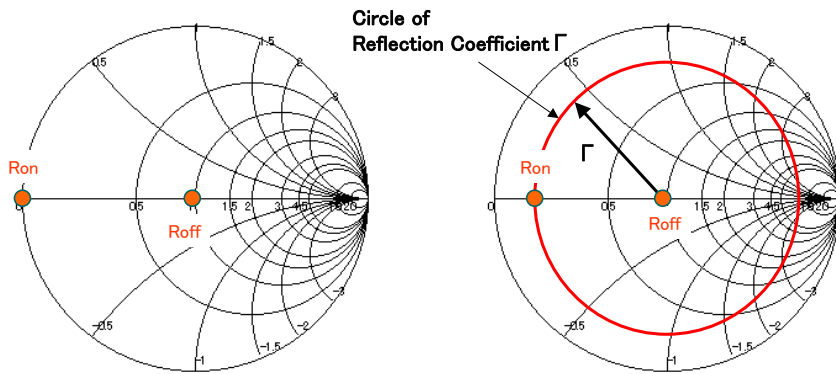
Feb. 23, 2017

Private & Confidential

10

In Case of ASK-RFID Tag Smithcart normalized for R_{ANT}

AMPLET Communication Laboratory



Ideal ASK-RFID
 $R_{on} = 0\Omega$
 $R_{off} = R_{ANT}$

In Case of ASK-RFID Tag
 $\rightarrow R_{ANT} = R_{off}$

Actual ASK-RFID
 $R_{on} = \text{Several } \Omega$
 $R_{off} = R_{ANT}$

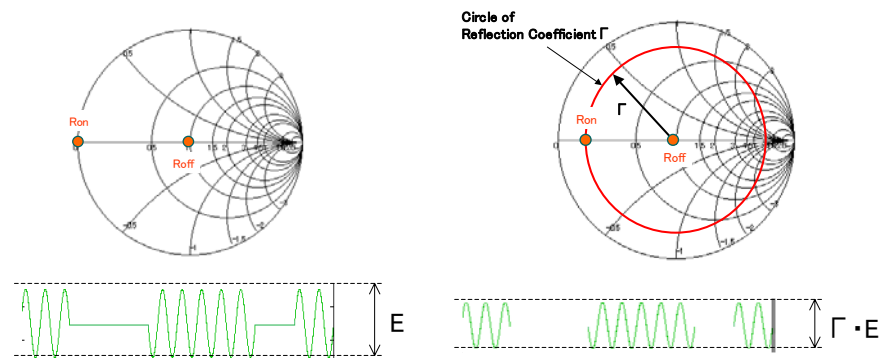
Feb. 23, 2017

Private & Confidential

11

In Case of ASK-RFID Tag Smithcart normalized for R_{ANT}

AMPLET Communication Laboratory



Ideal ASK-RFID
 $R_{on} = 0\Omega$
 $R_{off} = R_{ANT}$

In Case of ASK-RFID Tag
 $\rightarrow R_{ANT} = R_{off}$

Actual ASK-RFID
 $R_{on} = \text{Several } \Omega$
 $R_{off} = R_{ANT}$

Feb. 23, 2017

Private & Confidential

12

In Case of PSK-RFID Tag

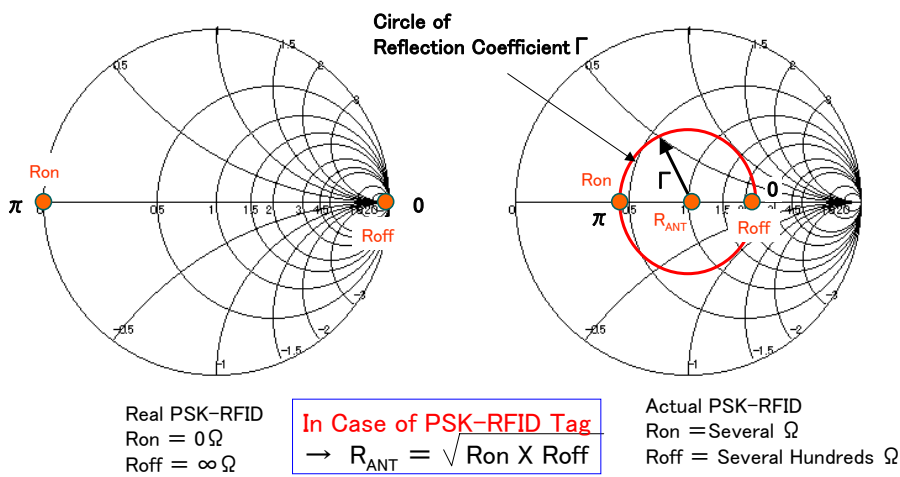
Feb. 23, 2017

Private & Confidential

13

In Case of PSK-RFID Tag Smithcart normalized for R_{ANT}

AMPLET Communication Laboratory

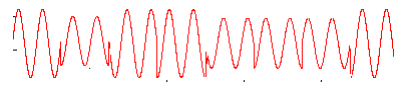
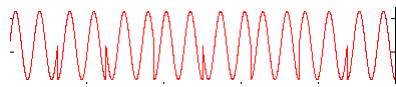
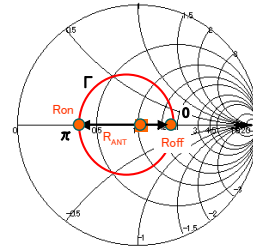
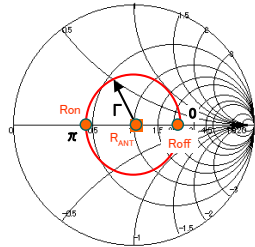


Feb. 23, 2017

Private & Confidential

14

**In Case of PSK-RFID Tag
Smithcart normalized for R_{ANT}**

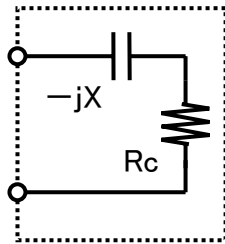


In Case of $R_{ANT} = \sqrt{R_{on} \times R_{off}}$

In Case of $R_{ANT} \neq \sqrt{R_{on} \times R_{off}}$

3. Antenna Design for RFID Tag

Impedance Matching between Antenna and RFID Chip



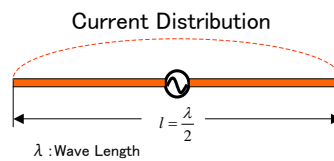
Equivalent Circuit of Passive RFID Chip

1. As an RFID Chip is too small, it is difficult to mount an impedance matching circuit on RFID wafer.
2. As an RFID Chip is too cheap, it is difficult to mount an impedance matching circuit because of price wise reason.

Current Distribution on Dipole Antenna

Resonance

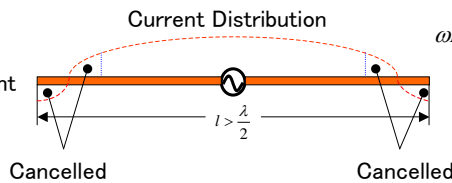
Length of Antenna Element = $\lambda/2$



$$\omega L = \frac{1}{\omega C} \rightarrow R$$

Impedance

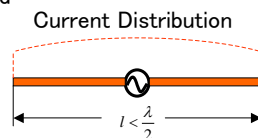
Length of Antenna Element $> \lambda/2$



$$\omega L > \frac{1}{\omega C} \rightarrow R L$$

Impedance

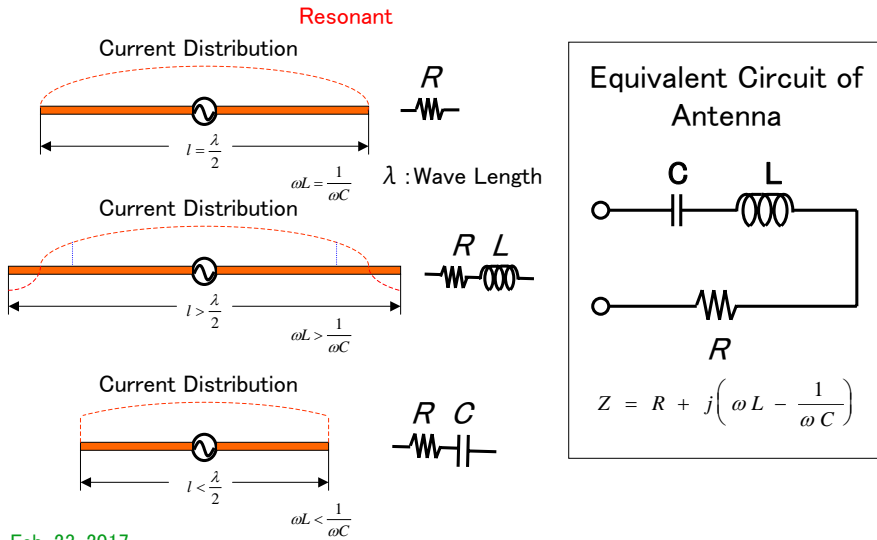
Length of Antenna Element $< \lambda/2$



$$\omega L < \frac{1}{\omega C} \rightarrow R C$$

Impedance

Antenna Impedance

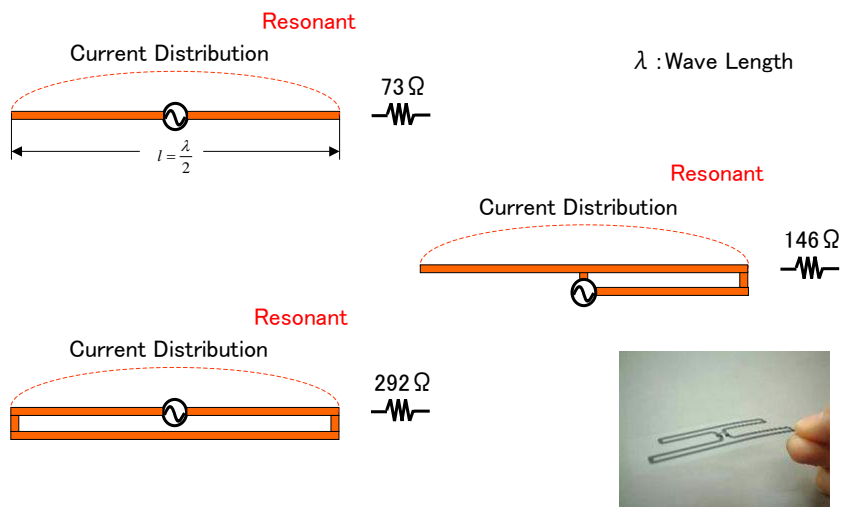


Feb. 23, 2017

Private & Confidential

19

Radiation Resistance of Dipole Antenna

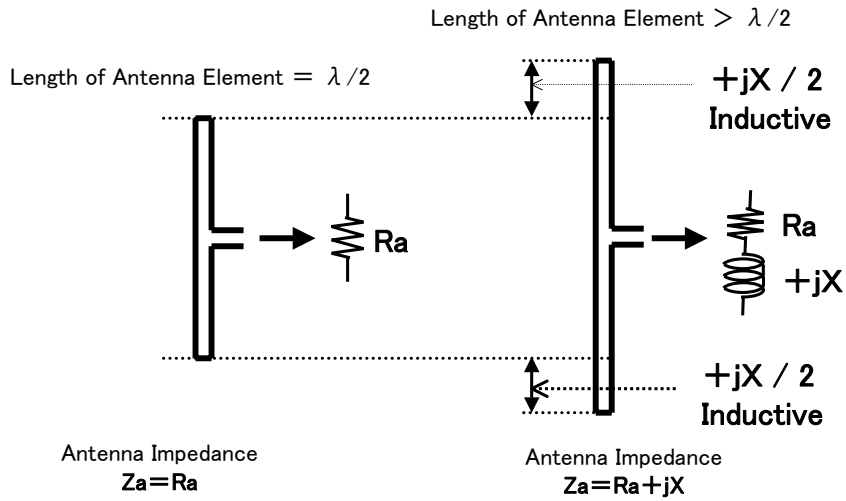


Feb. 23, 2017

Private & Confidential

20

Antenna Design for RFID Tag

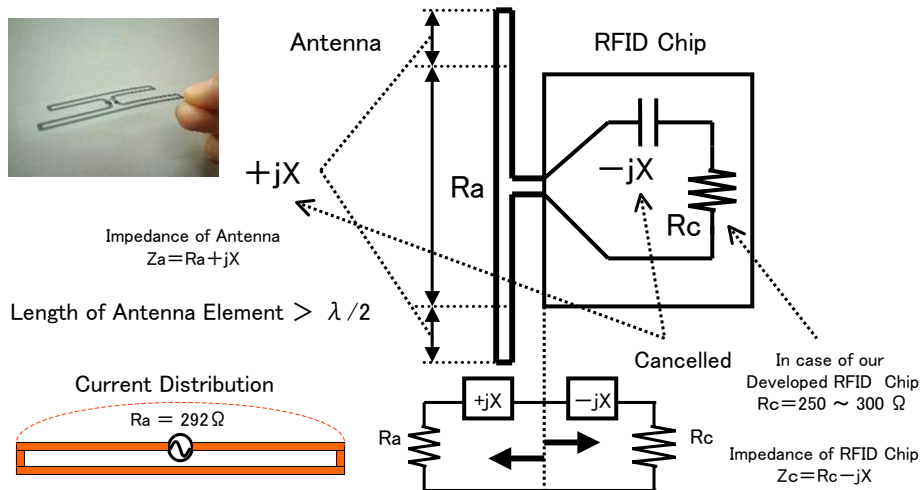


Feb. 23, 2017

Private & Confidential

21

Antenna Design for RFID Tag

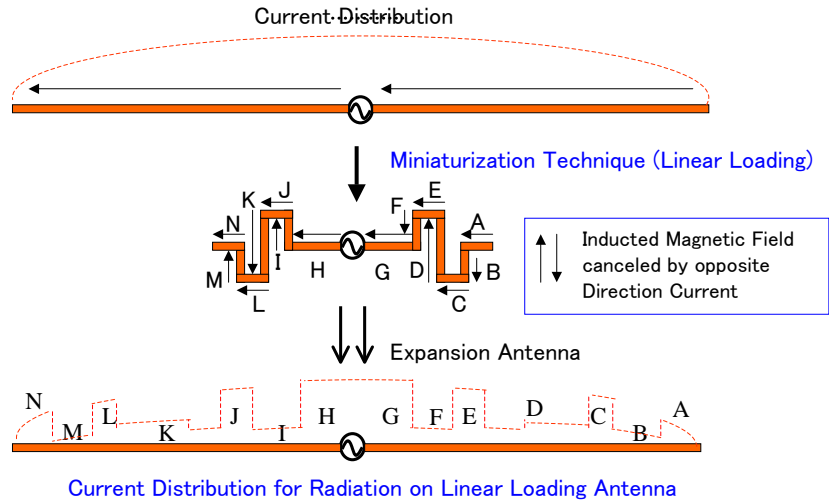


Feb. 23, 2017

Private & Confidential

22

Miniaturization of Antenna

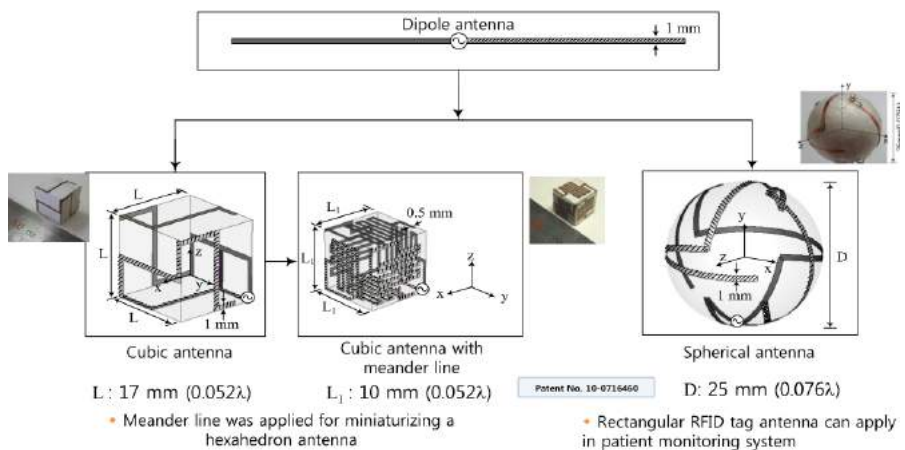


Feb. 23, 2017

Private & Confidential

23

3D Miniaturization of Antenna



(This article was reprinted from Text Book of Small Antenna Seminar by Dr. Jong-Myung Woo, GNU)

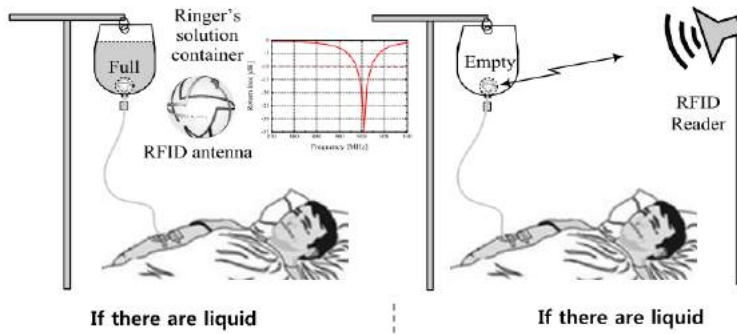
Feb. 23, 2017

Private & Confidential

24

RFID Application using 3D Small Antenna

AMPLET Communication Laboratory



- Spherical RFID tag antenna will not be recognized because of the impedance mismatching by Ringer solution

- When Ringer's solution has been consumed by a patient, the spherical RFID tag operate with exposure to air

(This article was reprinted from Text Book of Small Antenna Seminar by Dr. Jong-Myung Woo, CNU)

Feb. 23, 2017

Private & Confidential

25

4. RFID System developed by AMPLET

Feb. 23, 2017

Private & Confidential

26

Our Proposed RFID Tag

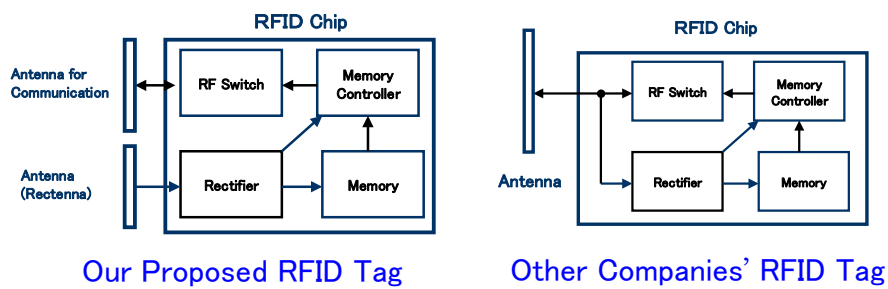
Feb. 23, 2017

Private & Confidential

27

Our Proposed RFID Tag

AMPLET Communication Laboratory



As Antenna Design Approach is much different between Antenna for Communication (Refraction RF) and Rectenna (Input RF), we determine to put separate two Antennas. Then we achieved to develop a long range RFID Tag.



Feb. 23, 2017

Private & Confidential

28

Our Economical RFID Reader

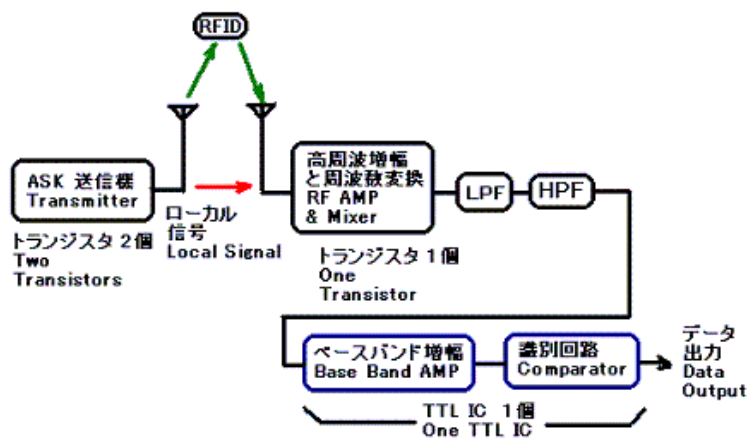
Feb. 23, 2017

Private & Confidential

29

Everybody wants to have our Economical RFID Reader !

AMPLET Communication Laboratory



Feb. 23, 2017

Private & Confidential

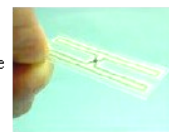
30

Toppan to Produce \$20 RFID Reader

The Japanese printing company says it will have an ultra-low-cost EPC reader on the market by June.

Jan. 23, 2003 - Toppan Printing Co., the \$10 billion Japanese printing, electronics and industrial products manufacturer is working with two other Japanese firms to mass produce readers that will cost less than \$20, as well as RFID tags and labels that will cost about 50 cents each.

Toppan has signed agreements with [Telemidic](#) and [Amplet](#). The companies will jointly develop radio frequency identification tags chips and readers that are compliant with the Auto-ID Center's specifications.



An Amplet RFID tag

Amplet, an engineering services company, has worked with Telemidic to develop a dual-frequency, small-scale, low-power RFID reader. Yoko Aikawa, a spokesperson for Toppan, told RFID Journal that the readers will cost about 2,000 yen initially, or about US\$17. Aikawa did not provide details on how the company could produce a reader that costs about one twentieth of what many others on the market sell for today.

Thank you for your attention.

AMPLET Communication Laboratory

President
Hideyuki Nebiya, Ph.D.
 Entrepreneur of the Year 2013 (Business Section)
 Lecturer, Tokyo Denki University
 Researcher, The University of Tokyo
 4-2, Taiko 3-chome, Taiko-ku,
 Tokyo 110-8618, Japan
 Tel & Fax : 03-5688-9403
 E-mail : nebiya@amplet.sakura.ne.jp
 Web : <http://amplet.tokyo/>