# DEVELOPMENT OF DUAL POLARIZATION PHASED ARRAY RADAR

M. Wada[1], H. Goto[1], F. Mizutani[1]
T. Ushio[2] S. Satoh [3]

[1] TOSHIBA Corporation, Tokyo, Japan
[2] Osaka University, Osaka, Japan
[3]National Institute of Information and Communication Technology (NICT), Tokyo, Japan

## 1. Introduction

In recently years, weather radar is more than ever required to have the capability of high precision observation, dual-polarization for hydrometeor classification and phased-array for rapid 3 dimensional observation. Toshiba Corporation has developed high precision dual-polarization weather radars which utilize solid state transmitters as well as one-dimensional phased-array weather radars with one-dimensional active phased-array antennas which allow fast three-dimensional observation.

And now, Toshiba started the research to develop the radar which integrates of dual-polarization and phased-array capabilities. This paper describes the overview of the research and development. This research is conducted jointly with National Institute of Information and Communications Technology (NICT) and Osaka University: NICT investigates the synchronization technology of plural radars, while Osaka University develops some of the signal processing method of digital beam forming and Toshiba is responsible for system design and equipment manufacturing.

## 2. Development concept

Toshiba already developed one-dimensional phased-array radars which mechanically drive the system in the azimuth direction and which perform electronic scanning in the vertical direction (elevation angle). Although this radar embodies 24 channels of transmitter system and 128 channels of receiver system in a single radar, Toshiba tried to provide low-cost radar systems by the use of highly integrated circuits even in this one dimensional radar. Moreover, If 100ch 1-dim array antenna has been converting into 2-dim array antenna with same elevation beam width and electrical scanning angle, as shown in Figure 1, 100×100 channels will be required for 2-dim phased array radar, and this results in a system with 10,000 channels. In this case, even if the cost per channel may be reduced by the high integration of conventional boards, the entire radar system may become extremely costly. Therefore, in order to realize the dual-polarization phased-array radar, the cost per channel should be reduced considerably.

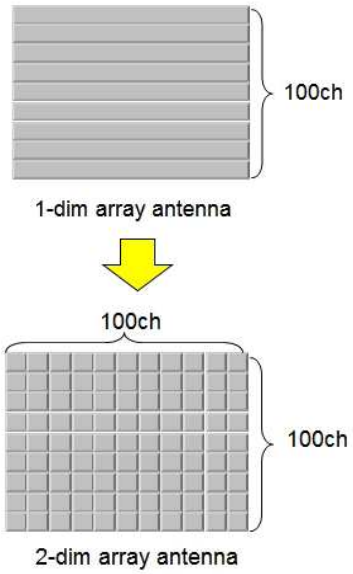


Figure 1: Conversion into 2 dimensional phased array antenna (example)

On the other hand, Toshiba has developed and manufactured all-in-one chips in the GHz band used for Bluetooth and Wi-Fi devices which have equivalent required functions for radar such as D/A conversion, A/D conversion, signal amplification and etc.

Because Toshiba has experience in producing massive semiconductors in-house, we have capability of adapting highly integrated semiconductor technology into radar system with relatively low-cost. Table 1 shows the top 20 ranking of semiconductor venders and Toshiba is the only weather radar manufacturer in the world that has expertise both in the high frequency semiconductor technology and in the weather radar technology.

Therefore, Toshiba started the research to develop dual-polarization phased-array weather radars which will bring forth unprecedentedly high cost effectiveness by utilizing the technical proficiency in the fields of electronic device and social infrastructure.

Table: 1 Top 20 semiconductor vendors in the world

**1Q13 Top 20 Semiconductor Sales Leaders ($M)**

| 1Q13 Rank | 1Q12 Rank | Company | Headquarters | 1Q12 Tot Semi | 1Q13 Tot Semi | 2012/2011 % Change |
|---|---|---|---|---|---|---|
| 1 | 1 | Intel | U.S. | 11,874 | 11,555 | -3% |
| 2 | 2 | Samsung | South Korea | 7,067 | 7,952 | 13% |
| 3 | 3 | TSMC* | Taiwan | 3,526 | 4,460 | 26% |
| 4 | 5 | Qualcomm** | U.S. | 3,059 | 3,916 | 28% |
| 5 | 4 | Toshiba | Japan | 3,255 | 2,938 | -10% |
| 6 | 6 | TI | U.S. | 2,934 | 2,718 | -7% |
| 7 | 8 | SK Hynix | South Korea | 2,115 | 2,577 | 22% |
| 8 | 9 | Micron | U.S. | 2,102 | 2,185 | 4% |
| 9 | 10 | ST | Europe | 1,999 | 1,977 | -1% |
| 10 | 11 | Broadcom** | U.S. | 1,770 | 1,954 | 10% |
| 11 | 7 | Renesas | Japan | 2,363 | 1,886 | -20% |
| 12 | 16 | GlobalFoundries* | U.S. | 1,170 | 1,240 | 6% |
| 13 | 14 | Infineon | Europe | 1,292 | 1,212 | -6% |
| 14 | 12 | AMD** | U.S. | 1,585 | 1,088 | -31% |
| 15 | 17 | NXP | Europe | 969 | 1,085 | 12% |
| 16 | 13 | Sony | Japan | 1,514 | 1,049 | -31% |
| 17 | 18 | Nvidia** | U.S. | 935 | 1,006 | 8% |
| 18 | 19 | Freescale | U.S. | 910 | 917 | 1% |
| 19 | 20 | UMC* | Taiwan | 804 | 898 | 12% |
| 20 | 15 | Fujitsu | Japan | 1,216 | 894 | -26% |
| Top 20 Total | | | | 52,459 | 53,507 | 2% |

*Foundry **Fabless

Source: IC Insights' Strategic Reviews Database

## 3. Development status

Our goal is to develop X-band, Dual-Pol, 2-dim phased array weather radar. This radar has multi-static capability which will be applied the synchronization technology developed by NICT. Also, this radar utilizing the latest RF semiconductor technology and is capable of DBF (Digital Beam Forming). For the development of this radar, Osaka University will be responsible for developing some of the DBF signal processing such as MMSE. Furthermore, the research and development are divided in two phases: Phase 1 is scheduled from 2012 to 2014.

In Phase 1, the radar cell will be developed, which is one of the basic elements that constitute the dual-polarization phased-array radar. In this Phase, the dedicated RF-chip will be developed for the radar. As shown in Figure 2, the radar cell is the highly integrated module which integrates multi channels receiving function.

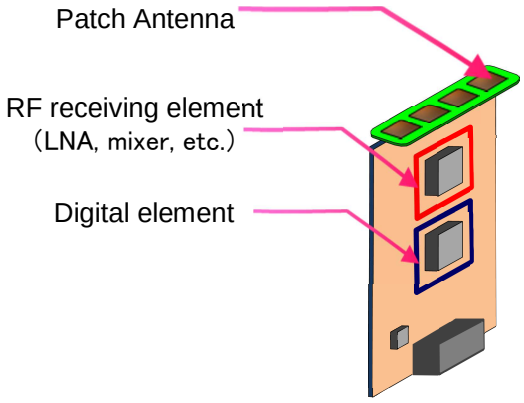


Figure 2: Radar cell for receiving antenna

For development of the RF-chip, we built Test Equipment Group (TEG), as trial production, such as amplifier circuit which shown in Figure 3. Various test patterns are implemented on a several square millimeter chip.

Figure 4 shows the gain of this amplifier, which results in 25 dB gain at 10 GHz. In addition, as shown in Figure 5, the isolation of 80 dB is obtained between the horizontal and vertical polarization, which is sufficient for the radar performance.

For phase 2, it is not fixed yet, but we are currently planning to build phased-array antenna by combining multiple radar cells, and actually manufacture the dual-polarization phased-array radar for system evaluation using actual weather environment.

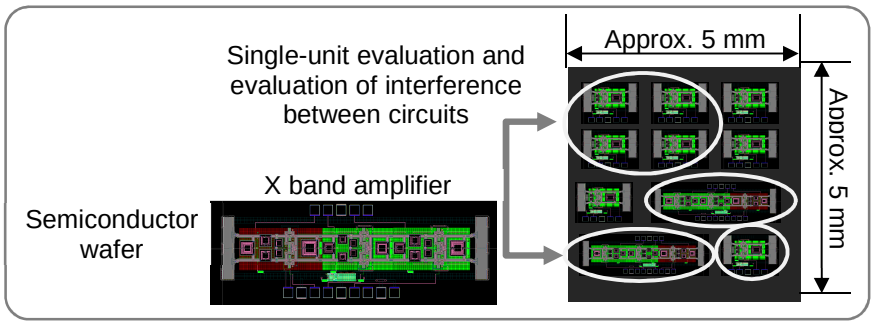


Figure 3: Sample of highly integrated circuit (RF-CMOS basic elements)

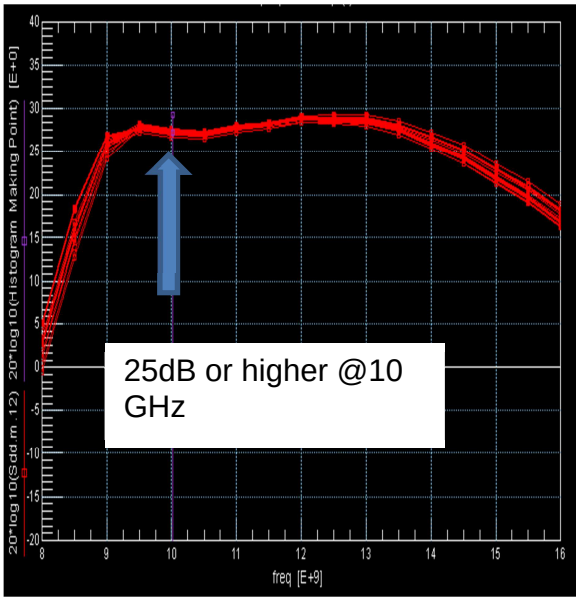


Figure 4: RF amplifier gain

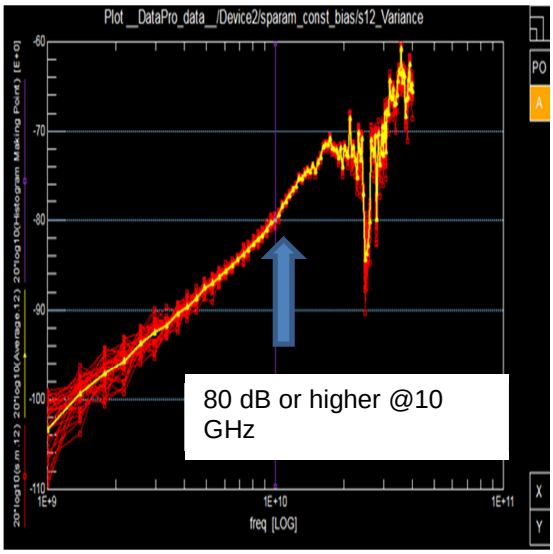


Figure 5: Isolation between channels

## 4. Conclusion

Toshiba started the research to develop dual-polarization phased-array weather radars for precise and rapid 3D observation of severe weather. Toshiba will develop radars which are suitable for a wide variety of applications by collaboration with various researchers and operators.

## 5. Acknowledgement

This research is subsidized by the research and development support program of Ministry of Internal Affairs and Communications, Japan.