Market & Technology of RF Modules: Focusing on Front end Modules For Cellular Terminals

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Abstract

The front end Module Market has been growing thanks to the expansion of multi-band multi-mode Cellular Terminals. In this paper, we will describe the market trends and product development of Front end Modules for Cellular Terminals.

1.Introduction

The market volume of portable electronic devices equipping wireless interfaces has been increasing recently. Mobile phone production volume grew from 680 million units to 1,400 million units in the past five years, including WWAN, China white box and FWT.

At the same time, mobile phones have been equipping additional Non Cellular Wireless Interfaces such as WiFi, Bluetooth, and GPS etc. Also, other electronic devices besides mobile phones are equipping various wireless interfaces. The net result is that wireless device market has been expanding greatly.

Such diffusion of various wireless devices has been increasing number of band frequencies for various wireless interfaces, and increasing the complexity of both the wireless standards and RF circuits themselves. For example, 15 band frequencies have been allocated for UMTS as a 3rd generation cellular standard. Multi-band UMTS terminals are now available up to quad-bands.

Furthermore, these new UMTS (WCDMA) terminals must maintain compatibility with the earlier GSM standard; to achieve this backward compatibility. As a result, UMTS terminals are compatible to UMTS/GSM dual-mode and more than dual bands for UMTS band frequencies.

At the same time that the Front end Module specifications have been made more complex with the evolution of the Cellular new standards and band frequencies, the Front end Module market has been expanding.

In this paper, we will focus on the Front end Modules for Cellular Terminals expected future market growth. We will describe the product specification, the utilization of Front end Modules by various Cellular standards, and give prospective on market trends and product development.

Current Front end Module products include Antenna Switch Module（Antenna Switch + Low Pass Filters Switchplexer”named by Murata Mfg）, RX Module(Antenna Switch Module + Band Pass Filters, generally called “FEM”）, and the TX Module (Antenna Switch Module + Power Amplifier Module), Duplexer + PA Module (“PAiD” named by EPCOS).

Multi Duplexer Module (Antenna Switch Module/RX Module + Duplexers) and RX + Duplexer Module (RX Module + Single Duplexer) are expected to be needed in the future. These modules are also called, “FEMiD” by EPCOS.

Figure 1 shows the adoption status for Front end Modules by Cellular standard. Figure 2 shows the functions of the Front end Modules.

FEMs	LTE/UMTS	UMTS	GSM	CDMA	TD-SCDMA	CDMA/GSM
Antenna Switch Module	★	●	●	–	●	●
RX Module	–	●	●	–	●	●
RX + Duplexer Module (FEMiD)	–	★	–	–	–	–
TX Module	–	●	●	–	–	–
Multi Duplexer Module	★	●	–	●	–	–
Duplexer + PA Module	–	●	–	●	–	–

● Available ★ Coming soon

Figure 1. Product Types & Applications of Front end Modules

Functions / FEMs	Antenna Switch	TX LPF	Duplexer	BPF	PA
Antenna Switch Module	●	●	–	–	–
RX Module	●	●	–	●	–
RX + Duplexer Module (FEMiD)	●	●	●	●	–
TX Module	●	●	–	–	●
Multi Duplexer Module	▲	▲	●	▲	–
Duplexer + PA Module	–	–	●	▲	●

● Indispensable Functions ▲ As the case may be – Disused

Figure 2.Constituent Functions For Front end Modules

2.Outline of Front end Module

Figure.3 shows the demand ratio of Front end Modules by Cellular Standard in CY2009. The greatest demand of Front end Modules is for GSM and UMTS/GSM terminals. The demand ratio for GSM is 59.3%, secondly, the demand ratio for UMTS/GSM is 34.7%.

Figure.4 shows the demand ratio of Front end Modules by product type in CY2009. The TX Module has the highest percentage of Front end Modules because of the dominant market share for GSM. However, the ratio of RX Module is highest in the promising UMTS/GSM market.

Most of TX Module manufacturers have Power amplifier modules as their original products. On the other hand, most of Antenna Switch Module and RX Module manufacturers have LTCC substrates and SAW filters as their original products.

TX Module for GSM integrates power amplifier with ASM, mostly using MMIC switch and organic substrates. Only Renesas Technology uses pin diode switch and LTCC substrate for some of their TX modules. Demand has been rapidly expanding since MOTOROLA started using TX Module in 2003. Adoption ratio of TX Module in GSM terminals became 60.7% in 2009. TX Module will continue to be main Front end Module for GSM terminals in future.

Most of Antenna Switch Module (=ASM) for GSM use LTCC substrates and pin diodes as antenna. Most basic Front end Module sometime classified as "discrete component" recently. Replacement is progressing to TX module in the GSM terminals. Most demand of ASM is for low-end GSM handsets such as the China white.

The RX Module for GSM integrates Rx Band Pass Filters with ASM. Recently, we call this module "FEM" (Front end Module). Only SAW devices are used so far for embedded Band Pass Filter. Concerning the supply/demand trend, the TX Module wins the market, so that RX module is dropping in the GSM market. Figure 5 shows circuit architectures of GSM Front end Modules by product.

Front end Modules for UMTS/GSM are becoming more diversified than Front end Modules for GSM. Figure 6 shows circuit architectures and demand trends of Front end Module for UMTS/GSM and LTE/UMTS/GSM. Three kinds

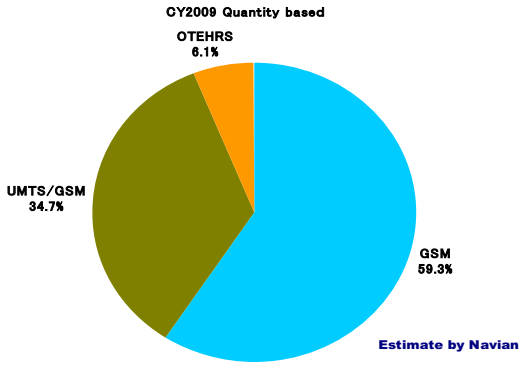

Figure 3. Front end Module Demand Ratio by Cellular Standard

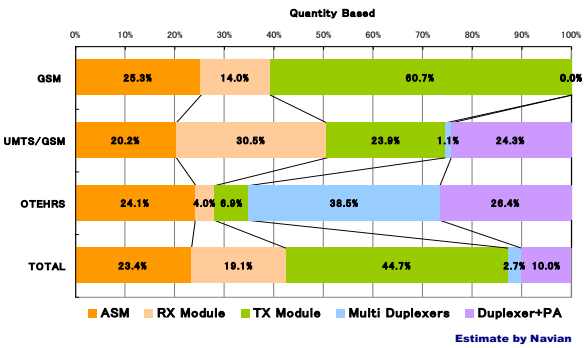

Figure 4. FEM Demand Ratio by Cellular Standard &

of Front end Modules for UMTS/GSM are allied to GSM, Antenna Switch Module, RX Module and TX Module. Unlike Front end Modules for GSM, every Front end Module for UMTS/GSM uses a MMIC switch comprised of GaAs or CMOS devices, and not pin diodes.

As per TX Module mostly adopted in GSM terminals, NOKIA adopts TX Module as standard Front end Module for their UMTS/GSM handsets too. However, other major handset manufacturers except NOKIA increase adoption of RX Modules. Therefore, the demand of TX Module for UMTS/GSM is mostly for NOKIA. On the other hand, SAMSUNG, LG, Apple and Huawei are major customers of RX Module.

In the GSM market, TX Module manufacturers constituting a large majority of power amplifier manufacturers have achieved a cost advantage to RX Module by self-manufacture of the antenna switch and power amplifier for TX Module. Therefore, we estimate that TX module won a commanding share in GSM market.

However, the demand of RX Module exceeds that of the TX Module in UMTS/GSM market. We estimate as one of the factors that most of TX Module manufacturers are less than successful in self-manufacture of antenna switch for UMTS/GSM SP7T and more.

We believe that RX + Duplexer Module and Multi Duplexer Module are most promising Front end Modules for UMTS/GSM and LTE/UMTS/GSM terminals. RX + Duplexer Module integrates one Duplexer with existing RX Module for UMTS/GSM. The demand expansion is expected

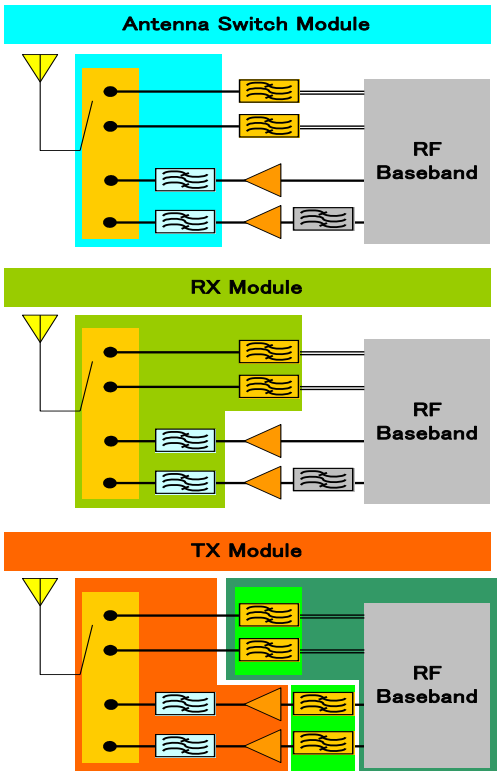

Figure 5. Outline of Front end Module For GSM

mainly in Korean handset manufacturers.

As per Multi Duplexer Module, NOKIA plans to expand its adoption. We estimate that other manufacturers will follow NOKIA for their multi-band handsets and terminals,

especially in Smart Phones and WWAN terminals required for global roaming compatible.

Antenna Switch Module is mostly adopted in smart phones from HTC and RIM, WWAN modules / dongles from OPTION and Novatel etc.

As per Duplexer + PA Module is mostly adopted in iPhone 3G/3GS and Huawei's WWAN Module/Dongle.

3.Market Trend & Forecast of Front end Module

Figure.7 shows the production volume forecast of Cellular Terminals and the market forecast of Front end Module. We forecast that production volume of Cellular Terminals will increase from 1,419million units in 2009 to 2,057 million units in 2013. Our data includes China white box, WWAN Dongles / both Modules and FWT (Fixed Wireless Terminal) .General data of mobile handset production volume does not include these devices. We believe that non-handset devices such as Smart Phones, Notebook PCs and E-Book Readers will be the driving force in expansion of production volume of Cellular Terminals.

We forecast that the market size of Front end Modules in Cellular Terminals will increase from $1,292M in 2009 to $2,121M in 2013. Figure.8 shows the forecast of product-by-product composition ratio of Front end Modules. Future demand of TX Module dominating GSM market will be limited for UMTS/GSM and LTE/UMTS/GSM, the composition ratio in Front end Module total market will decrease from 44.7% in 2009 to 27.8% in 2013.

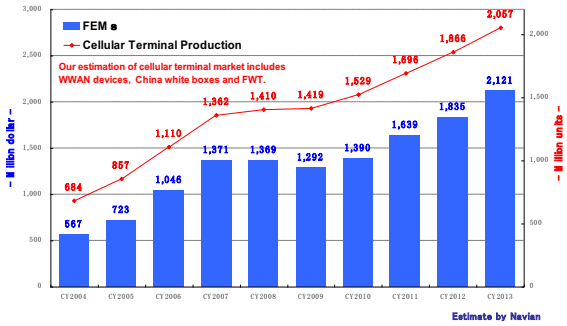

Figure 7. Front end Module Market Forecast

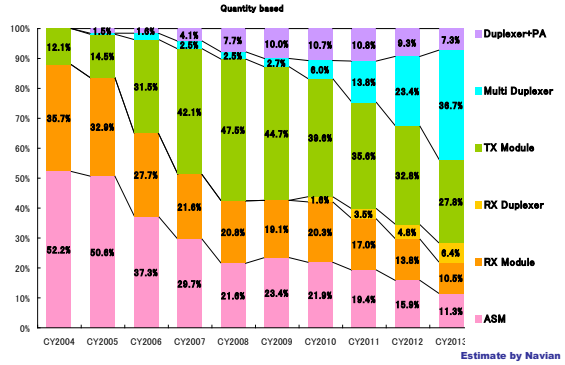

Figure 8. Front end Module Ratio Forecast by Product

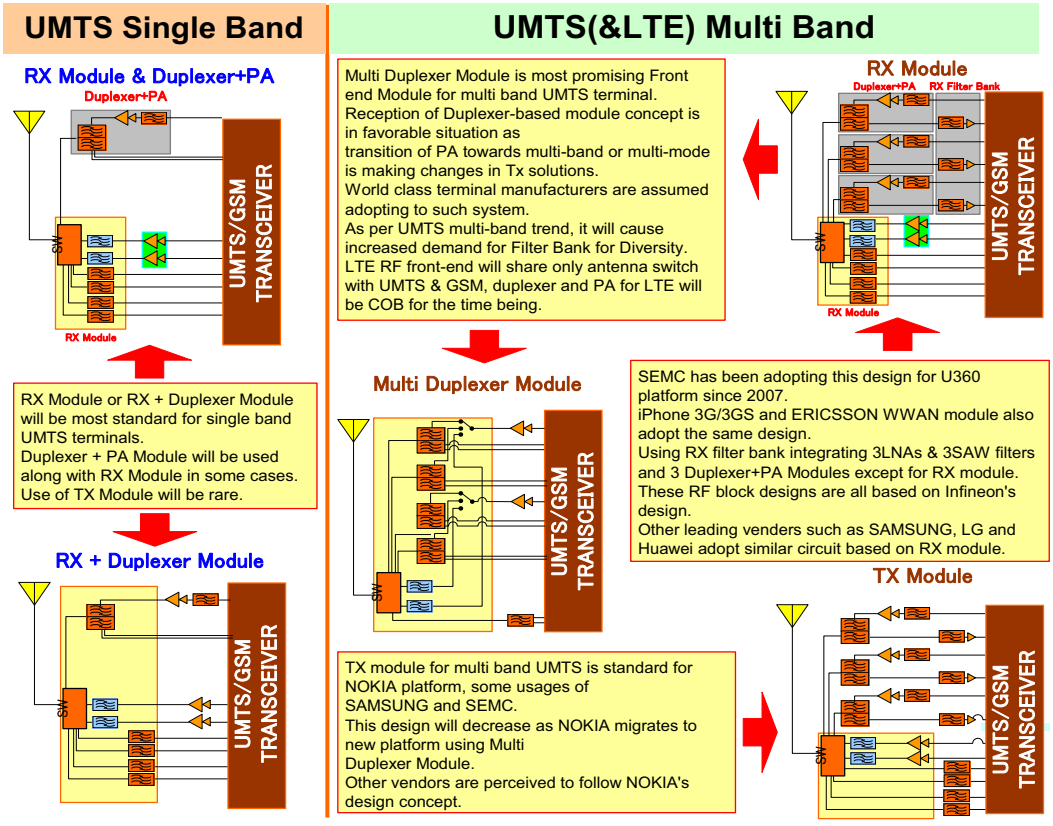

Figure 6. Future Front end Module Trend for UMTS (& LTE)

On the other hand, Multi Duplexer Module expected rapid growth for UMTS/GSM will increase the composition ratio from 2.7% in 2009 to 36.7% in 2013.

4.CONCLUSIONS

This paper introduced market trends and product development of Front end Modules for Cellular Terminals. The Front end Module specifications have been made more complex with the evolution of the Cellular new standards and band frequencies, the Front end Module market has been expanding. Above all, Duplexer-based Front end Modules such as RX + Duplexer Module and Multi Duplexer Module will achieve higher growth rates than other modules in future.

REFERENCES

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Acronyms

WWAN: Wireless Wide Area Network
FWT: Fixed Wireless Terminal
GPS: Global Positioning System
RF: Radio Frequency
UMTS: Universal Mobile Telecommunications System
WCDMA: Wideband Code Division Multiple Access
GSM: Global System for Mobile Communications
FEM: Front end Module
RX: Receive
TX: Transmit
PA: Power Amplifier
PAiD: Power Amplifier in Duplexer
FEMiD: Front end Module in Duplexer
LTE: Long Term Evolution
CDMA: Code Division Multiple Access
TD-CDMA: Time Division - Code Division Multiple Access
LPF: Low Pass Filter
ASM: Antenna Switch Module
LTCC: Low Temperature Co-fired Ceramics
MMIC: Microwave Monolithic Integrated Circuit
SAW: Surface Acoustic Wave
CMOS: Complementary Metal Oxide Semiconductor