

# RF Devices / Modules For 5G & 5G/NB-IOT



2018-2027

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English Version



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# 5G Products



Expecting a completely new kind of gadget with completely groundbreaking display and input-output style different from existing mobile gadgets, and it will be the engine of 5G era.



Market of cellular-supporting IOT will expand significantly, centered on NB-IOT. We should be able to expect GPS demands along with this.



LTE adoption would be the next step for Cellular V2X. Because of competition with WiFi-based 802.11p, demand size would be limited.



Cellular adoption in Tablet and Notebook PC will become full scale as 5G becomes widely used. It should become the adrenaline shot which will stimulate the Tablet and Notebook PC market.

Estimate by Navian



Product which would most likely adopt 5G. However, as for milli-waves, it is strongly thought that adoption would be limited due to issues with space, cost, and power consumption.

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Would be the last to adopt 5G. Also, it will only adopt either Sub 3GHz or Sub 6GHz, and not milli-waves.

# 5G Road Map

- ◆ We see that FWA (Fixed Wireless Access), which Verizon (America) etc. have either started or is scheduled to start the service by using 28GHz, does not conform to the standards of 5G. Therefore we have not included it in our market size calculation.
- ◆ AT&T will probably be the first to put 5G, the mobile communication standard, to practical use. They are scheduled to start 5G mobile service using 28GHz from year end of 2018.
- ◆ At the beginning they will only supply NETGEAR's mobile router, and release of smartphone supporting 5G is expected in/after 2019.
- ◆ SAMSUNG's GALAXY S series will support 5G from 2019. Apple will release 5G iPhone later in 2020. They will probably mainly use Sub 6GHz frequencies, supporting millimeter-waves like 28GHz in/after 2023 will be limited volume for the time being.

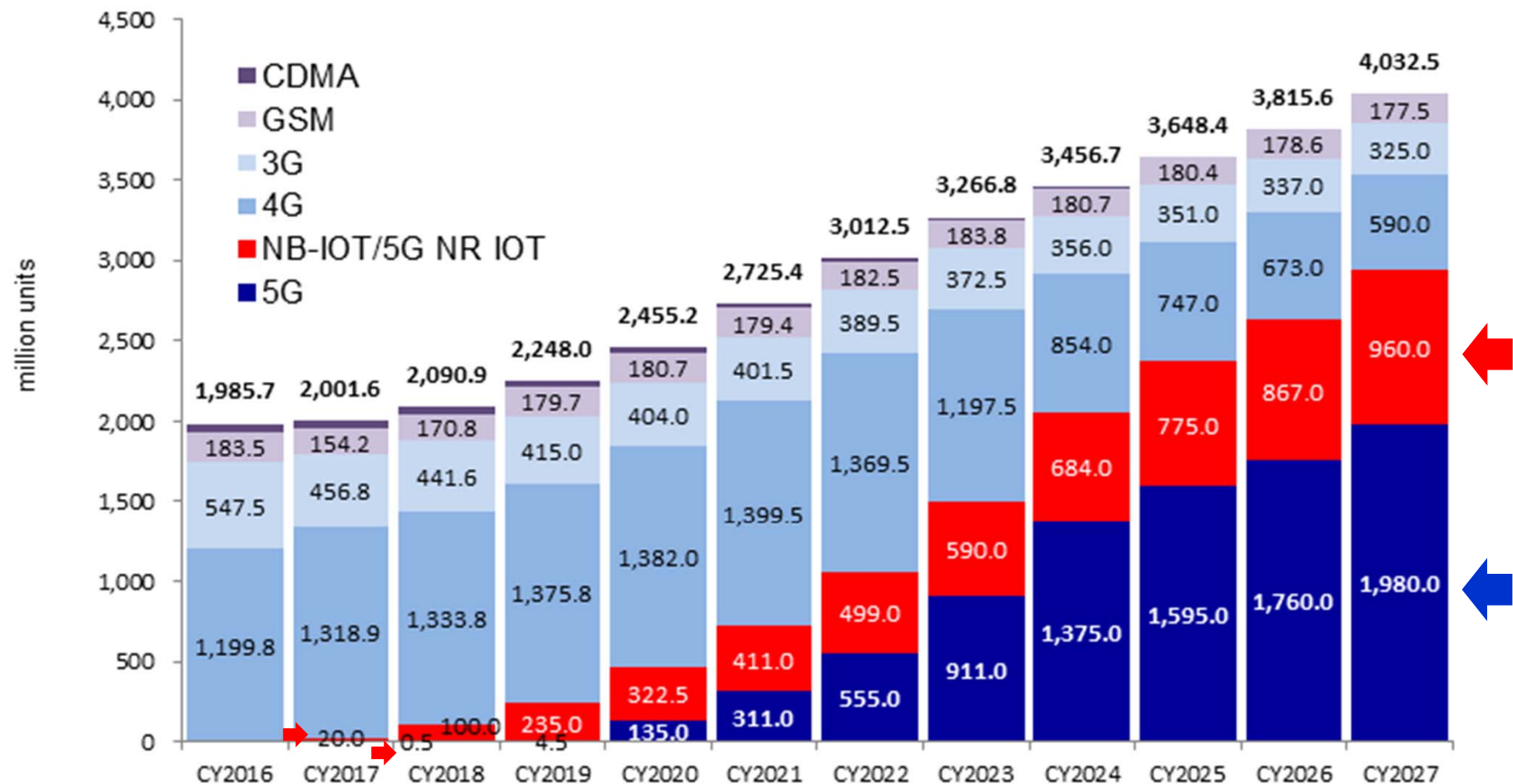
ITEMS			Y2016	Y2017	Y2018	Y2019	Y2020	Y2021	Y2022	Y2023	Y2024	Y2025
Standardization	Release13	EC-GSM/LTE-M/NB-IOT	●									
	Release14	5G Non-standalone		●								
	Release15	5G Phase1.Standalone			●							
	Release16	5G Phase2.NR-IOT/NR-V2X				●						
Commercialisation	USA	Verizon			●28GHz							
		AT&T			●28GHz							
		T-Mobile					●600MHz					
	JAPAN						●3.5/28GHz					
	KOREA					●3.5/28GHz						
Products	Mobile Router	NETGear			●28GHz							
Launch Schedule	Smart phone	Apple					●Sub-6GHz/28GHz?					
		SAMSUNG				●GALAXY S10 Sub6GHz/28GHz						
		SONY				●28GHz						
		OTHERS				●~Xiaomi/One Plus/Huawei/VIVO						
	Tablet/Note PC					●						
	NEW Product-X								●			
	Automotive	eCall/Connectivity									●5G	
		C-V2X						●LTE based				●5G NR
	NB-IOT/NR-IOT			●NB-IOT(4G)				●NR-IOT(5G)				

※FWA using 28GHz like Verizon's is not classified as 5G.



# Cellular Terminal Forecast by Standard

- ◆ 5G-supporting products (excl. NB/NR IOT) to be commercialized from year end of 2018 will surpass 4G (LTE) by volume in 2024.
- ◆ It is expected to expand to 1,980 million units in 2027.
- ◆ Devices that support NB IOT and NR IOT are expected to become 960 million units in 2027.



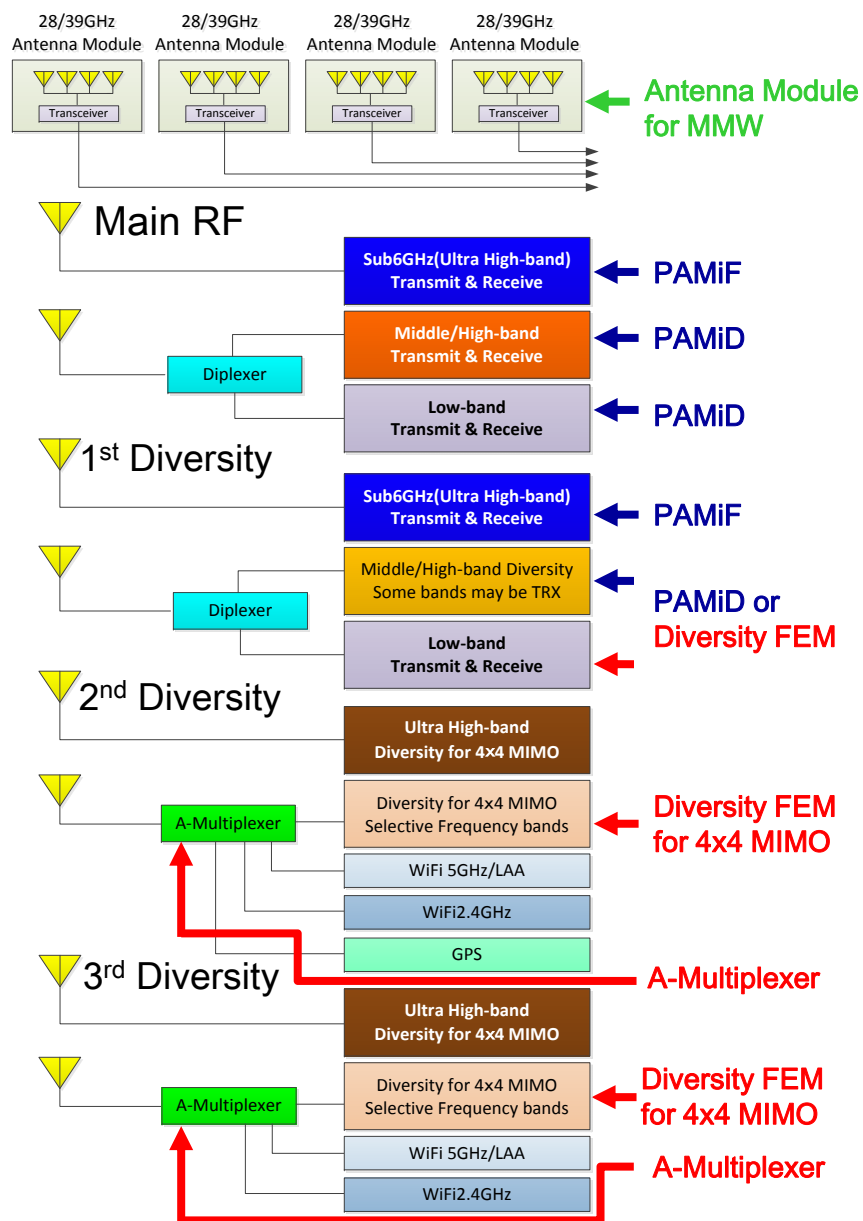
# RF Market Potential in 4.5G-5G

- ◆ Graph below shows new functions that will be commercialized from 4G to 5G, and the high-frequency components and modules which will see increased demands as a result.
- ◆ Red star shows newly added functions after shift to 5G. They are ①TX MIMO ②Dual Link ③usage of milli-waves
- ◆ TX MIMO is mainly adopted in circuit of Sub 6GHz. 2 circuits of Sub 6GHz with send-receive functions are used.
- ◆ Dual Link is a function which allows simultaneous connections to 4G and 5G networks. It is called NSA (Non-Stand Alone), and 5G-supporting devices of earlier period will all need to have this.
- ◆ Using same frequency band as NSA requires 2 types of RF circuits.
- ◆ Specifically, we mainly expect cases where Band-41 is shared by 4G and 5G, so devices that support it will need to have 2 send-receive circuits including Antenna of Band-41 (n41 in 5G).
- ◆ For milli-wave which is one of symbolic frequencies of 5G, adoption of “Antenna Module” (which integrates transceiver with Antenna) will be standard.

Wireless Interface	NEW Functions	Function for		Key Components/Modules			
		4G	5G	FEM	Duplexer	Filter	PA
Cellular	Uplink CA	Optional	Optional	PAMiD	↑	↑	↑
	TX MIMO	-	Required★	PAMiF	-	↑	PA
	4X4	Optional	Required	Diversity	-	↑	-
	Dual link	-	Required★	-	↑	↑	↑
	Sub 6GHz	Limited	General	PAMiF	-	↑	↑
	Millimeter Wave	-	Limited★	ANT Module	-	-	-
NCW	2x2 MIMO	Required	Required	-	-	↑	↑
	4x4 MIMO	-	Optional	-	-	↑	↑
	Multi band GNSS	Limited	General	-	-	↑	

NCW=Non Cellular Wireless WiFi/GPS

# FEM & Sub FEM For 5G NR in This Report



## Antenna Module

FEM for 5G milli-waves. Antenna functions are constituted on module substrate, and up to Transceiver IC is integrated. 4 or 3 are mounted per unit.

## PAMiF(PA Module in Filter)

FEM which is adopted for Sub 6GHz. Filter and PA are main constituting components. It will start off as single-band 3.5GHz, but we see it becoming dual-band with 4.5GHz.

## PAMiD(PA Module in Duplexer)

For frequencies under 3GHz where many FDD bands are used, PAMiD composed of Duplexer and PA should be adopted for high-end smartphones.

## Diversity FEM

Send function is expected to be added in 1st Diversity due to popularization of Uplink CA, therefore shifting to PAMiD. In 5G where 4x4 MIMO will be popular, 2nd and 3rd Diversity FEM should become main.

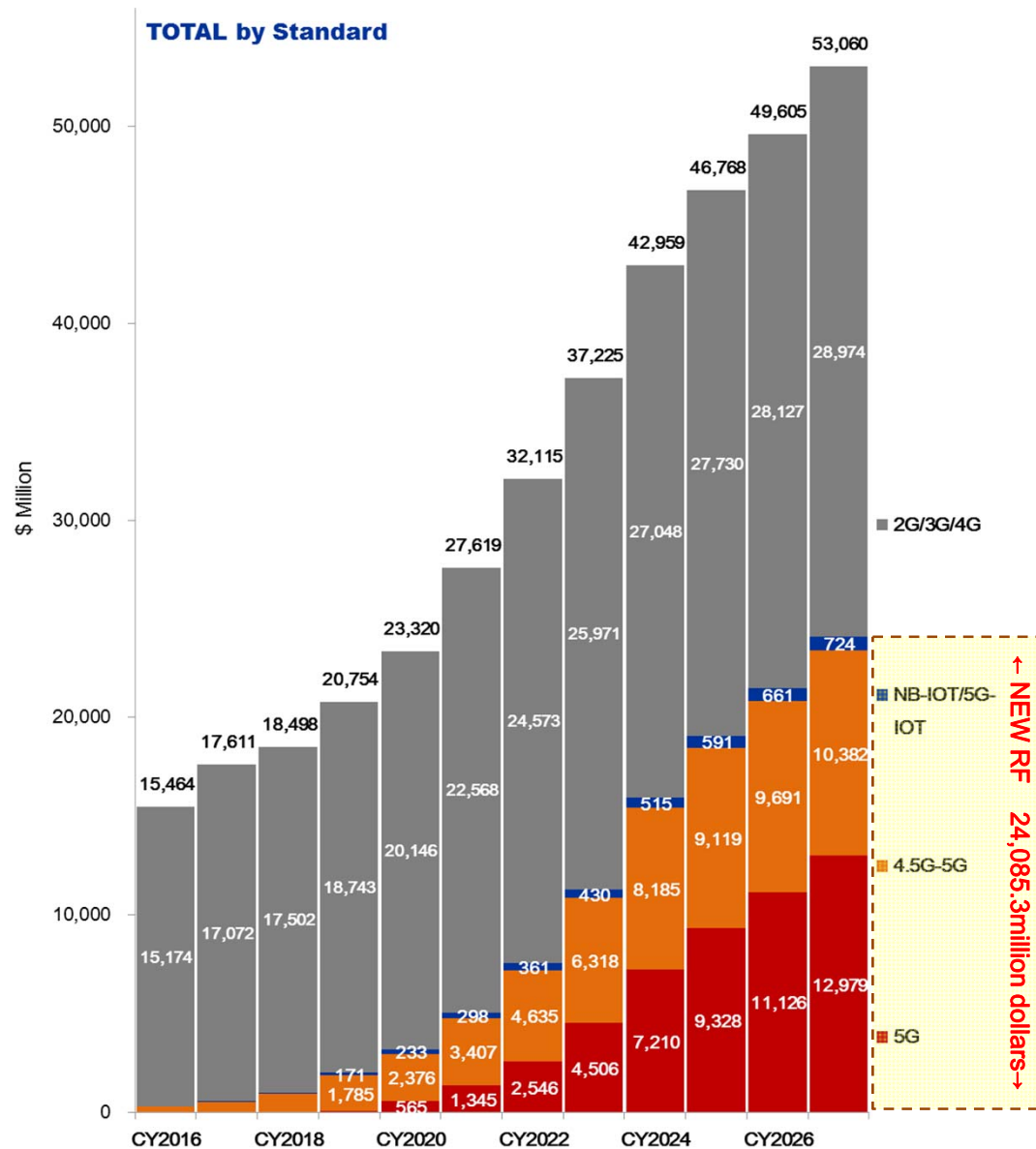
## A-Multiplexer

A compound component which has 3 or more de-multiplexing functions as a result of having multiple high-Q filters like SAW·BAW·IHP, or combination with other filters (LTCC/IPD).

# Outline of RF Devices / Modules in This Report

FEM	Category	Product-1	MMW	LAA	Sub 6GHz	Sub 3GHz	Note
<b>FEM</b>	ASM					●	Minimum unit of FEM. Limited adoption in 5G.
	TXM					●	Was main FEM until 4G, but limited adoption in 5G.
	FEMiD					●	Demand expansion after replacing TX Module. Certain amt of demand in 5G for products of Middle-end or lower.
	PAMiD	For Main RF				●	Adopted in High-end smartphones in 4G. Expected to become main FEM in 5G.
		For Uplink CA				●	Expected to be mounted by integrating Diversity FEM with PA, when Uplink CA become popular due to shift to 5G.
	All-in-One FEM	All-in-One FEM				●	Continuing from 4G, adoption is expected to be limited in 5G as well.
	PAMiF				●		Expected to be widely adopted in FEM for Sub 6GHz. Competes with on-board mounting.
	ANTENNA FEM	MMW	●				FEM for milli-waves. Mounts Transceiver on substrates with Antenna function.
	FEM for IOT	FEM for IOT				●	FEM that integrates all Front-end components for NB-IOT/5G-IOT.
<b>Sub FEM</b>	Antenna-Multiplexer (A-Multiplexer)					●	Module that lets multiple frequencies share one antenna. Simultaneous operation is mandatory.
	Diversity FEM					●	Demand will be on increasing note as 4x4 MIMO becomes popular.
<b>PAM</b>	Single PAM					●	Products for 3G/4G will decrease. Products for Sub 6GHz of 5G, both for FEM and for COB, will increase.
	GSM					●	Demand will continue in 5G period, since there will be many continued cases of supporting GSM.
	MMPA by Band group					●	Demand will increase for Middle/High-band and for Low-band, mainly for PAMiD.
	MMPAM for Main band					●	Cases of pairing with TX Module and ASM will decrease, while combination with FEMiD will increase.
<b>Duplexerr</b>	BAW					●	Dominating demand for Middle/High-band PAMiD.
	BAW/SAW					●	Its in-between characteristics will cause demand to stagnate.
	IHP					●	Still thought to need 2 to 3 years for development of Hexaplexer, and demand is expected to catch momentum from 2021 to 2022.
	SAW					●	Enhanced characteristics required for Duplexer will increase weight of TC-SAW, causing replacement with BAW and IHP to progress.
<b>BPF</b>	BAW				●	●	In addition to demand in WiFi 2.4GHz and TD-LTE, demand will increase in 4.5GHz(n79) for 5G and LAA, WiFi 5GHz.
	SAW					●	Due to popularization of 4x4 MIMO, demand increase is expected for products for existing frequencies. However, competition with IHP is expected.
	IHP				●	●	Demand for products for existing frequencies will surface, and will compete with BAW in 4.5GHz(n79) and LAA/WiFi 5GHz in the future.
	IPD		●		●	●	In addition to demand for FEM and for LPF and Coupler until now, demand will increase for Sub 6GHz in 5G.
	LTCC		●		●	●	In addition to demand for COB and for Diplexer and LPF until now, demand will increase for Sub 6GHz while competing with IPD.

# RF Market Forecast by Cellular Generation



- ◆ Market size of high-frequency components /modules for Cellular Terminal, including ones for 5G, will reach 53,059.6 million dollars.
- ◆ Of these, 24,085.3million dollars will account for market size of NEW RF, like “4.5G-5G”·“5G”, and “NB-IOT/5G-IOT”.
- ◆ The 12,979.4 million dollars’ worth of high-frequency components and modules are estimated to be mainly for Sub 6GHz and milli-waves, for 5G.
- ◆ Market size of high-frequency components/modules for 4.5-5G, mainly using frequencies below 3GHz, is 10,381.8 million dollars, and NB-IOT/5G-IOT would only reach 724.1 million dollars.