



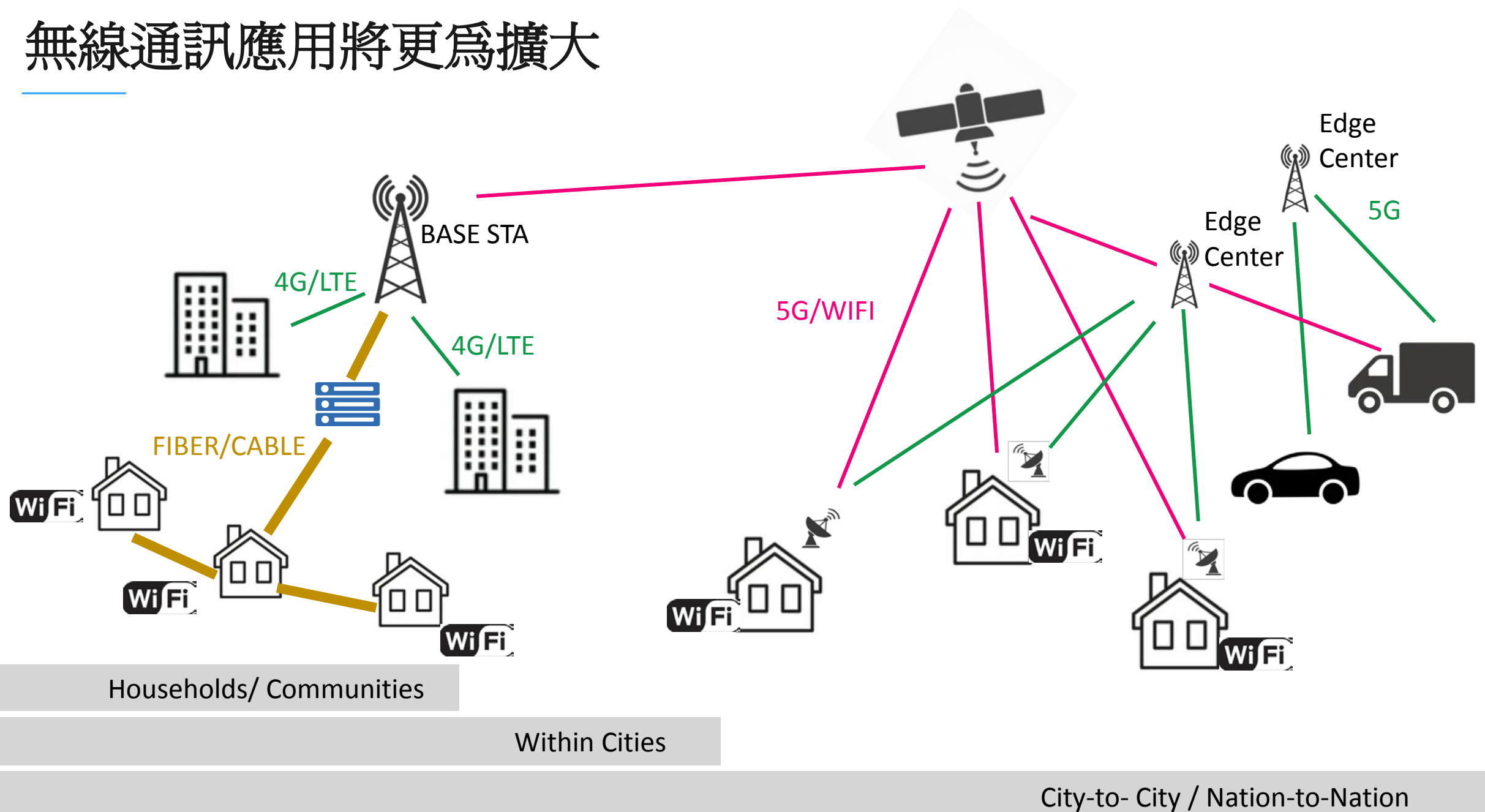
RichWave, 您可信賴的射頻夥伴

-WiFi and 5G

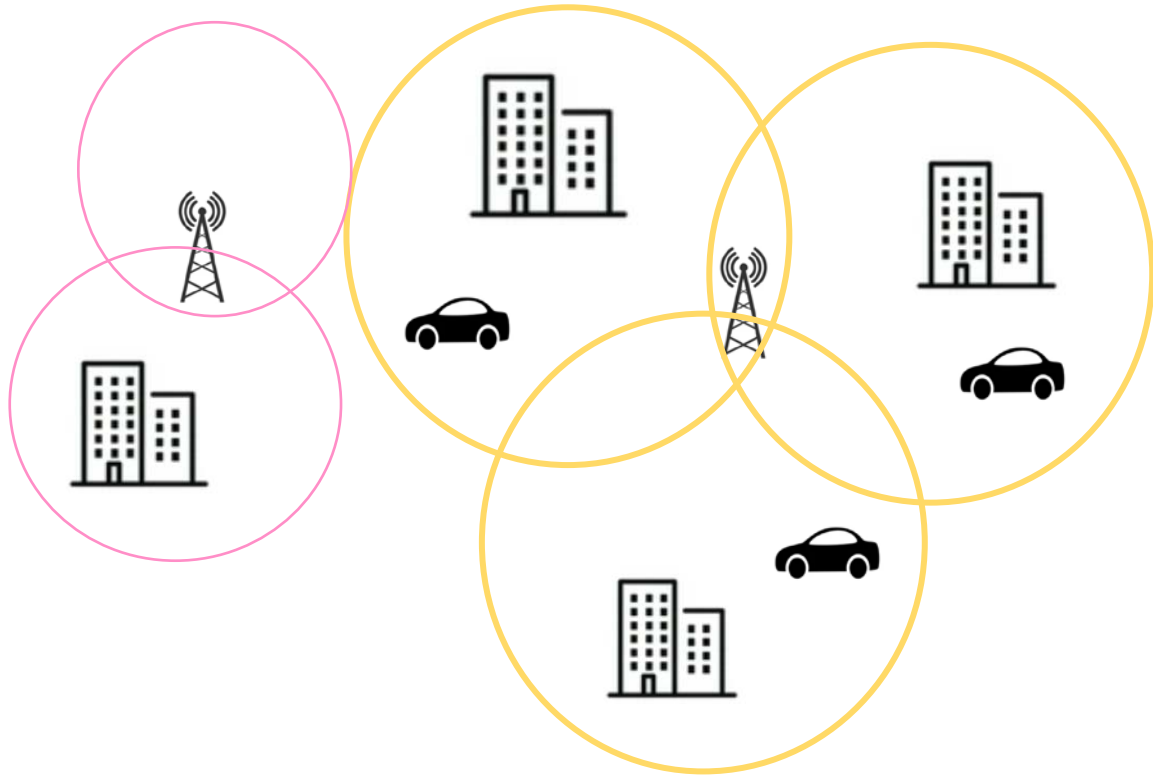
SC WONG

2021/12

無線通訊應用將更為擴大



5G + WiFi 將成爲未來最後一哩路的重要科技



5G NR



WIFI WILL OFFLOAD
59% OF GLOBAL
MOBILE DATA
TRAFFIC IN 2022*

WIFI

SPEED	~ 50Mbps	~ 1Gbps	~ 4Gbps
COMBINATIONS			MIMO CA

~ 3.2Gbps	~ 6.5Gbps	~ 9.6Gbps	~ 46.1Gbps
2+2+2 (BW80)	4+4+4 (BW160)	MIMO	MIMO

* Global Mobile Data Traffic Forecast Update 2017-2022 by CISCO

立積射頻元件加強您的無線產品



A GLOBAL INITIATIVE

3G^{'''} 2G^{'''} Lte^{'''} 4G^{'''} 5G^{'''}

Antenna
Tuner SW

Antenna
Swap SW

LFEM

5G SWITCH

LNA
Module



WiFi FEM

WiFi ePA

WiFi eLNA

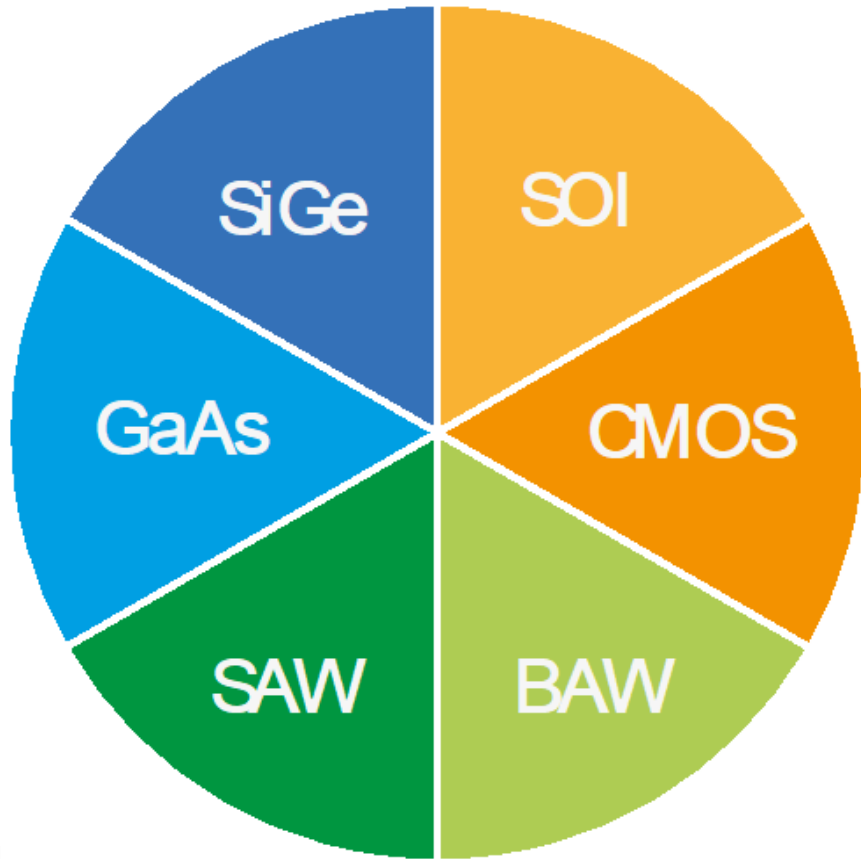
WiFi SW

FM

GPS

OTHER CONNECTIVITY

立積產品的競爭優勢



> 專長於多材料的設計及整合

GaAs and SiGe Process with our PA Design

SOI and CMOS Process with our LNA/SW Design

提供高性價比的產品

> 採用多重的上游及下游供應夥伴

Dual sources of each upstream tech. process

With >4 partners for backend assembly and testing

縮短產品上市的時程

➤ 產品皆為立積自主設計

Provide all combinations of active RF circuits

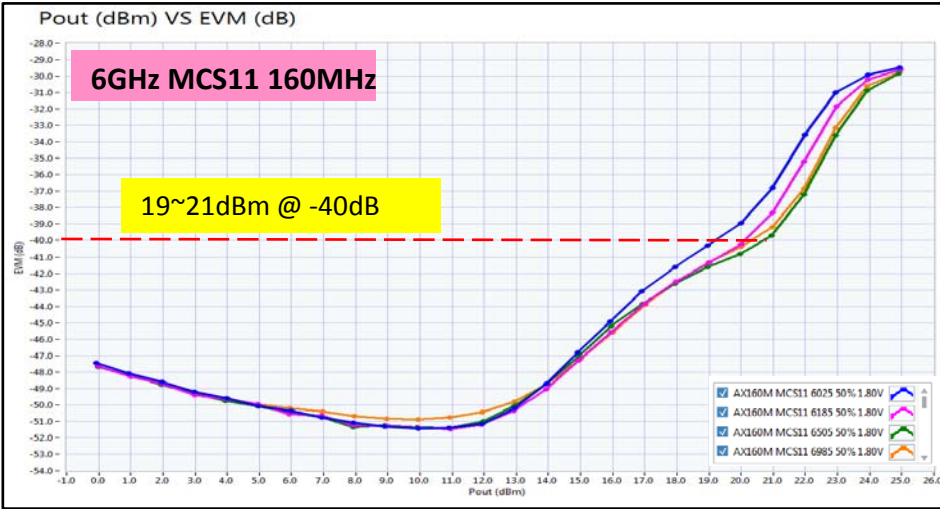
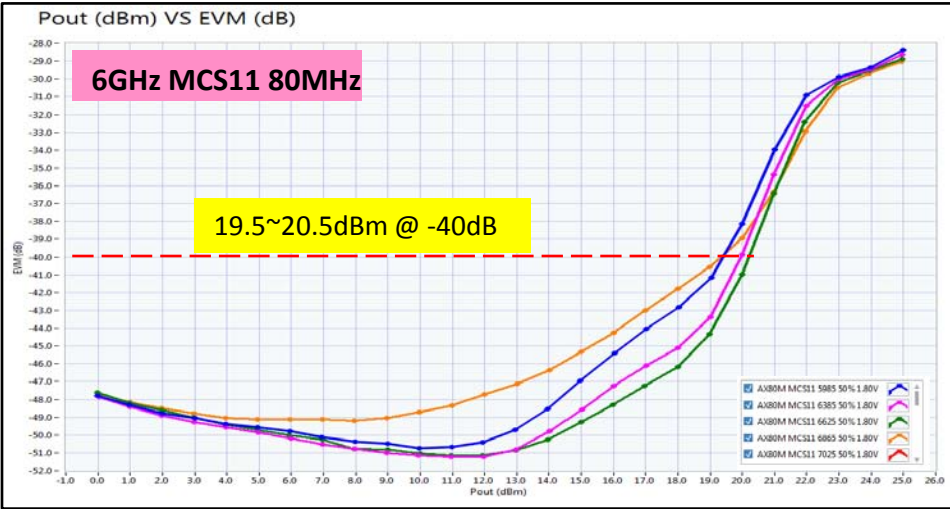
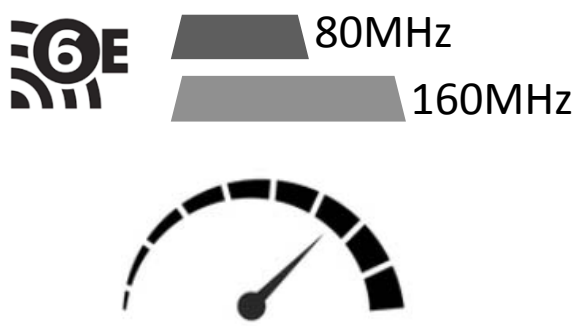
Self-designed SAW/BAW filters to RF Needs

貼近客戶不同設計需求

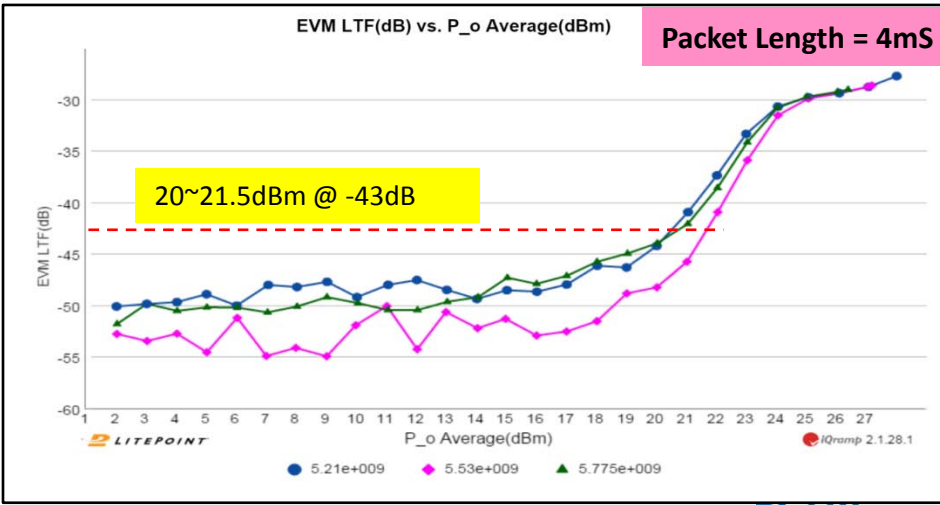
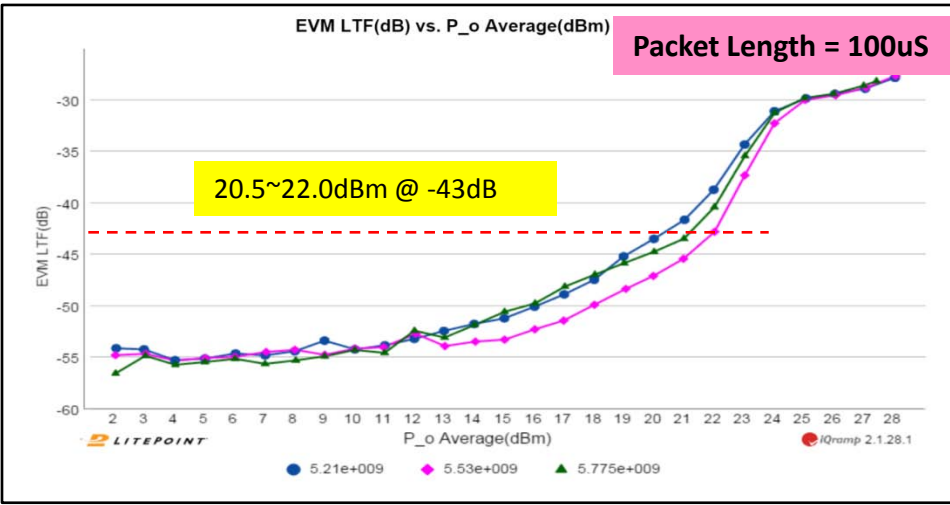
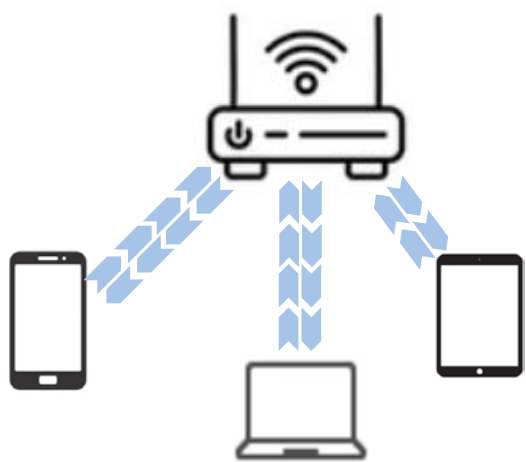
立積WIFI 射頻產品的特色

提供穩定且高線性度的發射功率

維持高吞吐量輸出

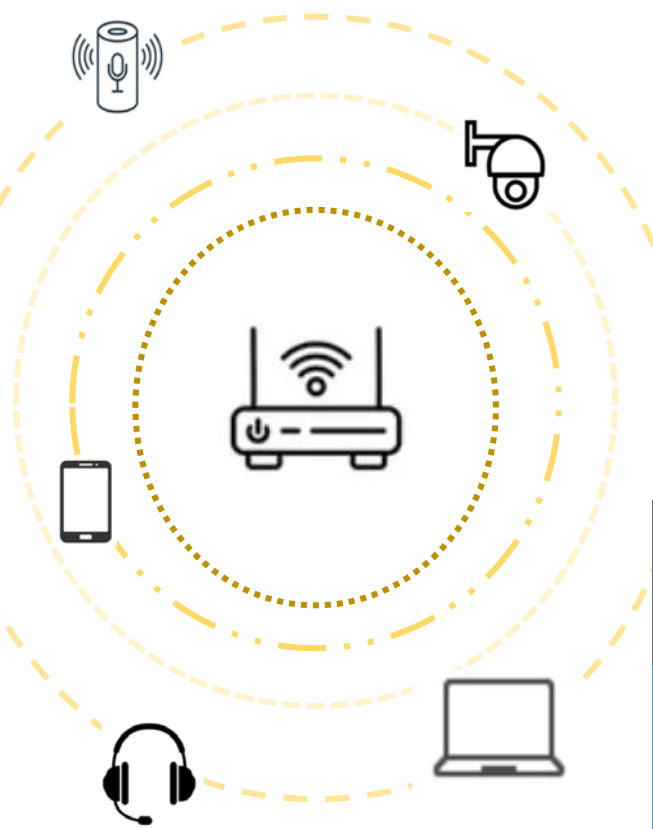


支援MU-MIMO

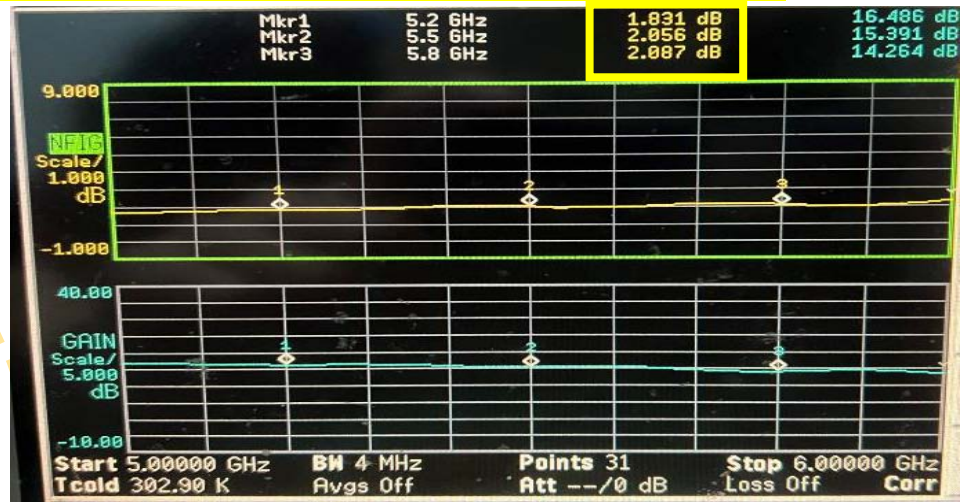


供應極佳的接收靈敏元件

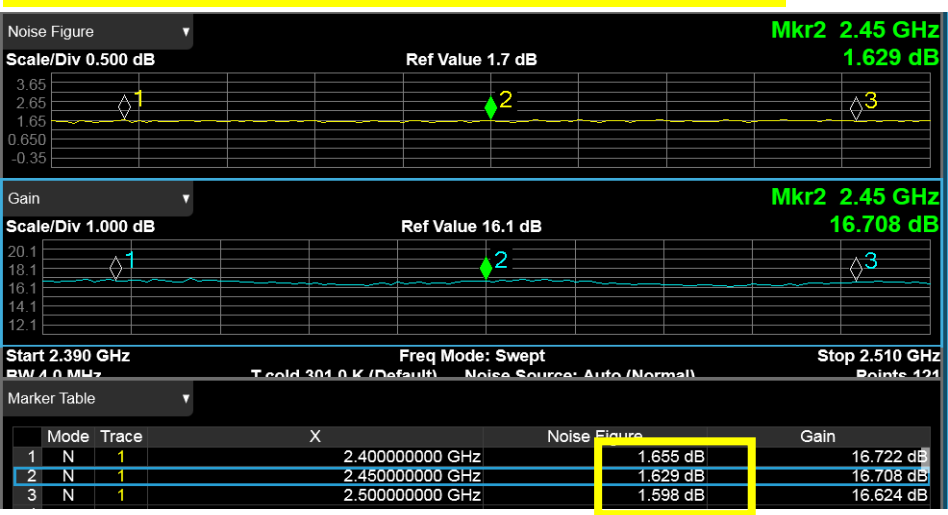
提升產品接收範圍



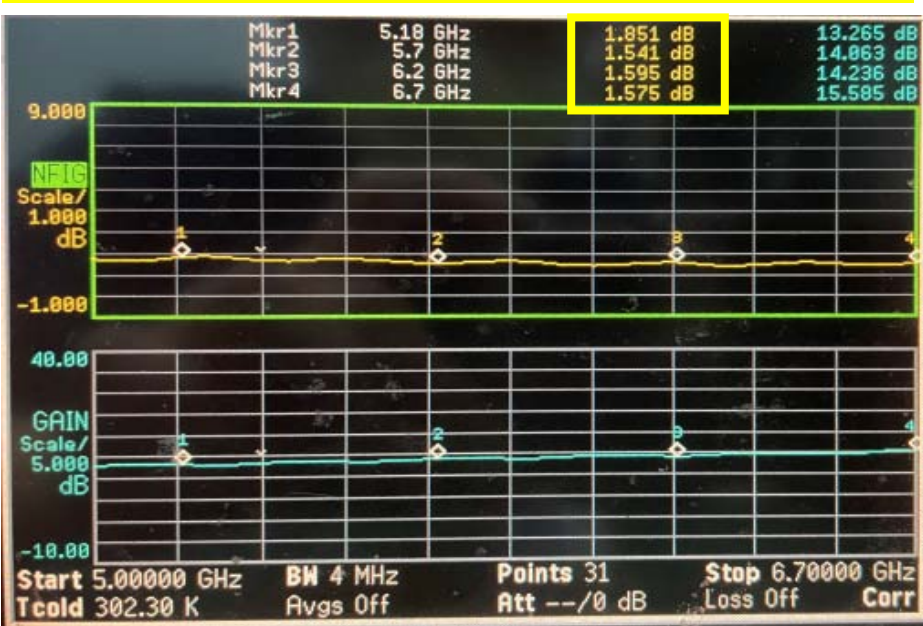
NOISE FIGURE =1.7dB @ 5GHz Band



NOISE FIGURE =1.4dB @ 2.4GHz Band

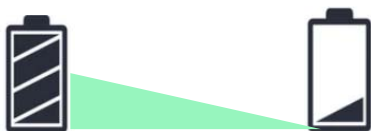


NOISE FIGURE =<2 dB @ 5GHz + 6GHz Band

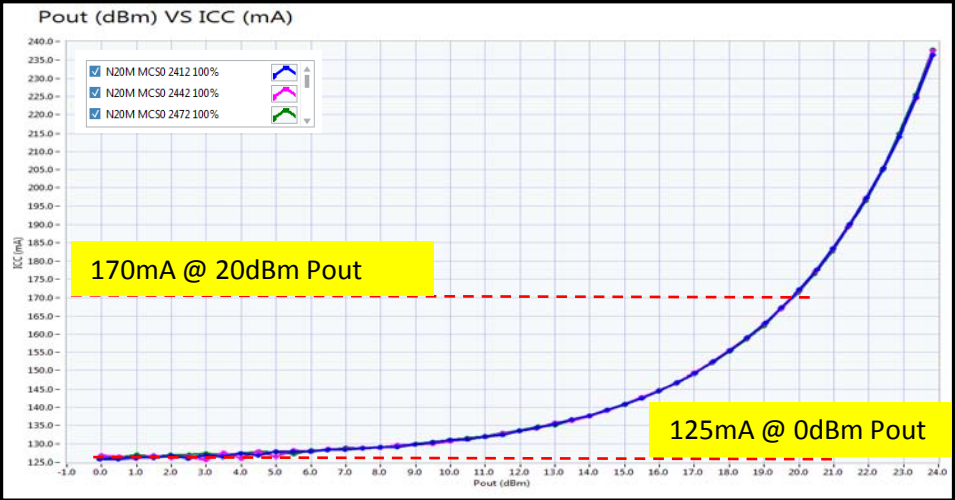


提供高效率且低耗電的射頻元件

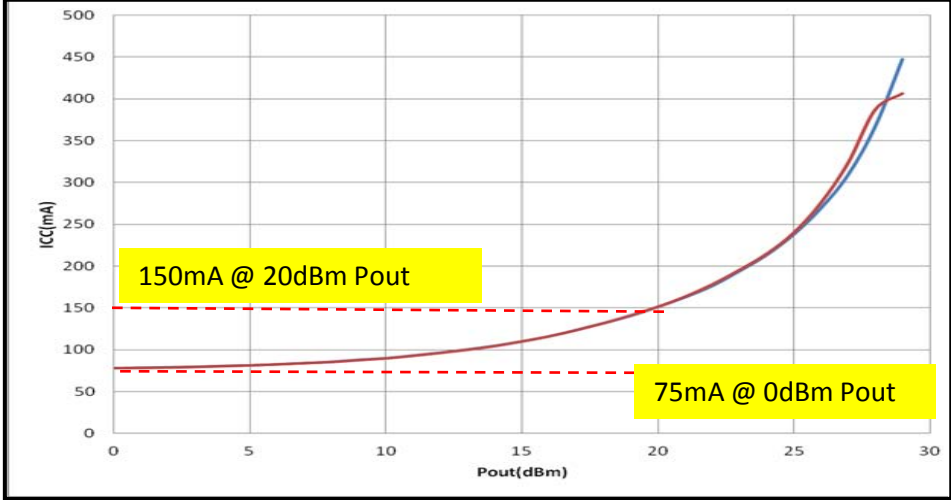
延長產品使用時間



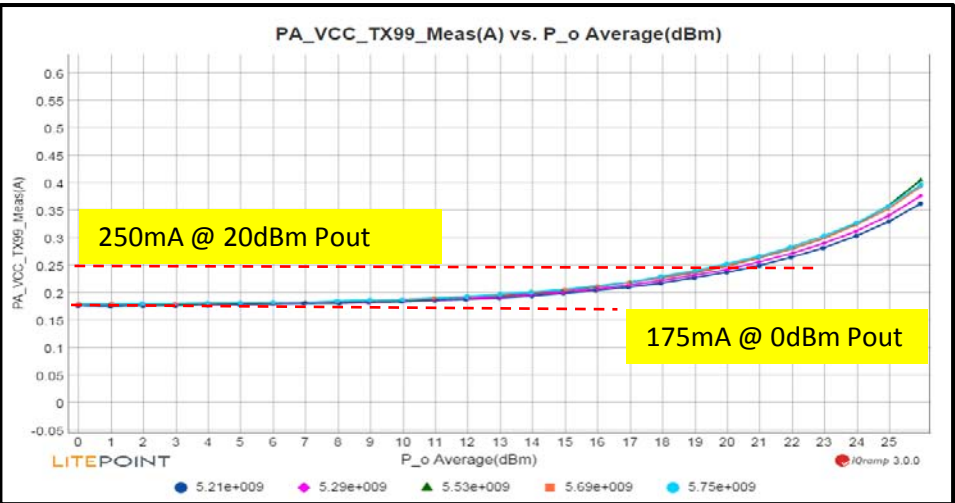
LINEAR FEM @ 2.4GHz FEM RTC66270



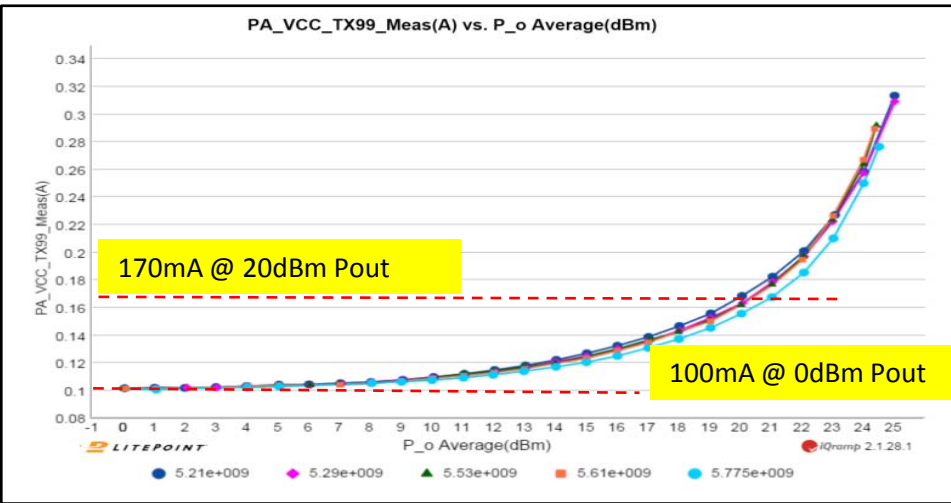
NONLINEAR FEM @ 2.4GHz FEM RTC66254



LINEAR FEM @ 5GHz FEM RTC7676EM

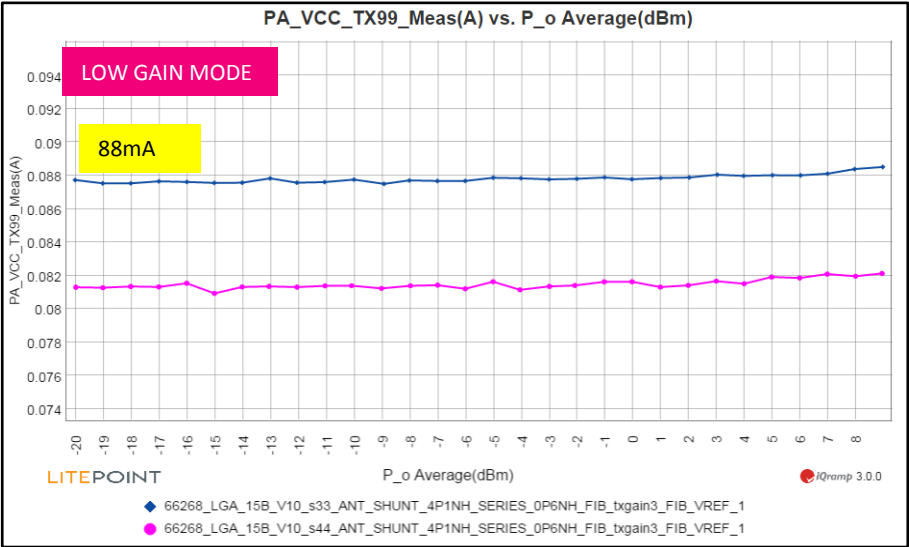
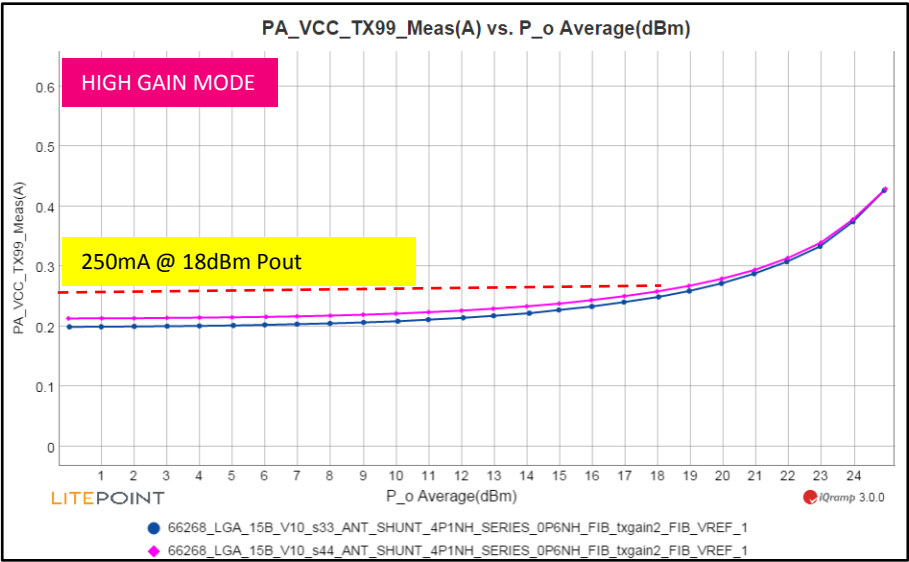
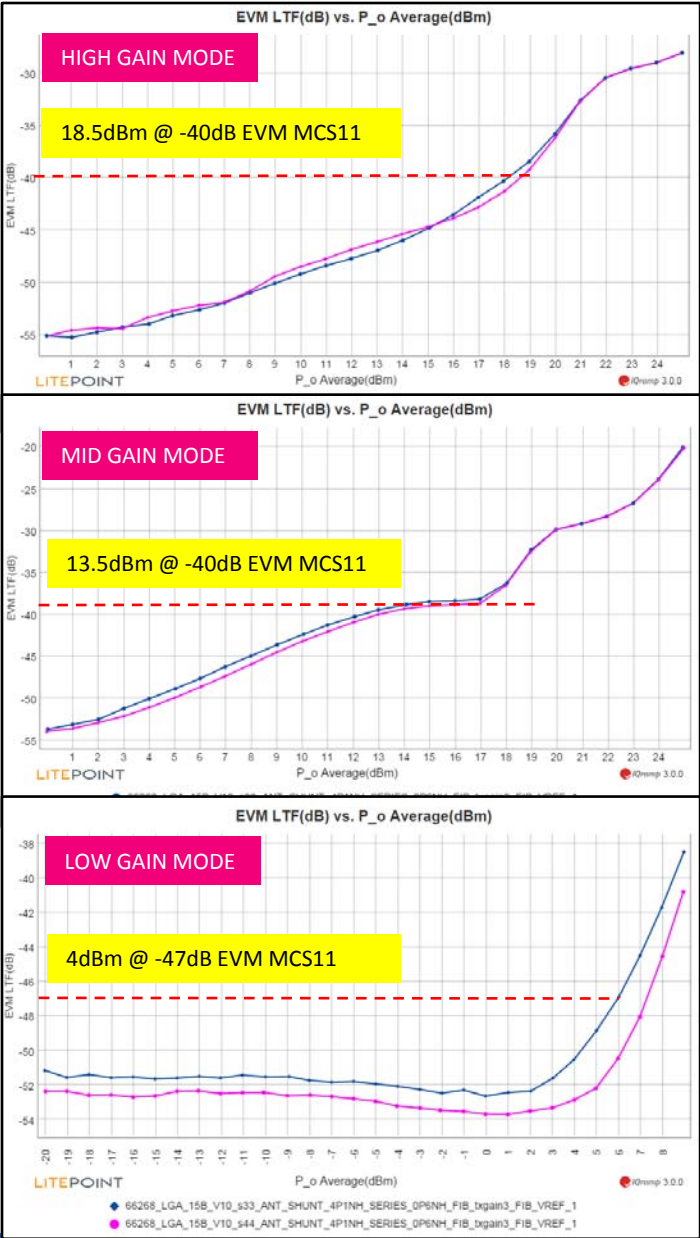
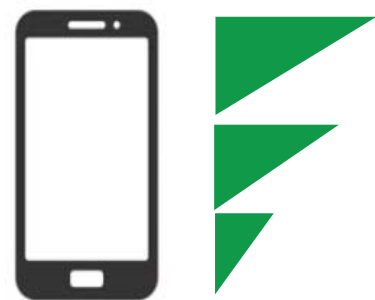


NONLINEAR FEM @ 5GHz FEM RTC66533



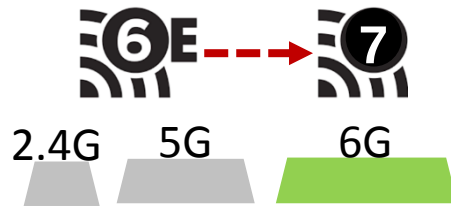
提供適用於行動裝置的多重發射模式設計

3- GAIN STAGES

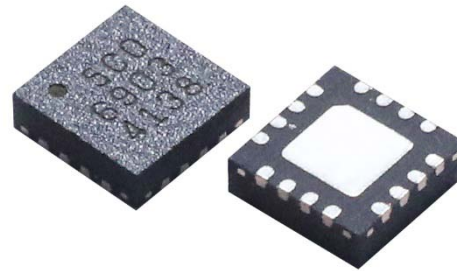


完整的新頻段(6GHz Band)射頻產品組合

NEW 6GHz BAND



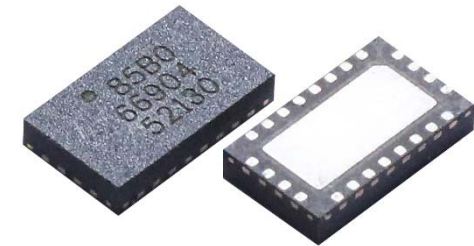
RTC66903



FEATURES

- SUPPORT 5.925-7.125GHz
- MCS11 HE160 19.5dBm Pout
- MCS0 HT20 25dBm Pout
- 3.0mm * 3.0mm PACKAGE

RTC66904



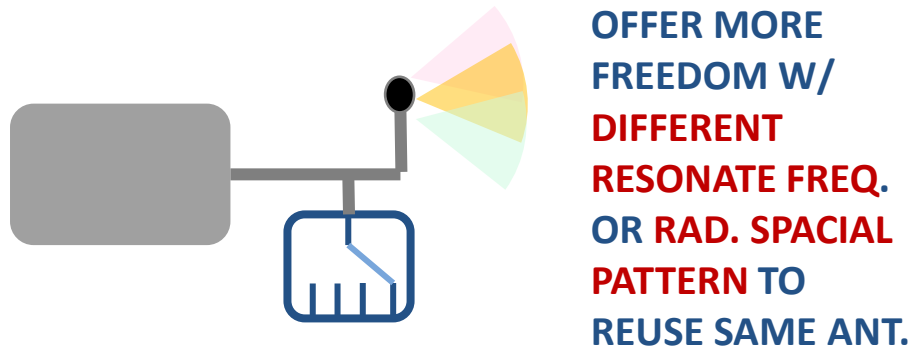
FEATURES

- SUPPORT 5.925-7.125GHz
- MCS11 HE160 20.5dBm Pout
- MCS0 HT20 26dBm Pout
- 3.0mm * 5.0mm PACKAGE

立積5G 射頻產品的特色

提升天線在多頻段下的使用效率

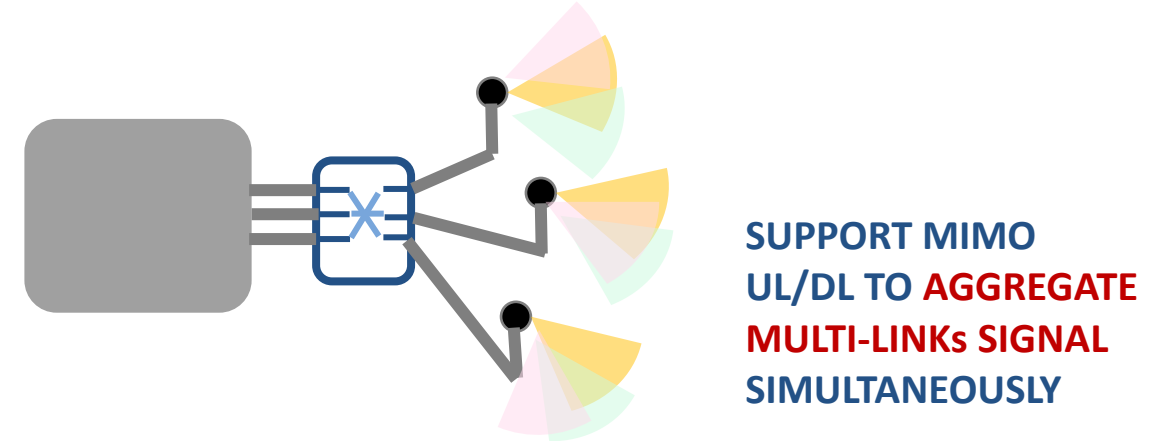
> ANTENNA TUNNING SWITCH



RTC8674A / RTC8674B / RTC8674C

- 4 PATHs SWITCH W/ INDIVIDUAL CTRL. (4*SPST)
- SUPPORT PEAK VOLTAGE LEVEL TO **45V/60V/80V**
- 1.1mm * 1.5mm PACKAGE

> ANTENNA SWAPPING SWITCH

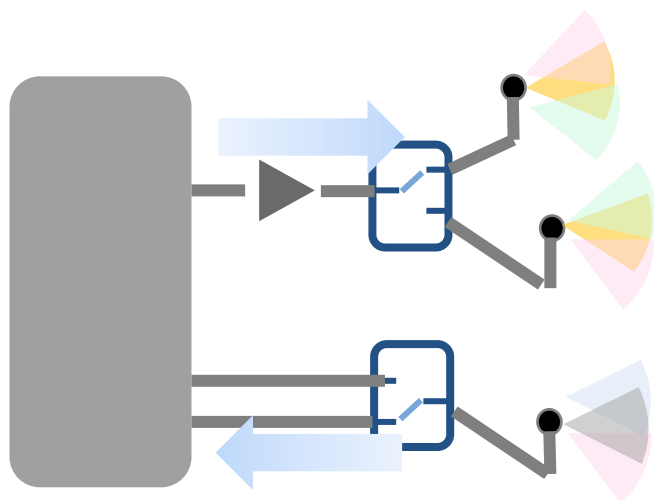


RTC86524AU / RTC86522BU / RTC86533AU

- DPDT/DP4T/3P3T SWITCH COMBINATIONS
- SUPPORT HIGH P0.1dB TO **36dBm**
- 1.1mm * 1.5mm / 2.0 mm * 2.0 mm PACKAGE

支援不同情況下的射頻電路設計考量

> GENERAL SWITCHs

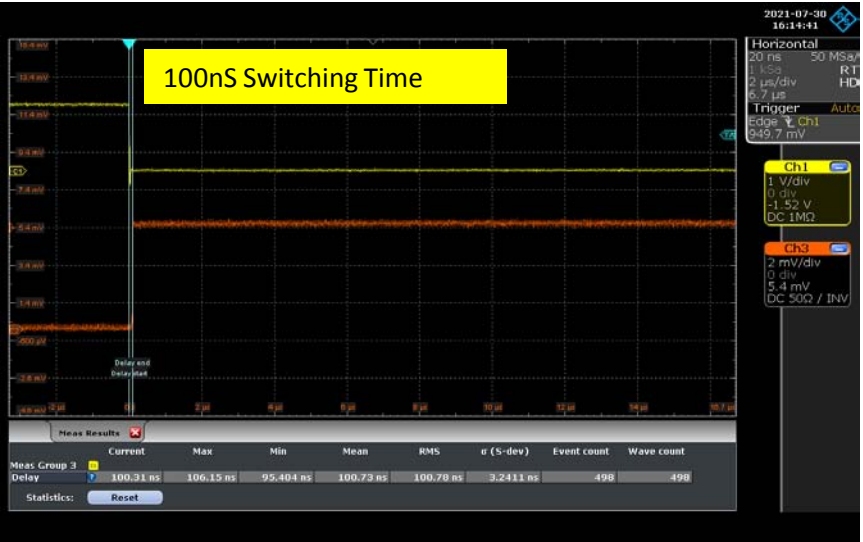


USE SWITCHs TO
CONSOLIDATE THE RF
TOPOLOGY, FLEXIBLE
TO ADAPT DIFFERENT
REGIONS

RTC86102x/ RTC86104x SERIES

- SPDT/SP4T SWITCH COMBINATIONS
- SUPPORT HIGH P0.1dB to 40dBm FOR TX PATH
- ALSO PROVIDE TYP. P0.1dB 33dBm FOR DIV. PATH
- 1.1mm * 0.7mm / 0.95 mm * 0.6 mm PACKAGE

> OTHER ADV. TO OUR SW



FAST SWITCHING TIME TO
SUPPORT SOUNDING REF.
SIGNAL(SRS) FEATURE BY 5G
REQUIREMENT

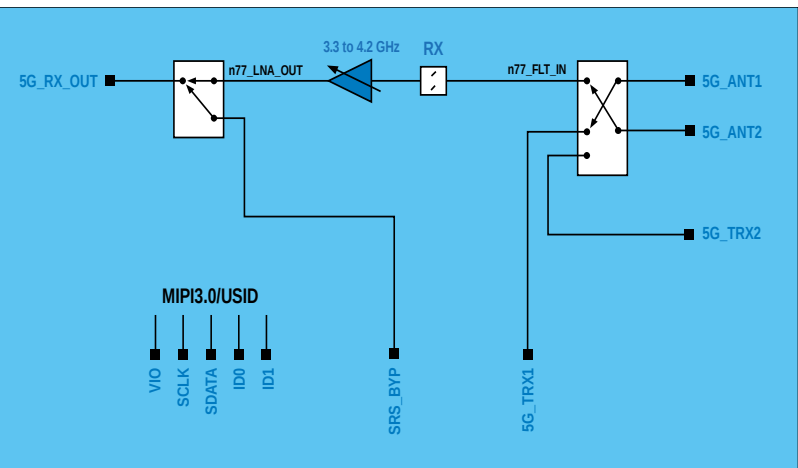
Parameter	Unit	Test condition	RichWave RTC86102GU (P0.1dB=33dBm)	RichWave RTC86102HU (P0.1dB=40dBm)
Insertion Loss	dB	617-960MHz	0.27	0.25
		960-2170MHz	0.27	0.35
		2170-2700MHz	0.29	0.36
		3300-3800MHz	0.30	0.39
		3800-4200MHz	0.30	0.41
		4400-5000MHz	0.32	0.44
		5150-5925MHz	0.35	0.48
		6000-7000MHz	0.42	0.64
		7000-8000MHz	0.60	0.87
		8000-8250MHz	0.64	0.96

WIDE FREQUENCY
SUPPORT, CAN BE USE
ON 5G SUB-6G AND
Ultra-Wide-Band (UWB)
APPLICATIONS

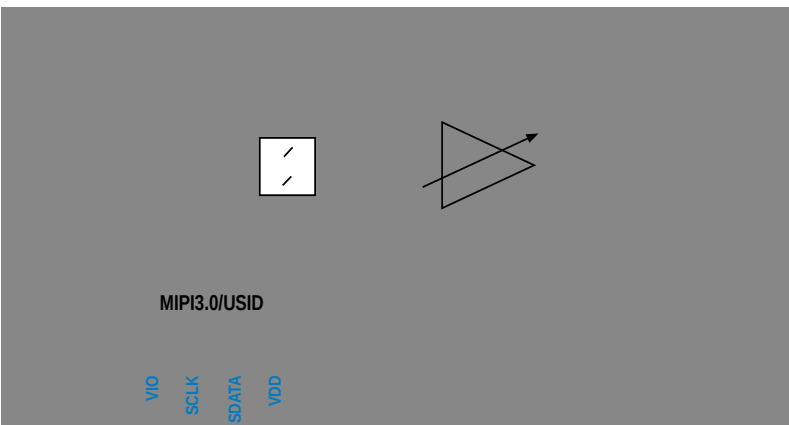
提供一系列的5G NR應用的接收射頻模組

BAND N77 LNA FAMILY

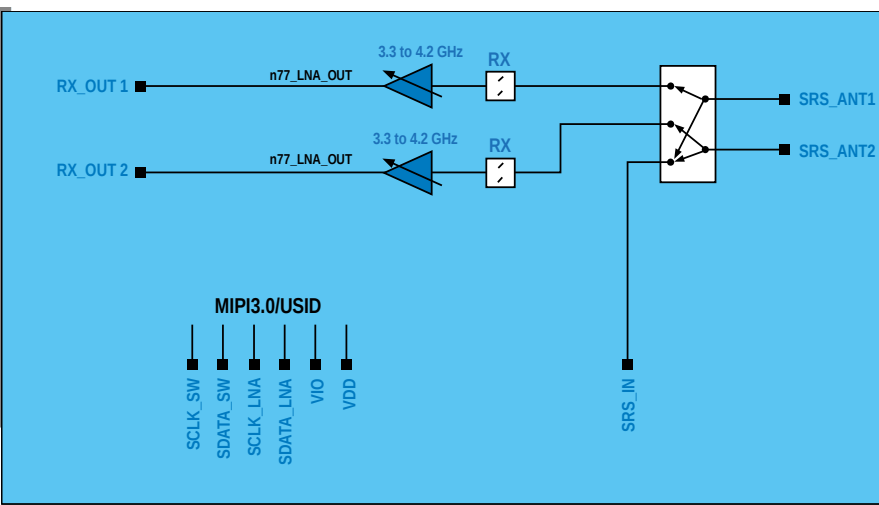
RTC86902



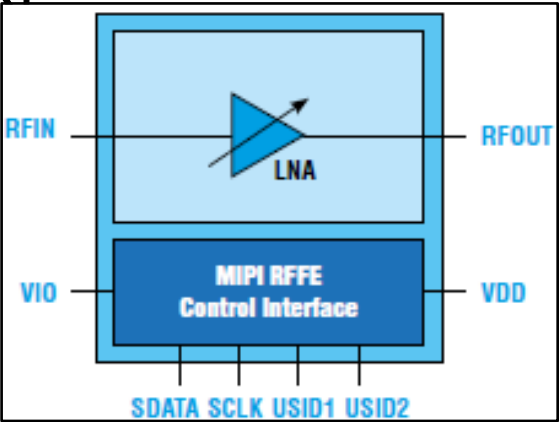
RTC86903



RTC86904



MULTI-GAIN LNA W/ LAA SUPPORT



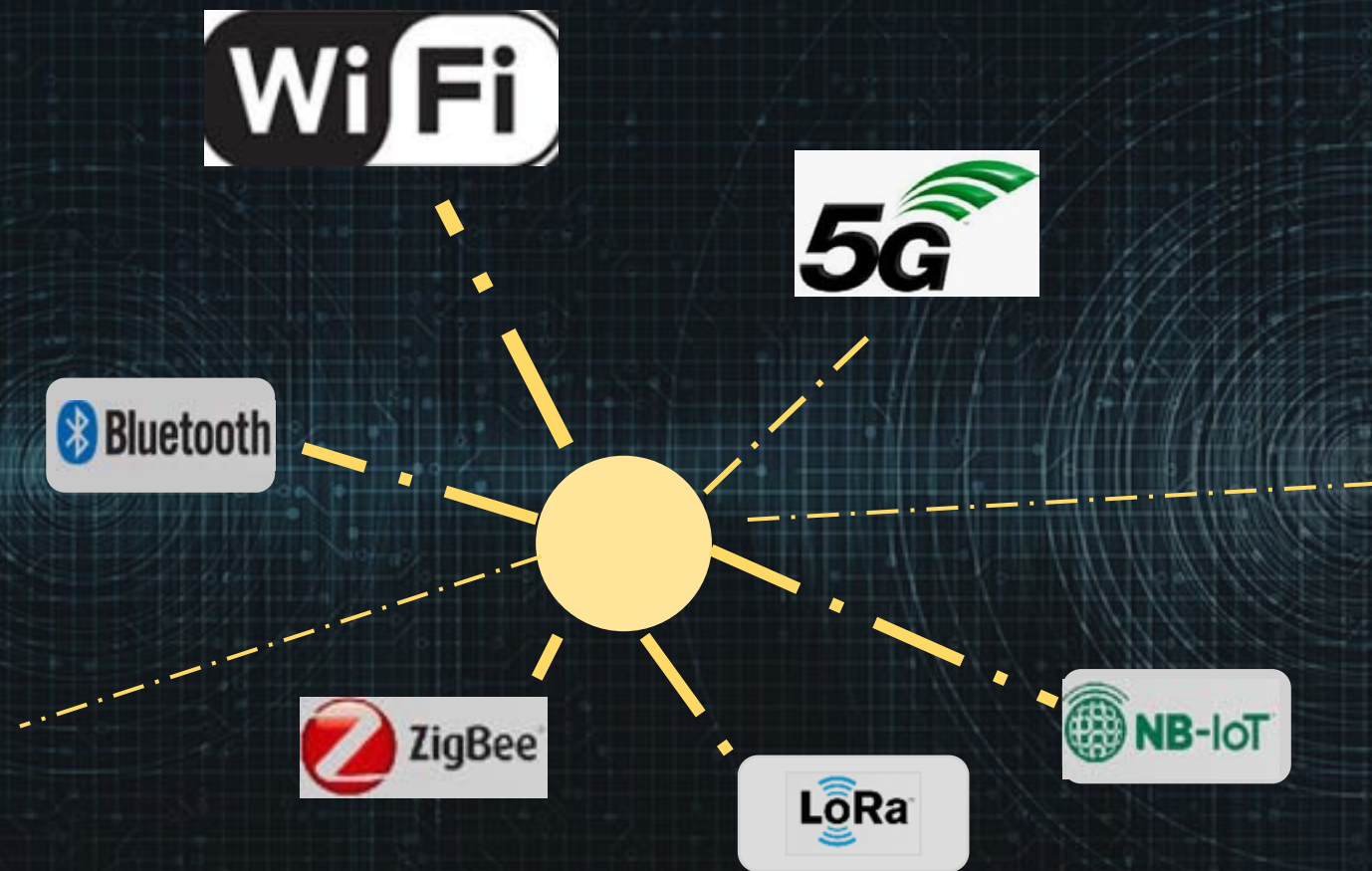
RTC86006U

- COVER 5.150~5925MHz
- WITH MIPI COMPLIANCE INTERFACE CONTROL
- SUPPORT UP TO 6 STAGE GAIN STEPS
- 1.5mm * 1.1mm PACKAGE

RichWave

RichWave

是您無線產品
的最佳後盾





Thank you

Follow us on:  

For more information, visit us at:
www.richwave.com.tw



引導您抓取想要的信號---濾波器

Champion Fu

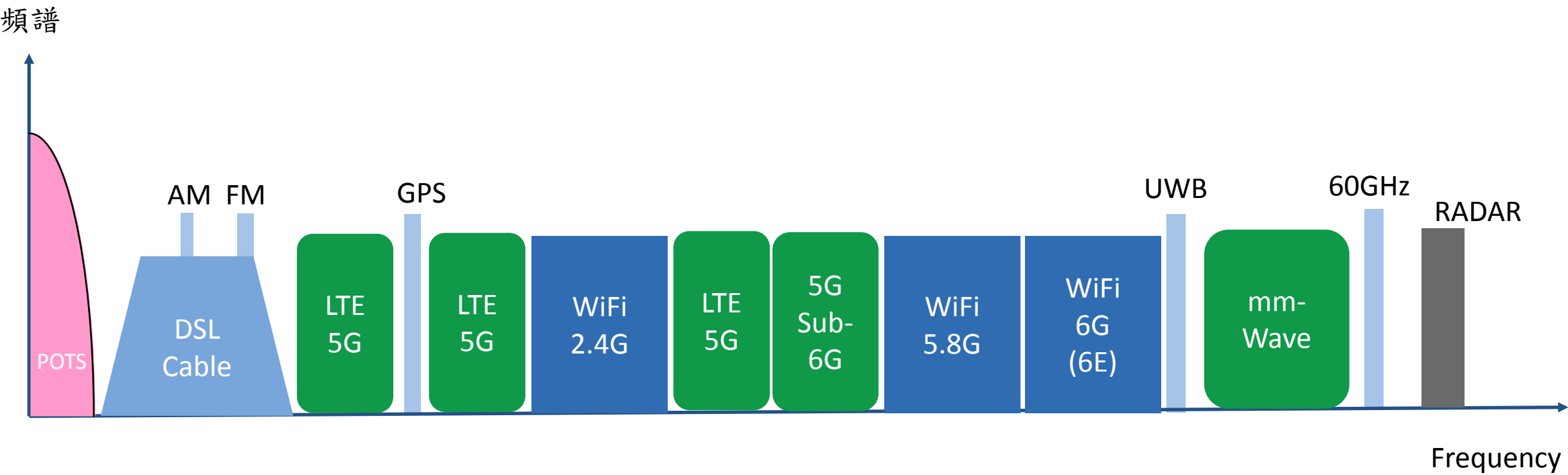
Dec. 2021

什麼是通訊?

- 相同頻率
 - V.90 數據機 (0~4K Hz) → DSL 數據機 (>30K Hz)
 - 信號干擾
 - 信號頻寬 $\leftrightarrow$ 取樣頻率 (Nyquist Rate)
- 相同通訊協議
 - 我講的你聽的到 你講的我聽的到
 - 我講的你聽的懂 你講的我聽的懂
- 雜訊
 - 如果傳輸通道是無雜訊的環境, 98%的工程師將會失業

無線技術應用頻段

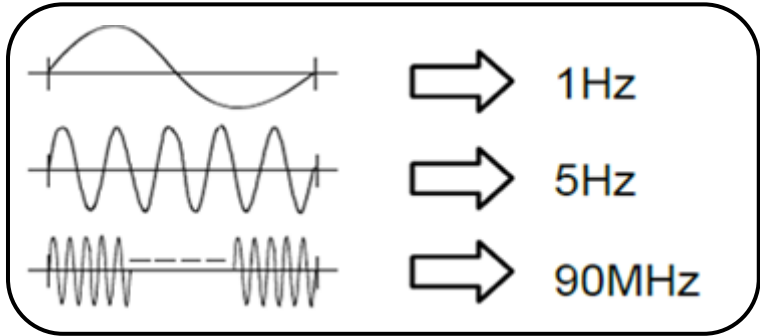
付費授權頻段
免費無須授權頻段(工業, 科學, 醫療)



濾波器產品應用



什麼是濾波器?



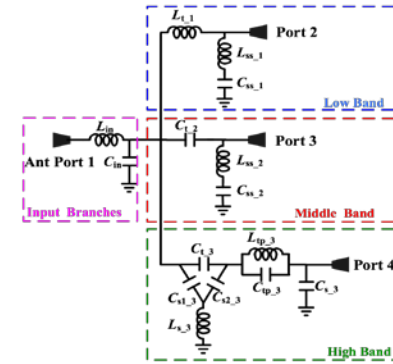
Band	Classification	Frequency range
LF	Low Frequency	30kHz ~ 300kHz
MF	Medium Frequency	300kHz ~ 3MHz
HF	High Frequency	3MHz ~ 30MHz
VHF	Very High Frequency	30MHz ~ 300MHz
UHF	Ultra High Frequency	300MHz ~ 3GHz
SHF	Super High Frequency	3GHz ~ 30GHz
EHF	Extremely High Frequency	30GHz ~ 300GHz

SAW Filter

濾波器的分類

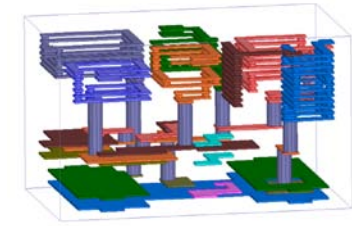
- 傳統分散式設計濾波器

- 電感/電容



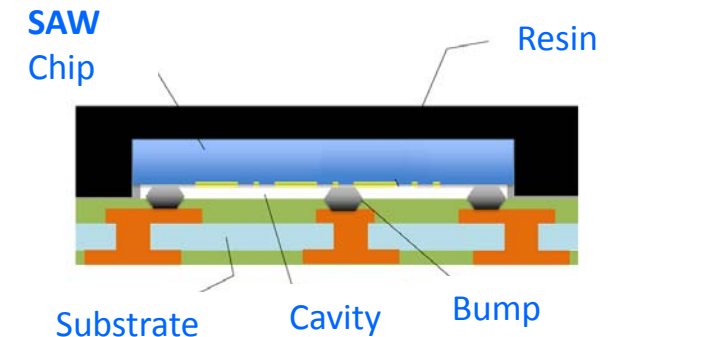
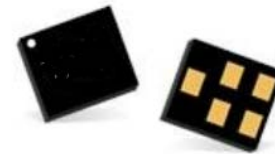
- 低溫共燒陶瓷

- 陶瓷, 銀/銅
- 可工作頻段 : 150M ~ 100G Hz



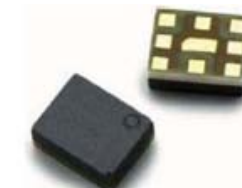
- SAW (Surface Acoustic Wave)

- 可工作頻段 : 50M ~ 3.5G Hz

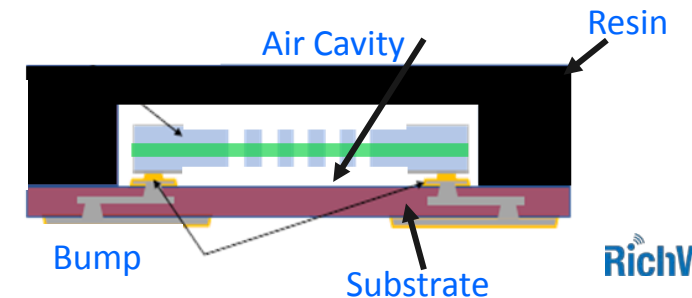


- BAW (Bulk Acoustic Wave)

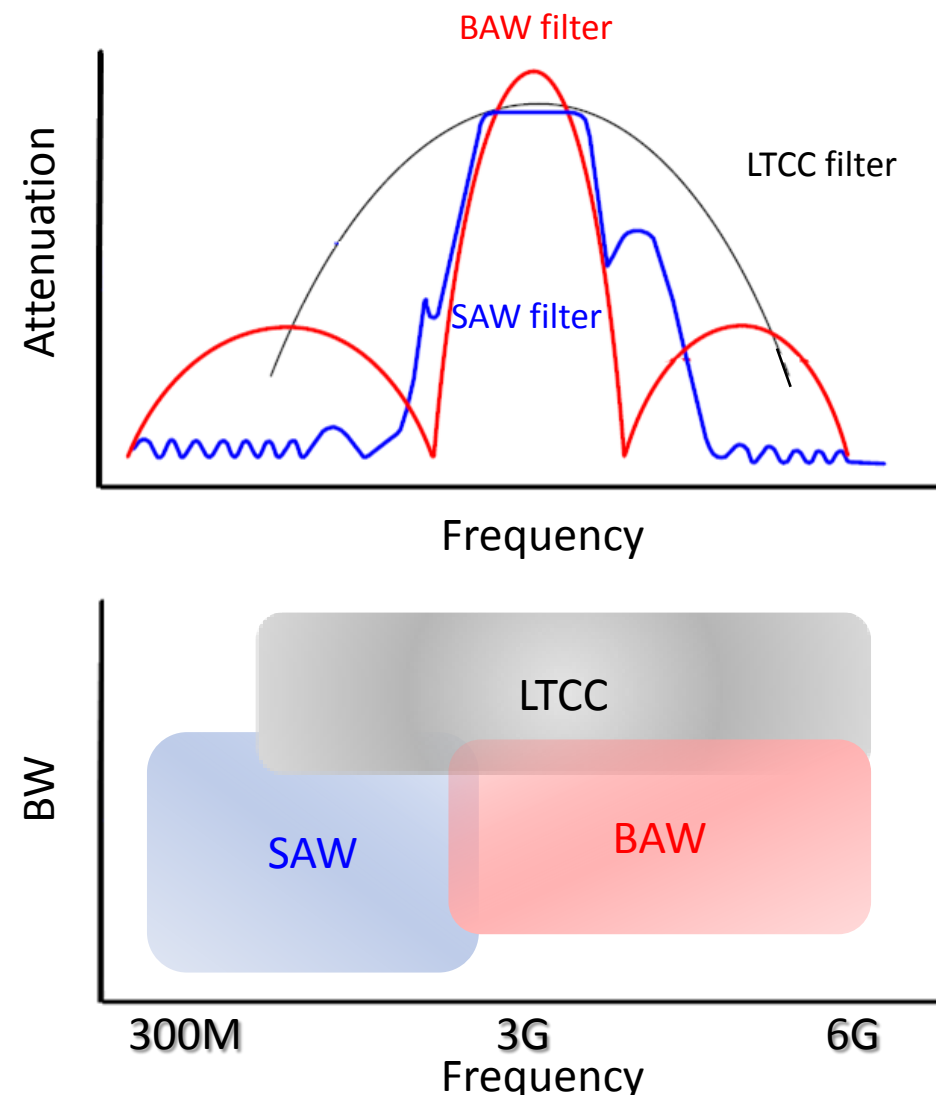
- 可工作頻段 : 400M ~ 10G Hz



XBAW chip



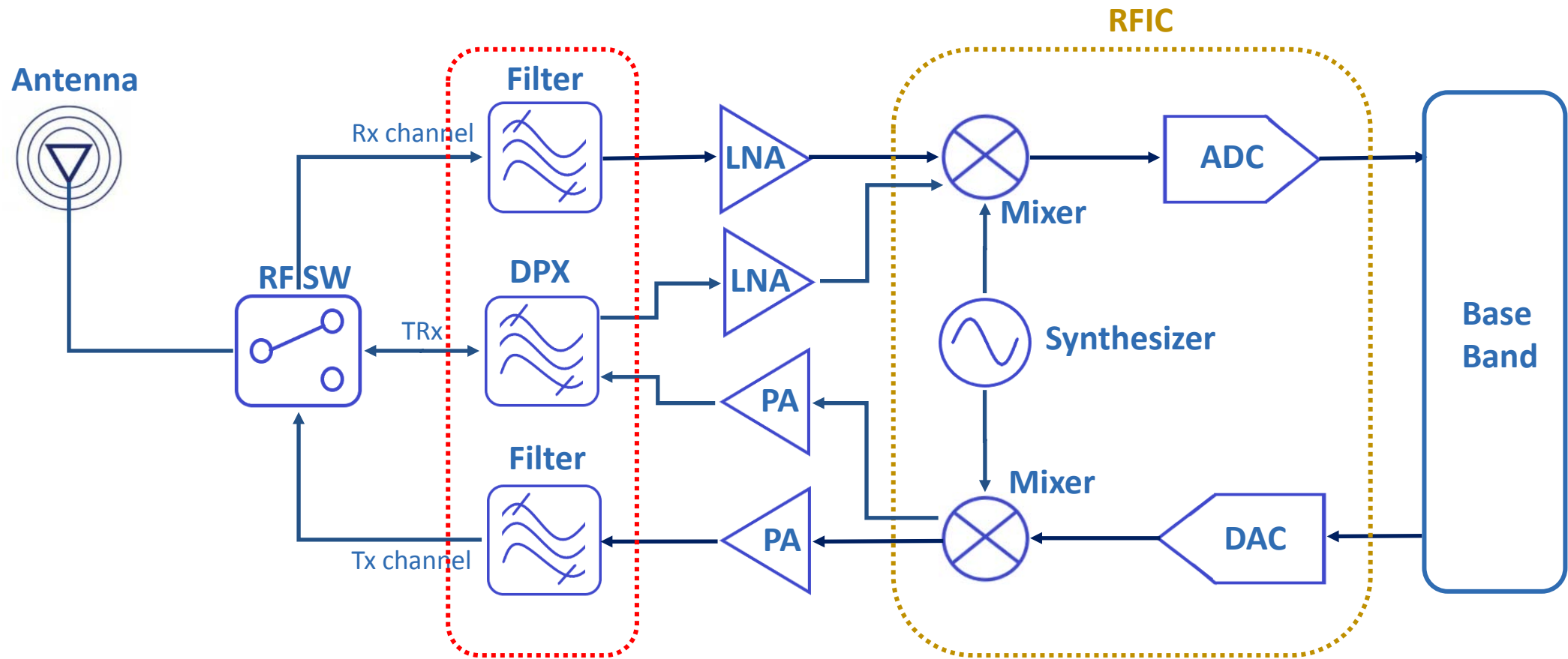
不同型態濾波器的頻率響應



	SAW	BAW	LTCC
Q	△	○	X
Loss	△	○	X
Att.	△	○	X
TCF	△	○	△
Size	○	X	○
Price	△	X	○
Power	X	○	○

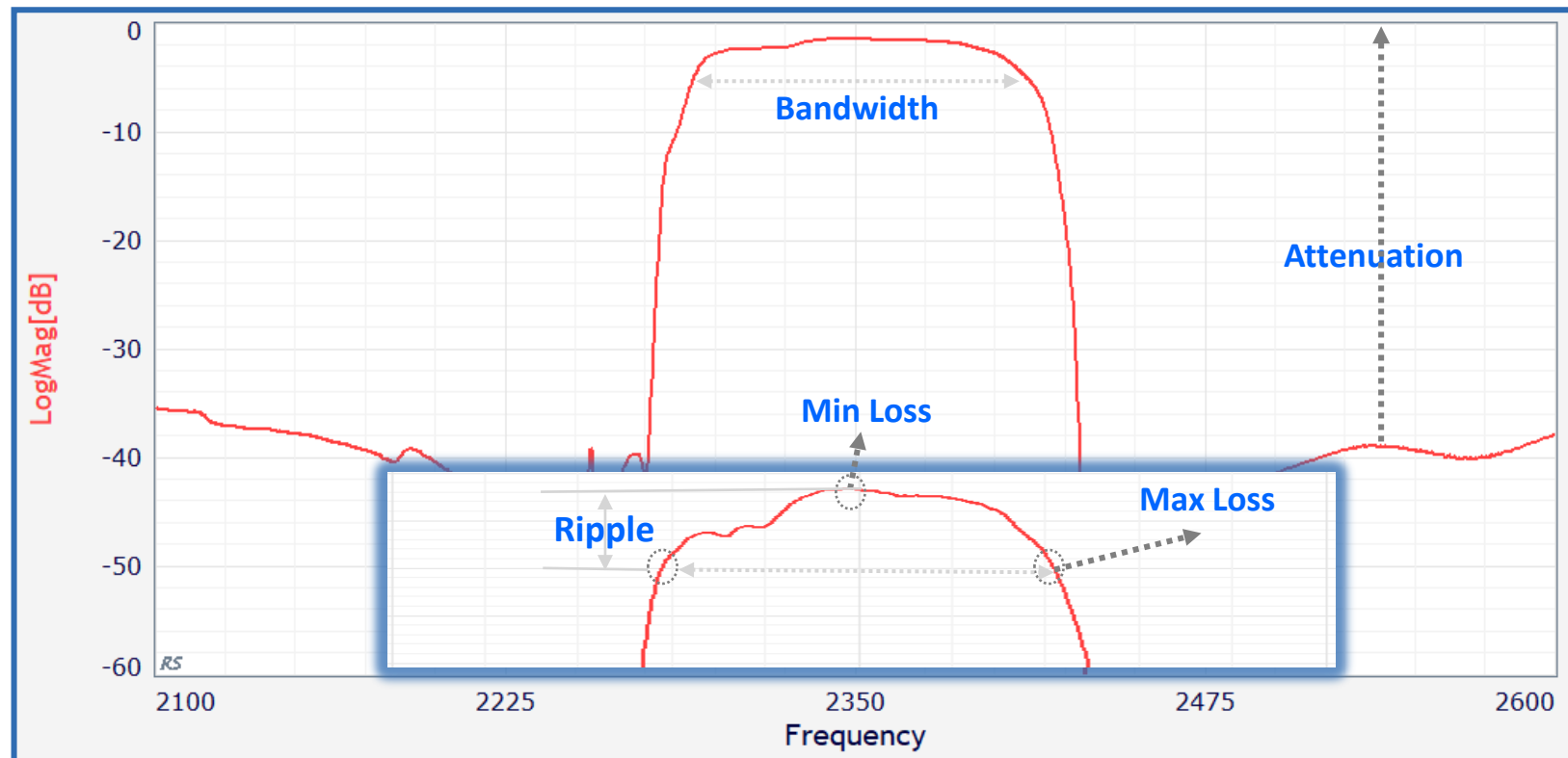
○: Good; △: average; X: Not so good

濾波器在無線通訊系統角色



濾波器的關鍵參數

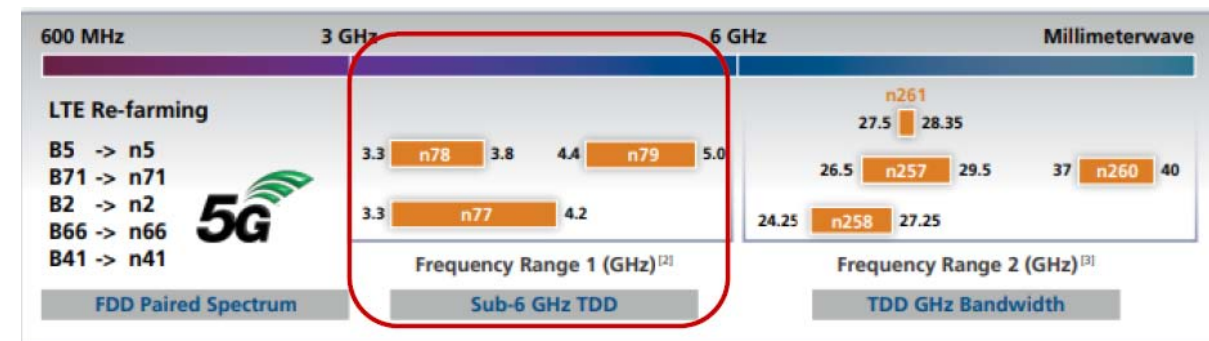
1. Fo: 中心頻率
2. Max Loss: 通道最大衰減
3. Ripple: (Max IL – Min IL) in Pass Band.
4. Pass Band Bandwidth:
High Freq Point FH – Low Freq Point FL
5. Attenuation: Side Band Attenuation (Reference 0dB)



LTE/5G 使用頻段

5G NR FR1 Band	Uplink Freq (MHz)	Downlink Freq (MHz)	BW (MHz)	Duplex Mode
n1	1920 ~1980	2110~2170	60	FDD
n2	1850~1910	1930~1990	60	FDD
n3	1710~1785	1805~1880	75	FDD
n5	824~849	869~894	25	FDD
n7	2500~2570	2620~2690	70	FDD
n8	880~915	925~960	35	FDD
n12	699~716	729~746	30	FDD
n20	832~862	791~821	30	FDD
n25	1850~1915	1930~1995	65	FDD
n28	703~748	758~803	45	FDD
n34	2010~2025	2021~2025	15/4	FDD
n39	1880~1920	1880~1920	40	FDD
n40	2300~2400	2300~2400	100	TDD
n41	2496~2690	2496~2690	194	TDD
n50	1432~1517	1432~1517	85	TDD
n51	1427~1432	1427~1432	5	TDD
n66	1710~1780	2110~2200	70/90	FDD
n70	1695~1710	1995~2020	15/25	FDD
n71	663~698	617~652	35	FDD
n74	1427~1470	1475~1518	43	FDD
n75	X	1432~1517	85	SDL
n76	X	1427~1432	5	SDL
n77	3300~4200	3300~4200	900	TDD
n78	3300~3800	3300~3800	500	TDD
n79	4400~5000	4400~5000	600F	TDD

Frequency Range Designation	Corresponding Frequency Range
FR1	450 MHz ~ 6000 MHz
FR2	24250 MHz ~ 52600 MHz



RichWave 手機應用濾波器產品

5G Mobile focus product

	Band 1	Band 2 Band 25	Band 3	Band 4	Band 5 Band 26	Band 7	Band 8	Band 12	Band 13	Band 20	Band 34	Band 39	Band 40	Band 41
US	v	v	v	v	v		v	v	v					v
EU	v		v		v	v	v			v				
China	v		v		v		v				v	v	v	v

1109 Filter : B1, 2, 3, 5(26), 7, 8, 12, 13, 20, 28FB, 39, 40, 41

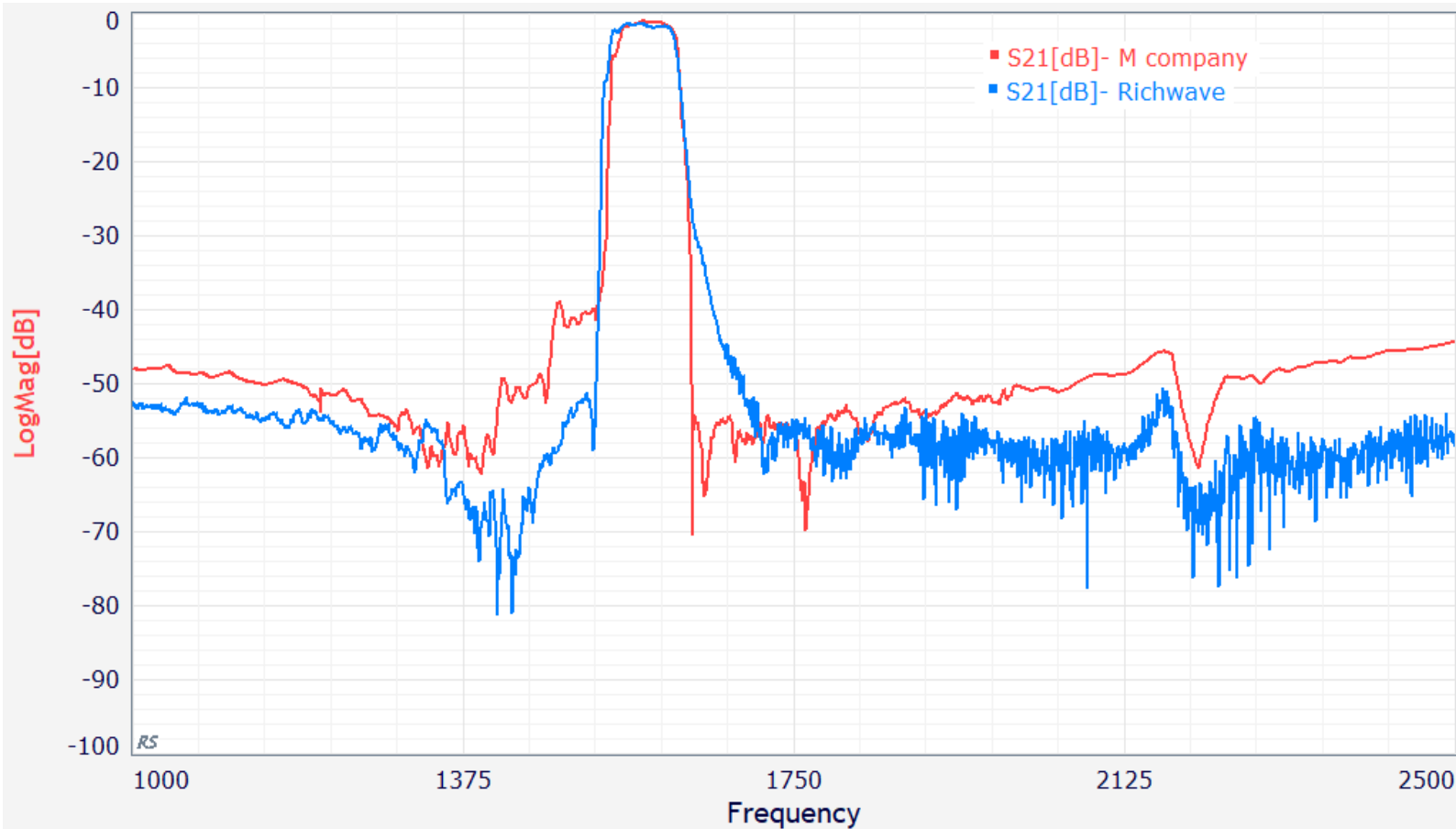
0907 Filter : n1, n2, n3, n5, n7, n8, n12, n20, n28FB, n39, n40, n41FB, n66.

1814 DPX : B1, 2, 3, 5, 7, 8, 12, 13, 28

1511 Dual : B1+B3, B25+B66, B39+B41

- Available part
- Developing
- Plan

SAW濾波器性能比較



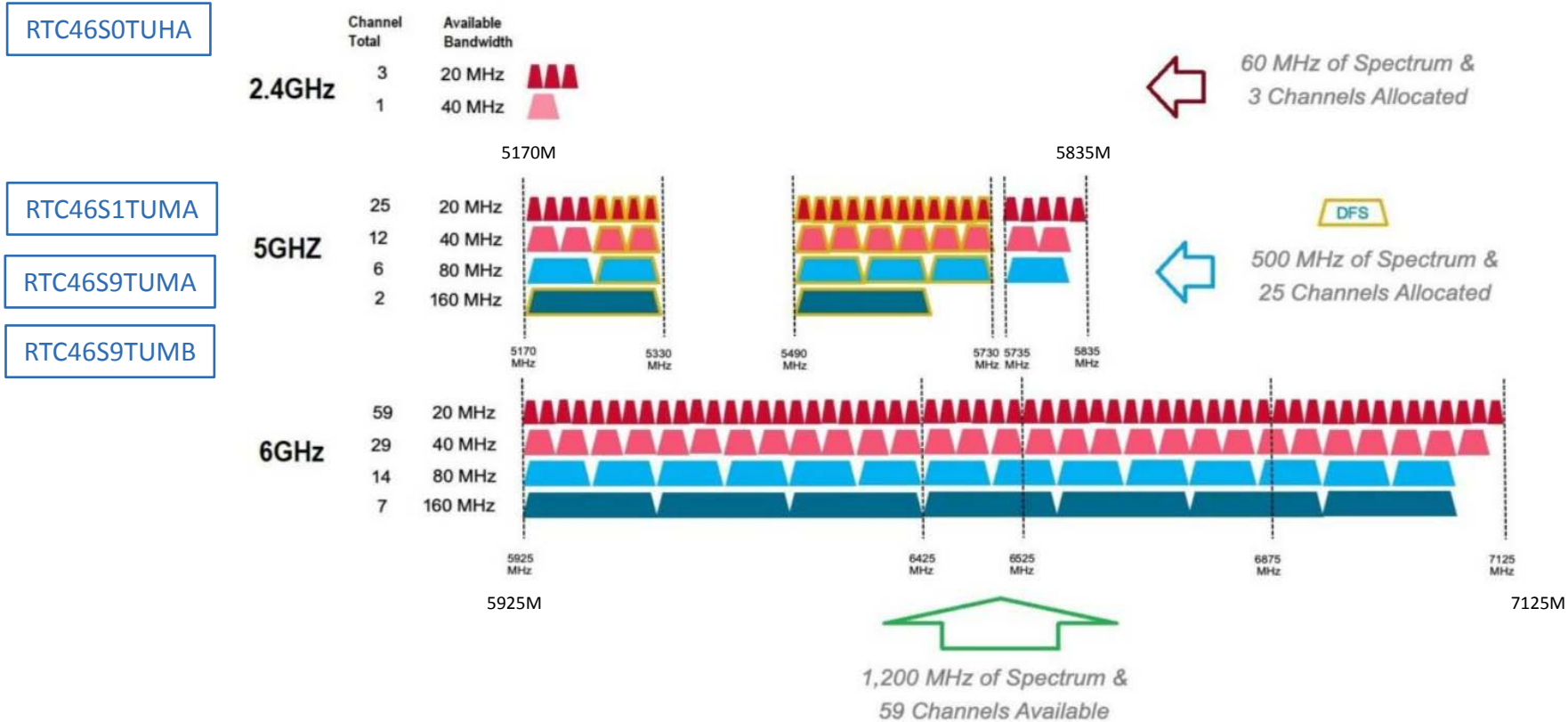
■ RTC46S2RUHA

■ Key Features

- Freq. : 1559~1605 MHz
- IL:
 - 1.8dB @ 1559MHz
 - 1.3dB @ 1575MHz
 - 1.6dB @ 1605MHz
- Attenuation:
 - 58dB @ B13 Tx (777~798MHz)
 - 57dB @ B5,B8 Tx (824~915MHz)
- Package: 5L QFN 1.1mm x 0.9mm

SAW/BAW WiFi應用濾波器

Wi-Fi Frequency Bands

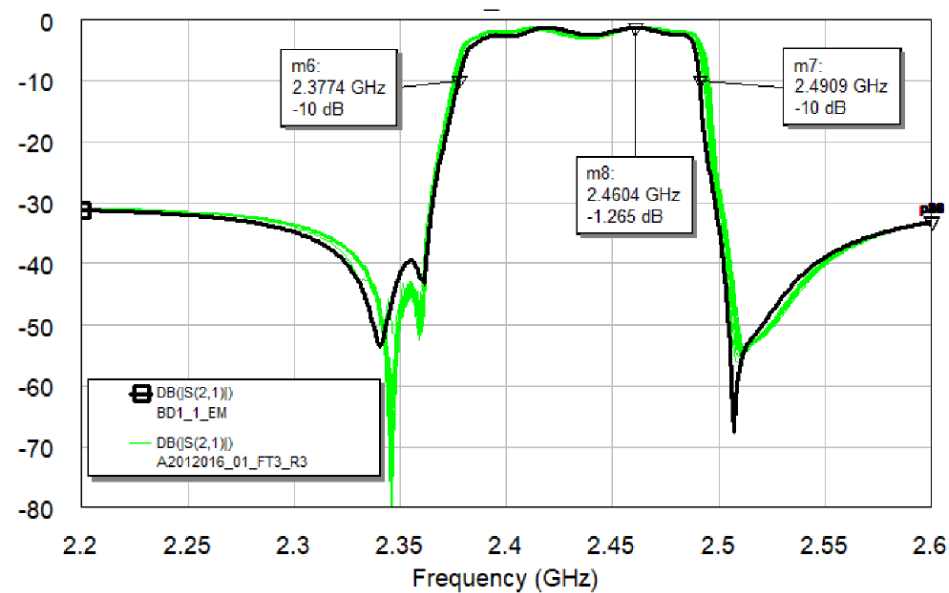


Sourced from Wi-Fi Alliance
RichWave

WiFi BAW 濾波器

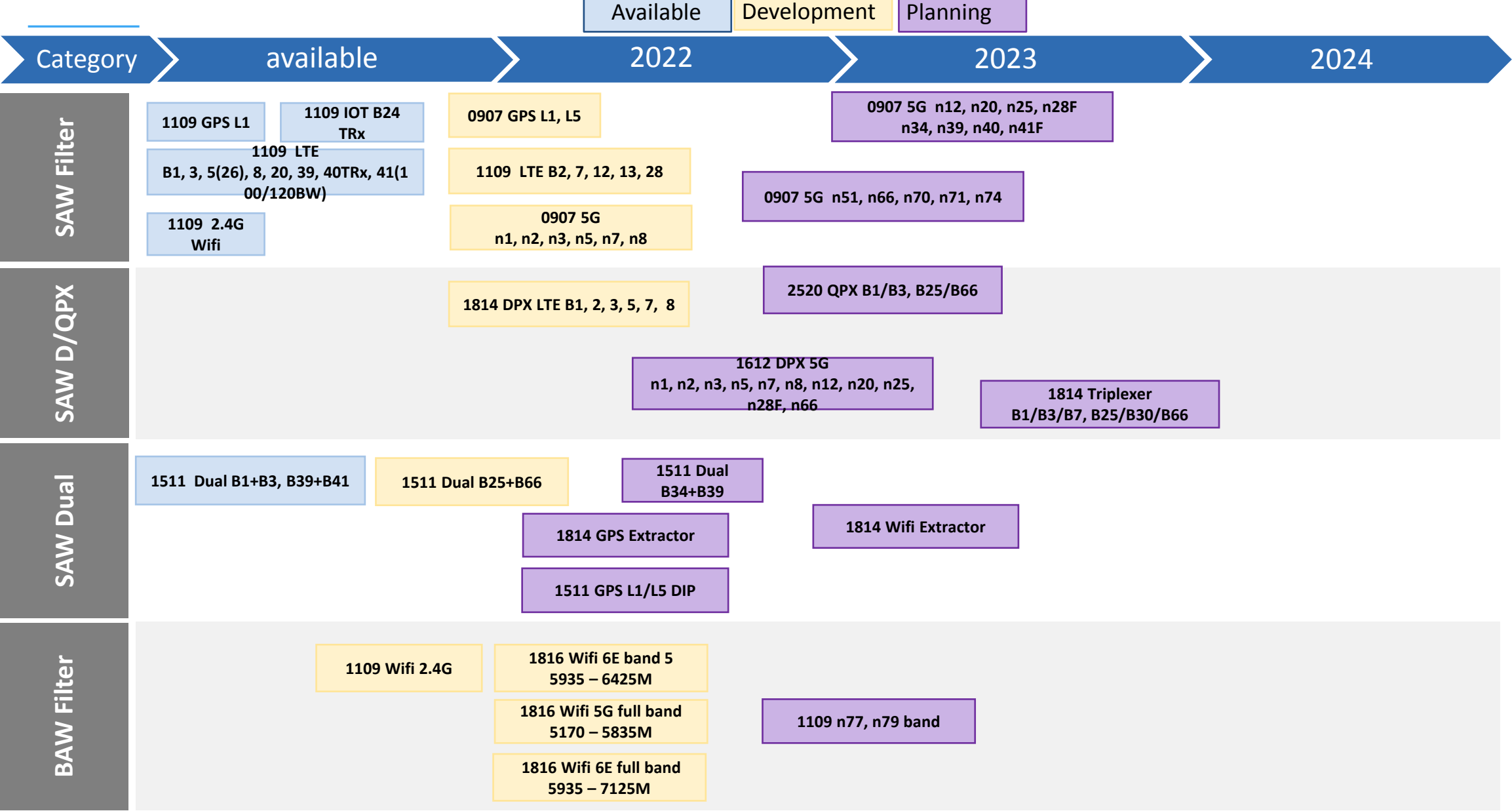
— Simulation
— Measured
on wafer

**Tested Filter on Wafer:
Measured and Simulated on Wafer**



- Pass Band : 2.4~2.483 GHz
- Insertion Loss (CH1~CH13)
 - 0.9~1.2 dB
- Rejection
 - 38dB @700~2370 MHz
 - 14dB @2496~2500 MHz
 - 38dB @2500~2520 MHz
 - 40dB @2520~2690 MHz
 - 36dB @3300~7200 MHz
 - 26dB @7200~10000 MHz

RichWave 濾波器產品規劃(WIFI/GPS/Mobile)





跟著RichWave一起迎接智能生活

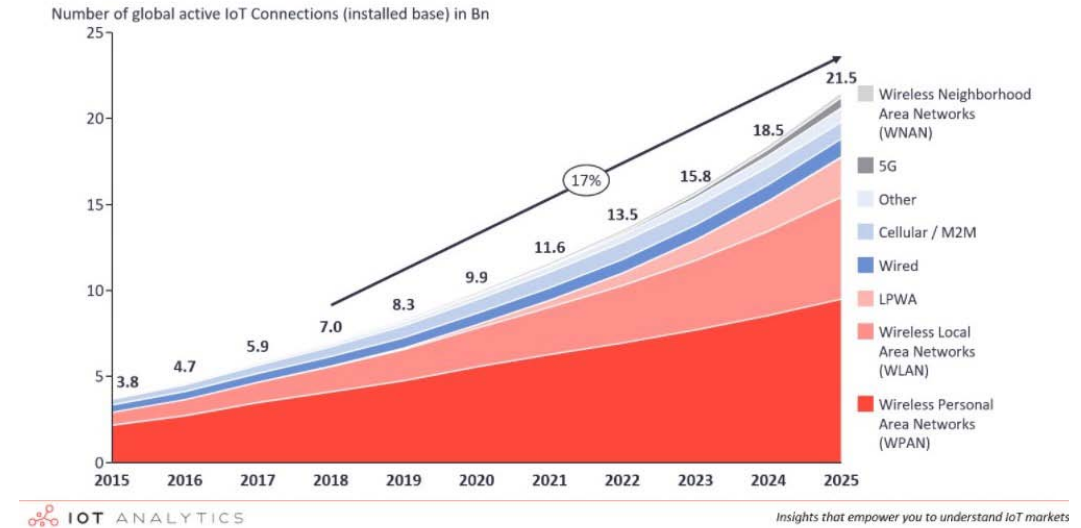
Champion Fu

Dec 2021

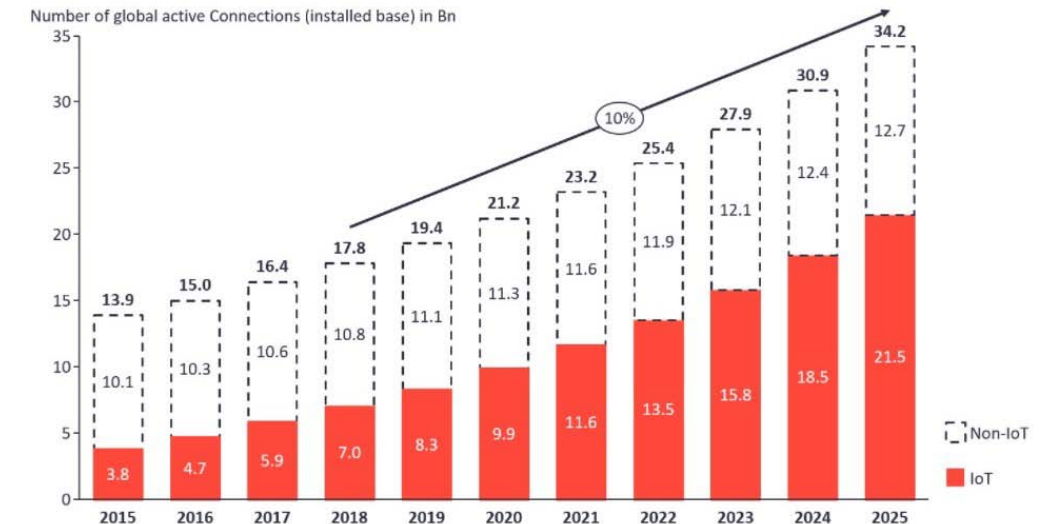
智能物聯網

- 人工智慧 (Artificial Intelligence)
- 物聯網 (Internet of Things)
- 大數據
 - 模糊理論
 - 訊號回授
 - 資料庫數據分析

Global Number of Connected IoT Devices



Total number of active device connections worldwide



Sourced by IOT Analytics

智能城市, 智能家居, 智能生態鏈



- 智能城市
 - 公車站, 停車場
- 智能家居
 - 手機/遙控器
 - 電視, 冷氣, 冰箱, 燈, 插座
- 車用電子升級
 - 胎壓偵測系統, 智能雷達防撞系統
 - 自動駕駛

物聯網應用在系統設計的考量點

- 資料傳輸量
 - 高吞吐量, 高訊號品質 (WiFi)
 - 低資料量, 需要時才傳送資料 (Low Power Wireless)
 - LPWAN – LoRA, NB-IoT
 - LPLAN – BT/BLE, Zigbee
- 系統功耗與供電方式
 - 電源供應器
 - 電池

Product Application



speaker



Home appliances

IP Cam

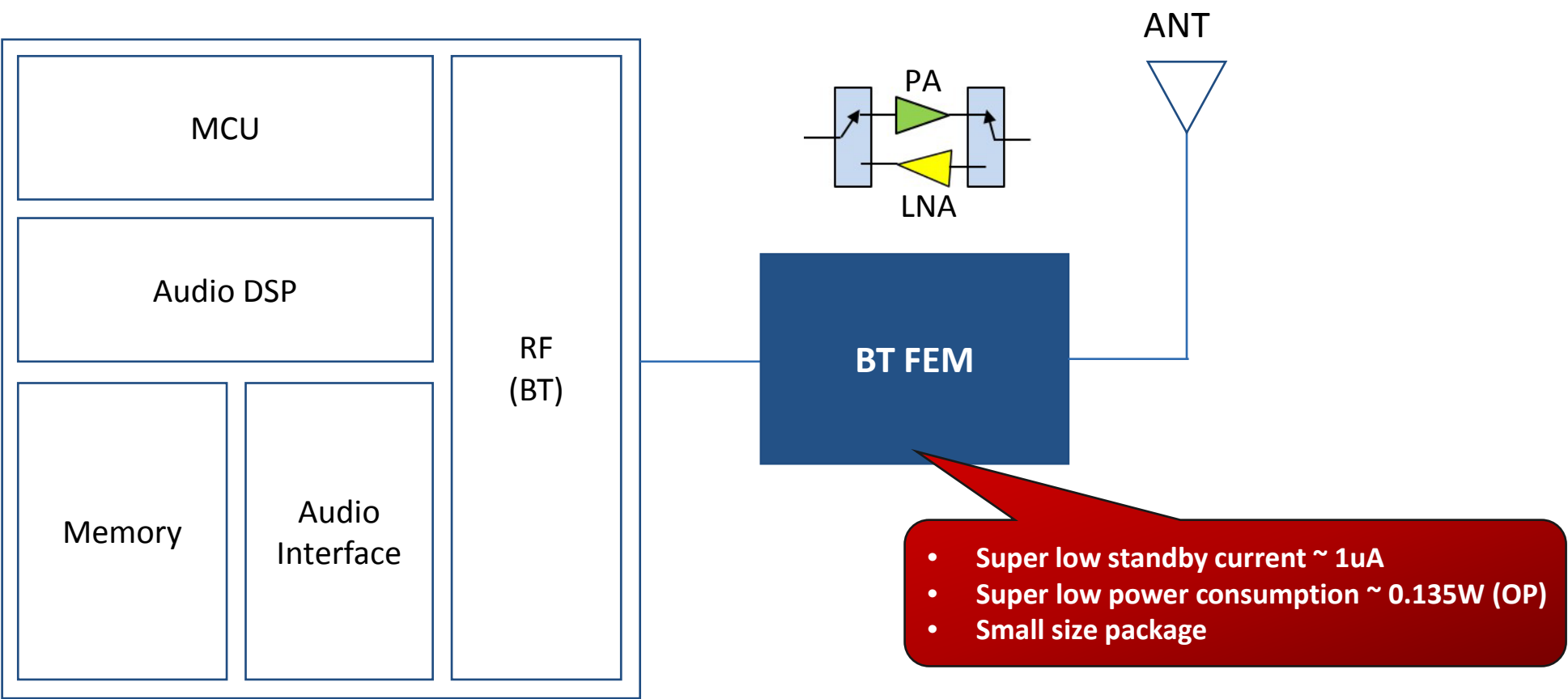


Doorbell

Smart Meter



Bluetooth/Zigbee 前端射頻模組



Part Number	Feature	Size	Support EDR	Status
RTC2624	Full FEM	16L QFN 2.4x2.4x0.8 mm	NO	MP
RTC26203	RX FEM	6L QFN 1.1x0.9x0.55 mm	NO	Developing

超低衰減物聯網射頻開關

Feature	Part No.	Insertion Loss (dB)	Isolation (dB)	P0.1dB (dBm)	Package (mm)
DPDT	RTC6615H	0.70 @ 2.40 GHz 1.00 @ 6.00 GHz	30 @ 2.45 GHz 29 @ 6.00 GHz	31	6L QFN 1.5x1.5x0.55
SPDT	RTC6603U	0.38 @ 2.45 GHz	23 @ 2.45 GHz	30	SC70
	RTC6608OU	0.24 @ 2.45 GHz	35 @ 2.45 GHz	32	6L QFN
		0.35 @ 5.80 GHz	26 @ 5.80 GHz		1.0x1.0x0.45
		0.65 @ 7.125 GHz	22 @ 7.125 GHz		
	RTC7608U	0.21 @ 2.45 GHz	35 @ 2.45 GHz	32	6L QFN
		0.35 @ 5.80 GHz	25 @ 5.80 GHz		1.0x1.0x0.35
		0.53 @ 7.125 GHz	23 @ 7.125 GHz		
	RTC6619U	0.33 @ 2.45 GHz	34 @ 2.45 GHz	34	6L QFN
		0.43 @ 5.80 GHz	25 @ 5.80 GHz		1.0x1.0x0.35
SP3T	RTC6617U	0.31 @ 2.45 GHz 0.53 @ 5.90 GHz	22 @ 2.45 GHz 19 @ 5.90 GHz	30	8L QFN 1.5x1.5x0.45
SP4T	RTC8614U	0.2 @ 1.0 GHz	49 @ 1.0 GHz	32	14L QFN
		0.3 @ 2.7 GHz	34 @ 2.7 GHz		2.0x2.0x0.6
		0.4 @ 3.8 GHz	29 @ 3.8 GHz		



車用電子射頻產品規劃

WiFi FEM

5GHz full FEM

- RTC1630 (3mmx3mm)
- PA+LNA+SW
- pass AEC-Q100 Level 2
- support 802.11p

5GHz RX FEM

- RTC1631 and RTC16504
- SW+ LNA
- pass AEC-Q100 level 2

6GHz RX FEM

- RTC16xx
- SW+LNA

2.4GHz full FEM

- RTC1620 (3mmx3mm)
- PA+LNA+SW
- pass AEC-Q100 Level 2

2.4GHz RX FEM

- RTC1621 and RTC16206
- SW+ LNA
- pass AEC-Q100 level 2

WiFi SW

SPDT and SP3T for WiFi 6

- RTC1602 (SPDT)
- RTC1603 (SP3T)
- pass AEC-Q100 Level 2

SPDT and SP3T for WiFi 6E and UWB

- RTC16004 (SPDT)
- RTC16006 (SP3T)

5G/NR SW

SPDT (Up to UWB)

- RTC86102EU/FU (1.1mmx0.7mm)
- RTC86102GU/HU (0.95mmx0.6mm)

SP4T (Up to UWB)

- RTC86104CU (1.1mmx1.1mm)
- RTC86104DU (0.95mmx0.95mm)
- ES: 2021/Q2

LNA

LTE LNA (L/M/H)

- Non-Bypass
- Bypass Mode
- QFN1.1*0.7

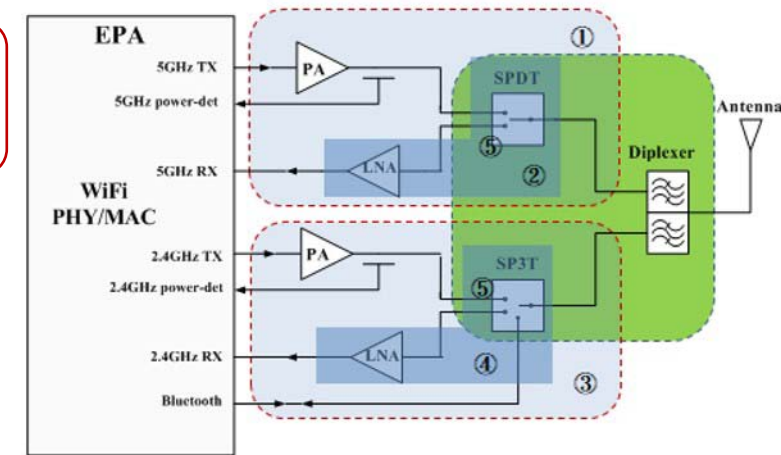
LNA Module

- LNA+SP5T
- QFN1.1*1.9

GPS LNA

- RTC8604 (L1 Band)
- RTC9601N (L5 Band)

符合 AEC-Q100





感測器在家用,消費性產品,工業與 汽車的應用

V1.3

Dec 2021

雷達感測器的應用

家用



智慧照明



智慧家電



語音助理



住家安全



存在偵測

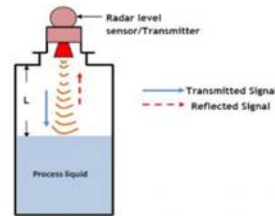
工業



工業或農業無人機



工業用交通及機器手臂



液面偵測

消費性商品



筆記型電腦



生理訊號偵測



手勢偵測

車用



行李箱自動開啟



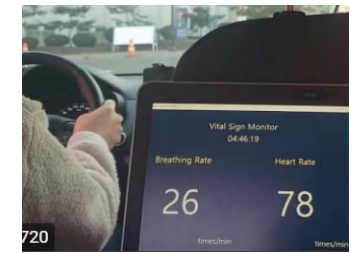
盲點偵測/停車



後座小孩偵測



防盜



駕駛生理監控

全球雷達感測器市場



Global RADAR SENSOR Market OPPORTUNITIES AND FORECAST, 2021-2030

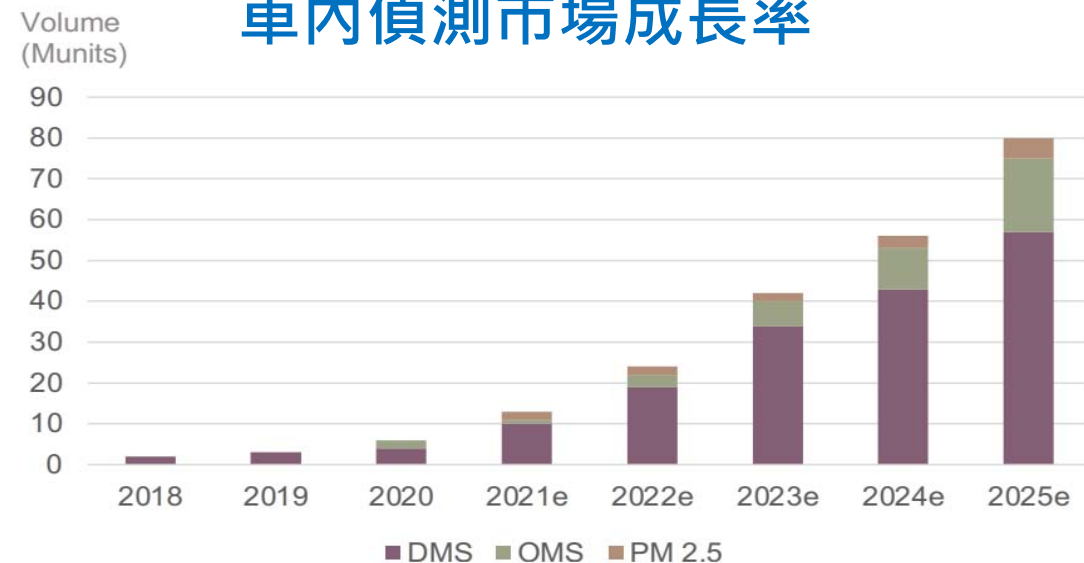
Global Radar Sensor Market is expected to reach **\$33.14 Billion** by 2030

Growing at a **CAGR of 13.10%** (2021-2030)



1. 消費性跟家用 – 56%成長 (2020-2025)
2. 車內偵測 – 72%成長 (2020-2025)

車內偵測市場成長率



DMS: 駕駛生理偵測 OMS: 後座人員偵測

RichWave

現有產品搭配立積感測器

智能家電



省電. 偵測人的距離跟存在

車內防盜



當偵測有碰撞, 侵入, 車子被拖吊或是有人試圖開門, 會發送訊號

智慧照明

智能光控省电省钱

自动识别光线, 白天或光线充足时保持休眠状态, 夜晚或光线暗时感应开启发光, 雷达光控范围5-8米, 角度120°



RichWave

更多跟客戶在合作中的案子 (現場有影片)

筆記型電腦應用



- 立積超寬頻感應器已經支援 Intel 平台

液面偵測

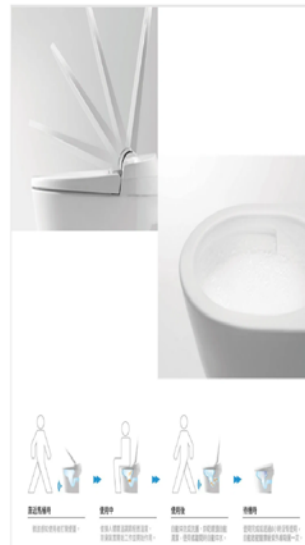


更多跟客戶在合作的案子

存在偵測



採用雷達技術，新款Nest Thermostat藉由感測是否有人靠近，並且喚醒裝置顯示當前溫度，



ACCURATE RADAR SENSE
精準微波掀蓋/人體感應
便蓋自動開啟/關閉

精準微波技術，將微波回波訊號轉化為電信號，準確的感知動作，實現厘米級的辨識。如輕微手指揮動，即能感知，相比常規技術更精準感知並辨識出人過來、人存在、人離開的狀態，實現來去自如。

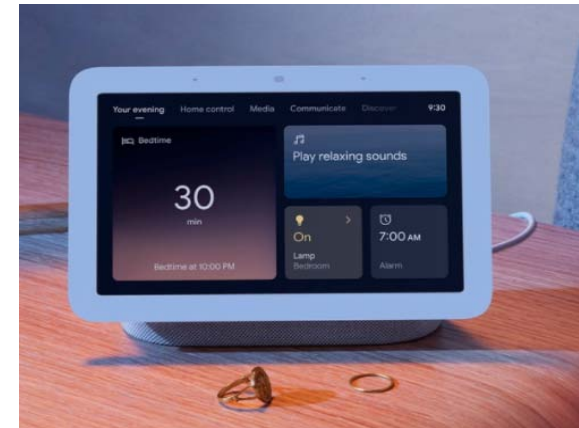
RADAR SENSE
微波掀蓋/人體感應
便蓋自動開啟/關閉

感知人過來、人存在、人離開的狀態，自動開啟與關閉便蓋，實現來去自如，離座後自動沖水。

生理訊號偵測



Column: Amazon wants to use radar so
Alexa can watch as you sleep

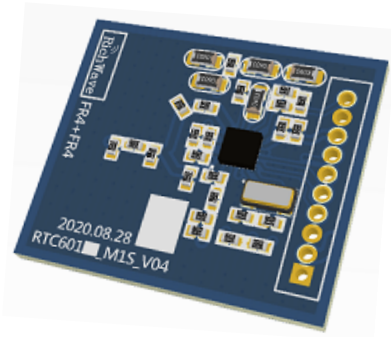


Google 新一代的 Nest Hub 能靠雷達
來記錄你的睡眠狀態

*FCC issued approval

立積感測器產品規劃

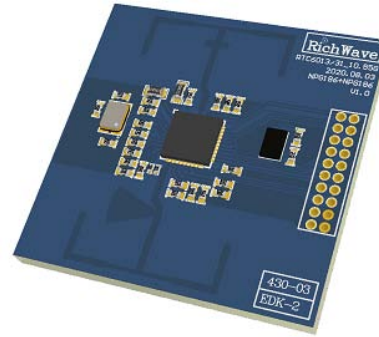
2020



5.8GHz 雷達感測器
(RTC6012)

- QFN2.2x2.2
- Single antenna
- Very low operation current (50uA)
- Motion detection

2021



超寬頻雷達感測器
(RTC6013/6022/6031)

- QFN 5x5
- 1 TX antenna, 1 RX antenna
- DSP with Algorithm
- Motion + Range detection

2022



60GHz 毫米波感測器(AiP)



超寬頻雷達感測器
(1T2R,AoA) RichWave

二維軌跡追蹤演示



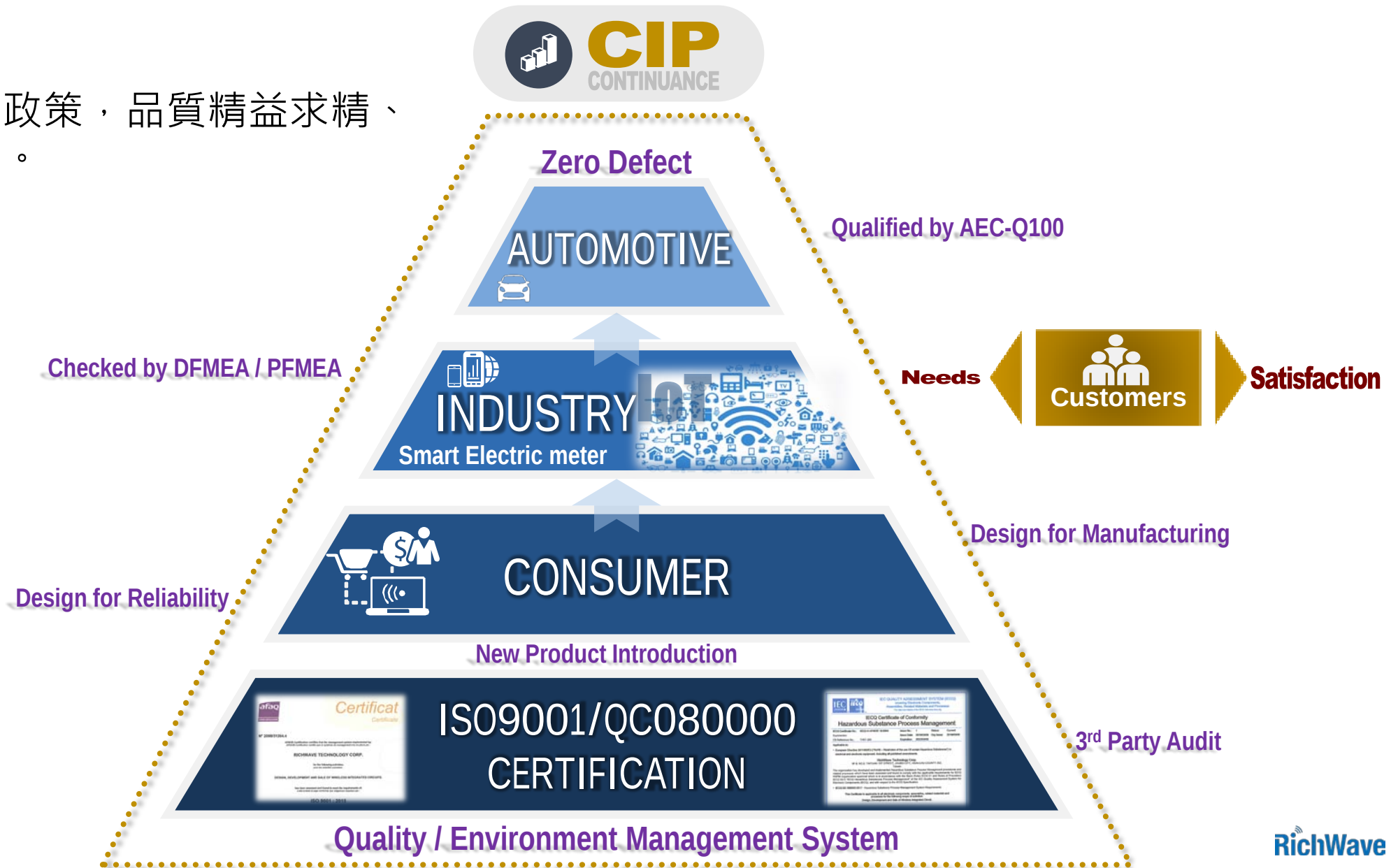
品質與生產

TS Liou

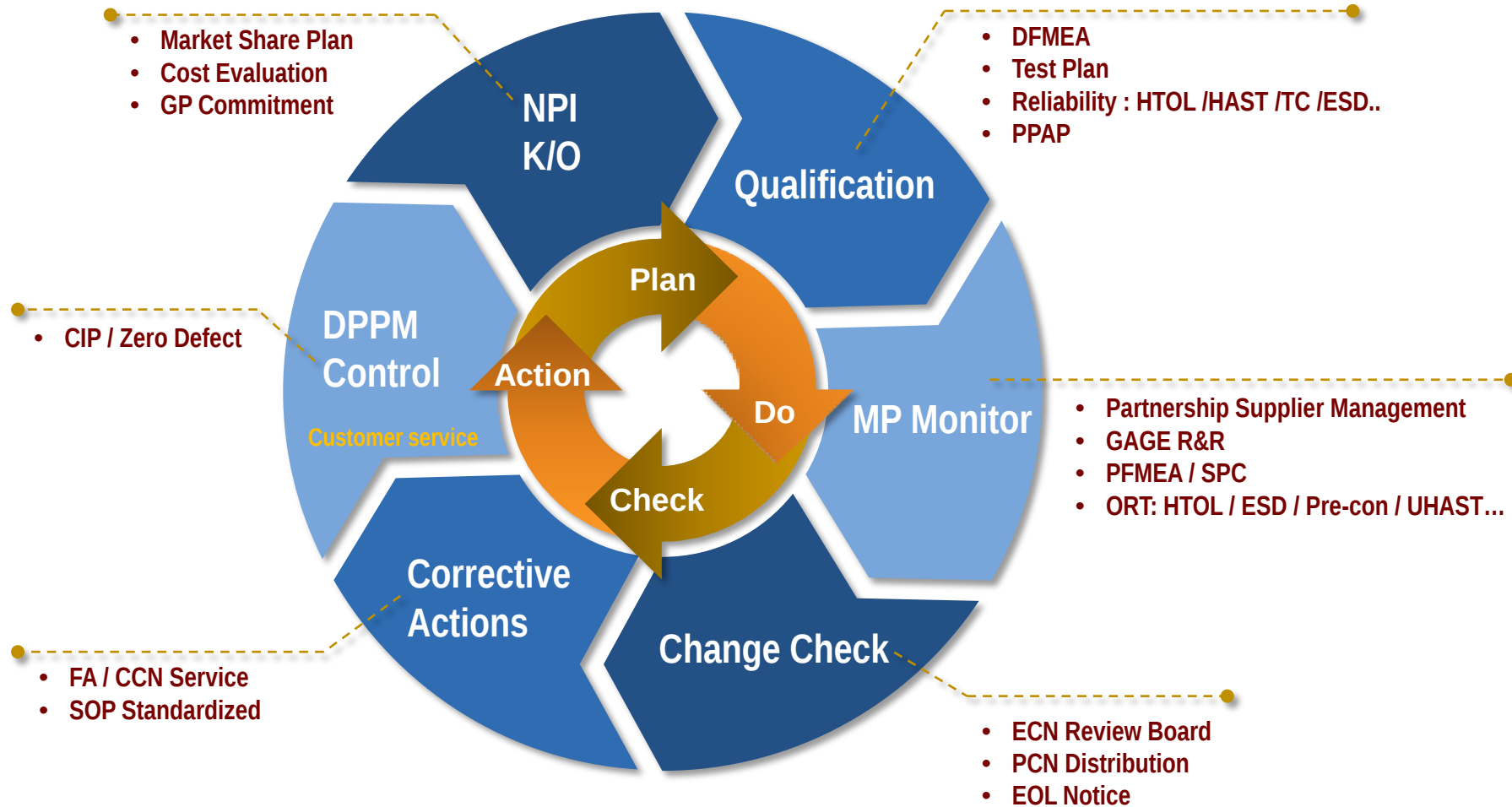
Dec. 2021

品質保證

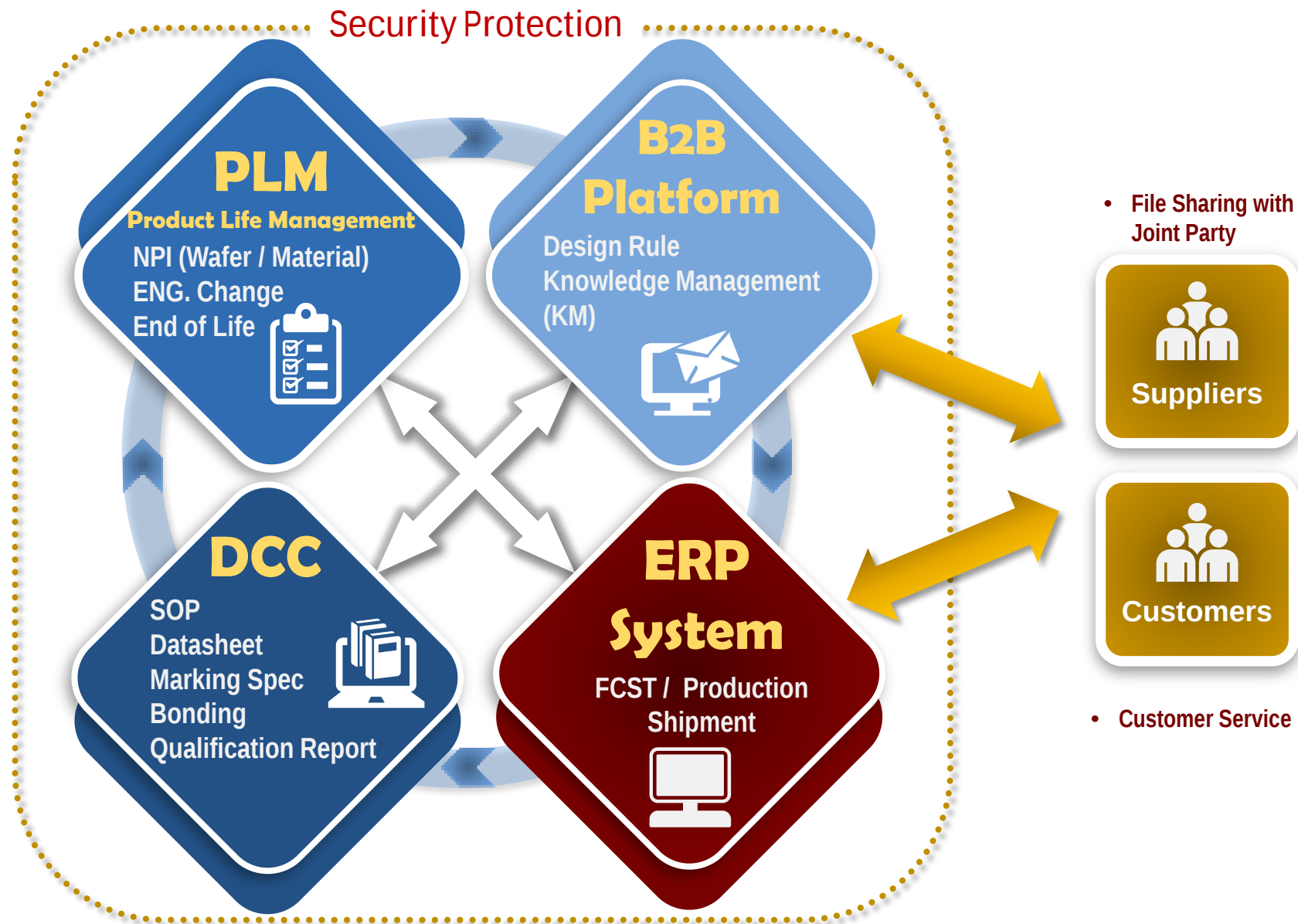
- 立積電子品質政策，品質精益求精、客戶滿意至上。



PDCA 導向的品質管理系統



良好的效率和保護造就品質保證



製程/ 材料/ 封裝藍圖

	2021		2022	
Active-TX	PA	PA	PA	PA
	- GaAs - SiGe	- GaAs - SiGe	- GaAs - SiGe - GaN	- GaAs - SiGe - GaN
Active-RX				
	- GaAs - CMOS/SOI	- GaAs - CMOS/SOI	- CMOS/SOI - GaAs	- CMOS/SOI - GaAs
Passive				
	- IPD - SAW	- IPD - SAW - BAW	- IPD/wafer & Substrate type - SAW - BAW	
Package				
	- QFN / DFN (thin) - LGA + CSP - WLCSP	- QFN / DFN (thin) - LGA + CSP - WLCSP	- QFN / DFN (thin) - LGA + CSP (thin) - AiP/AoP - WLCSP	- QFN / DFN (thin) - LGA + CSP (thin) - AiP/AoP - WLCSP

測試藍圖

2021



NI PXI



NI STS T1



NI STS T4

2022

靈活與相容性

SoC and Wi-Fi 6E/7 (Low EVM noise floor)

Radar Sensors

Industrial, Automotive Certification

新進的測試平台

SG9000, GS I2C, NI STS T4, RedDragon

Low/High temperature characterization

高品質與高效率的 成本競爭力

Dual/Quad-site production



Cohu



ESG - 供應鏈管理

- 近年來除了營收與獲利，立積更注重永續目標，加強三個永續經營的能力，包含環境永續（Environment）、社會責任（Social）與公司治理（Governance）。今年成立了永續專案團隊，由供應商合作小組之品保部門負責監督供應鏈之環保、職業安全衛生及勞動人權等各面向確保符合法規要求並善盡社會責任。2021年針對晶圓、封裝、測試三大供應鏈共23家主要供應商全面進行稽核，稽核涵蓋率達100%，發現完成稽核的供應商皆正向並積極面對接受ESG的挑戰。



Thank you

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2021, 2022年中國運營商標案市場

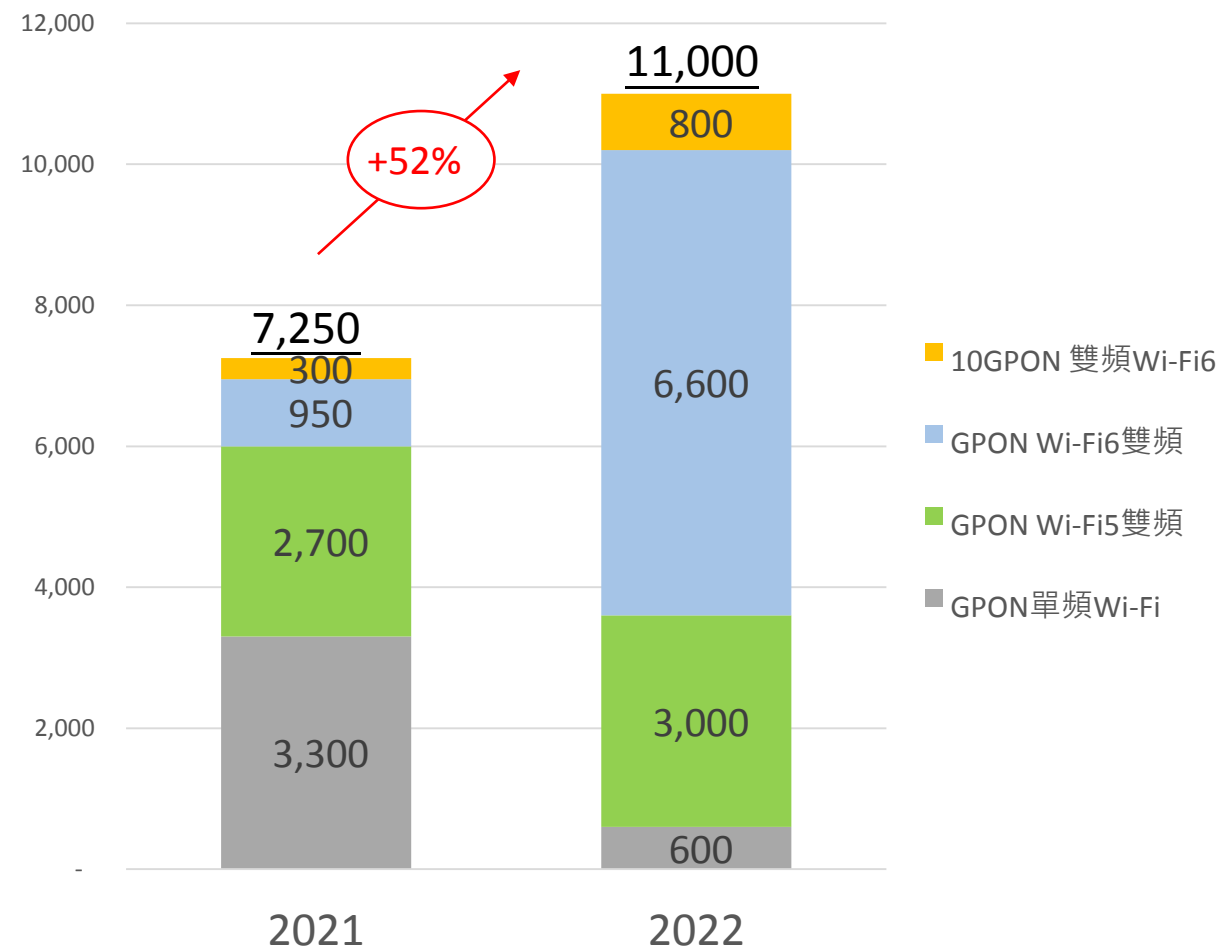
Kick Huang

Dec. 2021

中國網關標案市場

單位: 萬台

規格	2021	2022	YoY
GPON單頻Wi-Fi	3,300	600	-82%
GPON Wi-Fi5雙頻	2,700	3,000	11%
GPON Wi-Fi6雙頻	950	6,600	595%
10GPON 雙頻Wi-Fi6	300	800	167%
Total	7,250	11,000	52%





Thank you

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