

PATENT MONITOR

RF Front-End Modules & Components

Quarterly Report

Q1 2021

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1st QUARTER 2021	8
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Introduction

Main IP players

New patent families

Patent families newly granted

Patents expired or abandoned

MAIN IP PLAYERS OF THE QUARTER	25
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Murata manufacturing

Qualcomm

Skyworks

Oppo Mobile

MAIN IP TRANSFERS OF THE QUARTER	30
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No transfer this quarter

MAIN PATENT LITIGATIONS	32
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No new or closed litigation this quarter

PATENT MONITOR

Take advantage of quarterly updates on IP activities



CONTENTS

Quarterly IP database (Excel file)

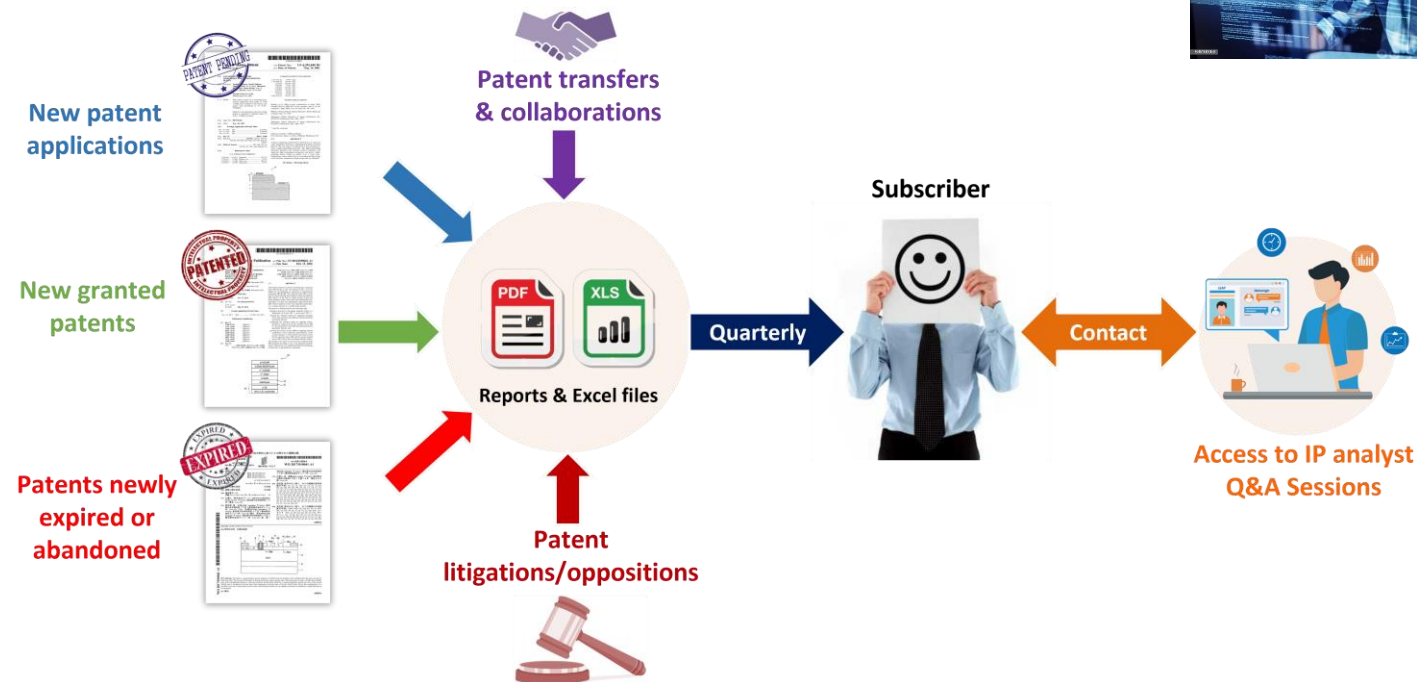
- New patent applications
- Patents newly granted
- Patents expired or abandoned
- Transfer of IP rights (re-assignment, licensing)
- Patent litigation & opposition

Quarterly IP report (PDF slide deck)

On a quarterly basis, this report will provide the IP trends over the last three months, with a close look to key IP players and key patented technologies.

Access to IP analyst (20h a year)

Q&A session and open discussion on the quarterly report results with our analyst in charge of the patent monitoring service.



WHY YOU SHOULD SUBSCRIBE

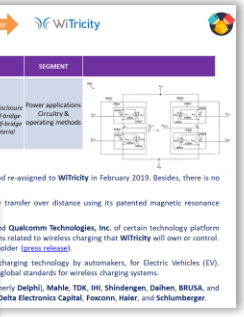
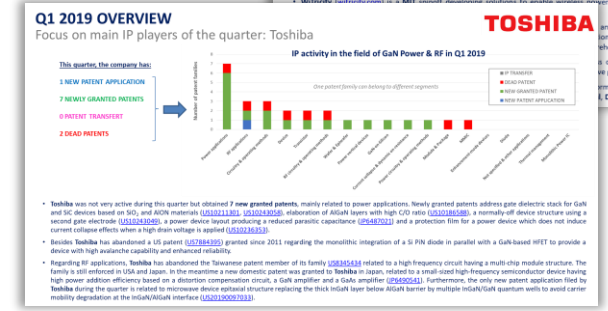
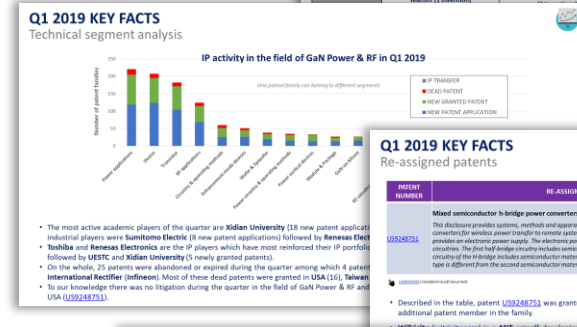
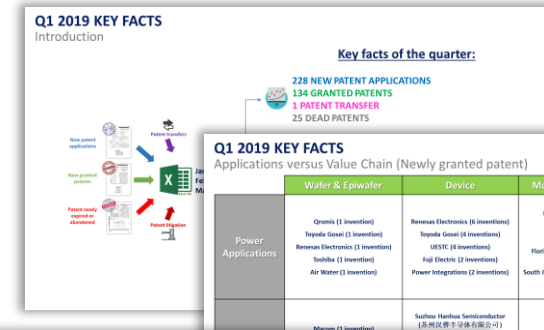
- ✓ Track your **competitors**, partners or clients
- ✓ Identify **newcomers** to your technology field
- ✓ Early detect **opportunities** and risks for your business strategy
- ✓ Be ahead of **technology trends**
- ✓ Identify emerging research areas and **cutting-edge technology** developments
- ✓ Mitigate patent **infringement risks**
- ✓ Take advantage of **free technologies**

QUARTERLY REPORT

Contents

On a quarterly basis, this report will provide the IP trends over the last three months, with a close look to key IP players and key patented technologies.

- Main patent applicants, their notable patent filings and technologies.
- New entrants and their patents.
- Technology trends and notable patented technical solutions.
- Key patents newly granted, their owners and claimed inventions.
- Main IP right transfers (reassignments, licensing agreements).
- Key patents newly expired or abandoned, their owners and their potential market impact.
- Noteworthy news on patent litigation and opposition, plaintiffs and defendants, patents and products involved.



1st Quarter, 2021

(January – February – March)

Q1 2021 OVERVEIW

Introduction

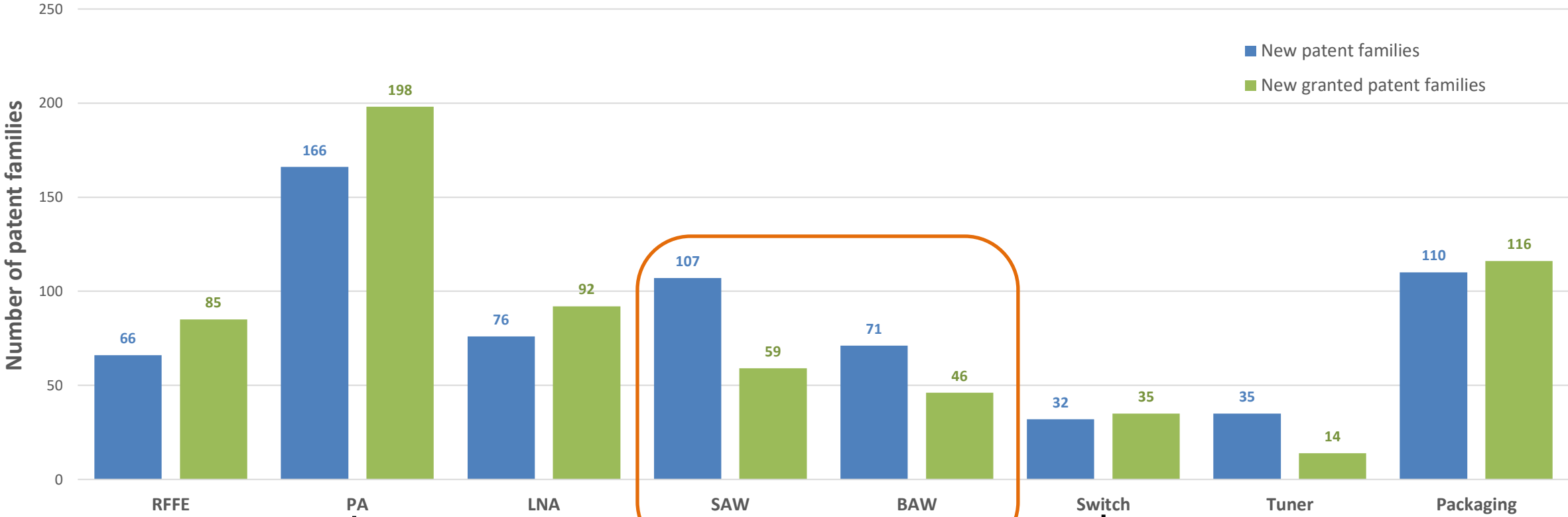
- This report covers patents published/granted/abandoned/expired in **Q1 2021**, from January 2021 to March 2021, and it provides a detailed picture of the **IP activity** related to **RF FE Components**. In that period, Knowmade has selected and analyzed all patents related to acoustic wave filters, PA/LNA, RF Switch, RF Tuner and RF FE modules.
- The data are extracted from the **FamPat worldwide patent database** (Questel-ORBIT) which provides 100+ million patent documents from 100 worldwide patent offices (US, Japan, Europe, China, Korea, Taiwan, etc.).
- The patents are grouped in **patent families**. A patent family is a set of patent applications filed in multiple countries to protect a single invention by a common inventor(s). A first patent application is filed in one country – the priority country – and is then extended to other countries.
- The **selection of relevant patents** is **manually** performed using **keywords analysis** of patent title, abstract and claims, combined with **patent classes** (IPC, CPC), in conjunction with **expert review** of the subject-matter of inventions.
- The patents are **manually categorized in technical/application segments** by manual analysis of each patent title, abstract, descriptions, illustrations and claims, combined with patent classes (IPC, CPC) and in conjunction with expert review of the subject-matter of inventions.

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

	Q1 2021	SEGMENTS							
		RFFE	PA	LNA	SAW	BAW	Switch	Tuner	Packaging
New patent families (inventions)	453	66	166	76	68	15	167	35	110
Patent families newly granted	568	85	198	92	108	71	35	14	116
Patents expired or abandoned	357	44	142	27	99	6	24	8	34

Q1 2021 OVERVIEW

IP activity of the quarter per main RF FE segment



↓
Larger segment with high number of patent applicant

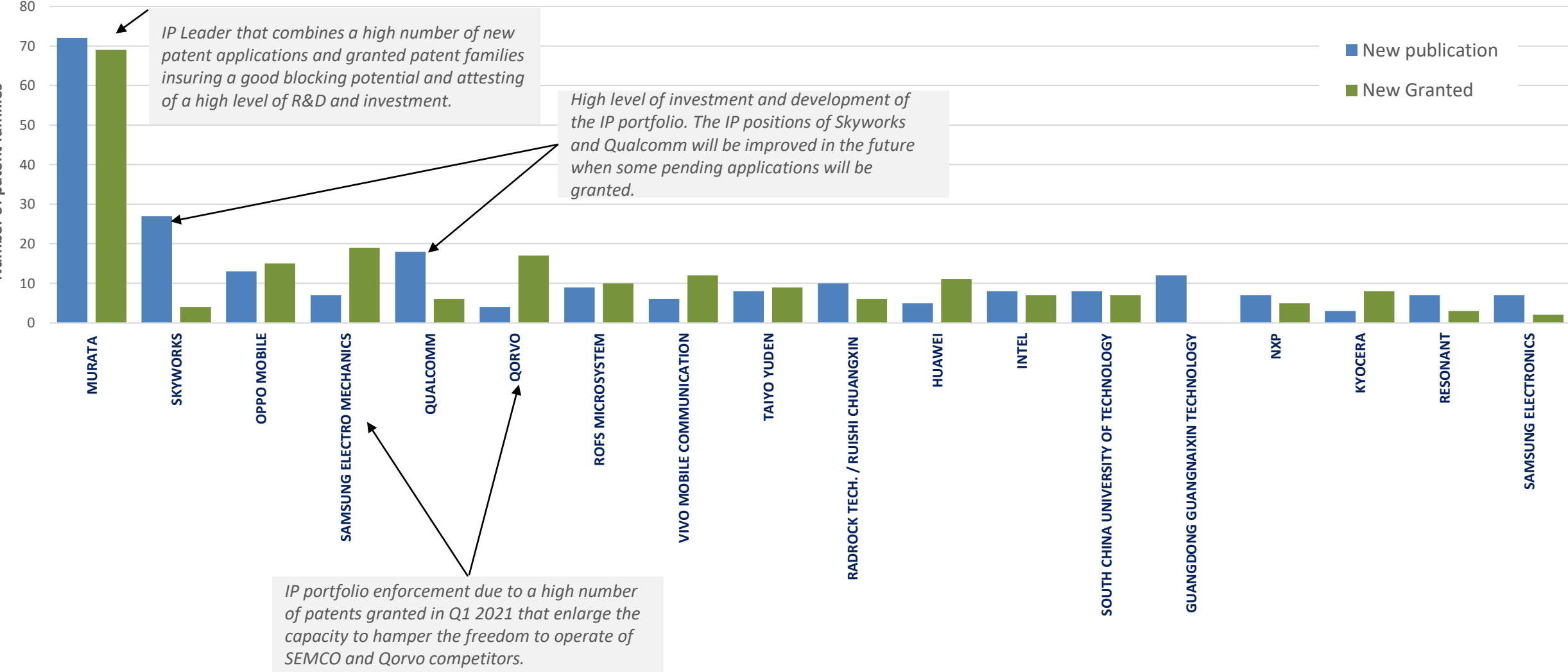
→
Strong patenting activity → enlarging the patent portfolio and more and more competition with the entrance of IP players

↓
Small IP segments mainly driven by Chinese OEM that develop solutions to integrate the antenna in the smartphone case

Q1 2021 OVERVIEW

Most active IP players of the quarter

Most active IP players of Q1 2021 RF FE components IP landscape



Q1 2021 OVERVIEW

Most active IP players of the quarter per RF FE segment

Top IP players

RF FE module

muRata
INNOVATOR IN ELECTRONICS

oppo

锐石创芯
RADROCK

vivo

XIAN KERUI SHENG
INNOVATIVE TECHNOLOGY

HUAWEI

QUALCOMM

SAMSUNG
ELECTRO-MECHANICS

intel

PA / LNA

muRata
INNOVATOR IN ELECTRONICS

SKYWORKS

NXP

QUALCOMM

锐石创芯
RADROCK

oppo

intel

CETC 中国电科

MITSUBISHI

HUAWEI

TOSHIBA

Acoustic Wave Filters

muRata
INNOVATOR IN ELECTRONICS

SKYWORKS

QUALCOMM

SAMSUNG
ELECTRO-MECHANICS

TAIYO YUDEN

RESONANT

KYOCERA

intel

QORVO

Switch / Tuner

oppo

vivo

HUAWEI

muRata
INNOVATOR IN ELECTRONICS

SKYWORKS

锐石创芯
RADROCK

QORVO

NXP

芯谷微电子
HeFei IC Valley Microelectronics

Q1 2021 OVERVIEW

Q1 RF FE module noticeable patents



[USXXXXXXX](#) Clickable link to PDF document

Assignee - Title	Abstract
New pub : Murata - US20210092209 Radio frequency module and communication device	A radio frequency module that simultaneously receives a first reception signal and a second reception signal includes: a module board including a first principal surface and a second principal surface on opposite sides of the module board; a first reception low noise amplifier that is disposed in a first semiconductor IC and amplifies the first reception signal; a second reception low noise amplifier that is disposed in a second semiconductor IC different from the first semiconductor IC and amplifies the second reception signal; and an external-connection terminal that is disposed on the second principal surface. At least one of the first semiconductor IC or the second semiconductor IC is disposed on the second principal surface.
New pub : Murata - US20210092213 Radio frequency module and communication device	A radio frequency module includes: a module board including a first principal surface and a second principal surface on opposite sides of the module board, a transmission input terminal, an antenna connection terminal, and a transmission power amplifier. At least one of one or more first circuit components that are disposed on a transmission input path connecting the transmission input terminal and the transmission power amplifier is mounted on the first principal surface, and at least one of one or more second circuit components that are disposed on a first transmission output path or a second transmission output path each connecting an output terminal of the transmission power amplifier and the antenna connection terminal is mounted on the second principal surface.
New pub : Murata - US20210091796 Radio frequency module and communication device	A radio frequency module includes a module board including a first principal surface and a second principal surface on opposite sides thereof; a transmission power amplifier; a control circuit configured to control the transmission power amplifier; a first transmission filter and a second transmission filter; and a first switch configured to switch connection of an output terminal of the transmission power amplifier between the first transmission filter and the second transmission filter. The control circuit is disposed on the first principal surface, and the first switch is disposed on the second principal surface.
New pub : Vivo Mobile - CN112468179 Radio frequency circuit, electronic device and control method thereof	The embodiment of the application provides a radio frequency circuit, electronic equipment and a control method thereof, wherein the radio frequency circuit comprises: the wireless connection module comprises a wireless connection module, a first front-end channel and a second front-end channel, wherein the first front-end channel comprises a first radio frequency front-end module, and the second front-end channel comprises a second radio frequency front-end module; the wireless connection module is provided with a Bluetooth independent channel interface, a WIFI Bluetooth common channel interface and a WIFI independent channel interface; the WIFI bluetooth common channel interface is connected with the first radio frequency front end module and used for receiving and sending WIFI signals and bluetooth signals through the first front end channel; the WIFI independent channel interface is connected with the second radio frequency front end module and receives and sends WIFI signals through a second front end channel; the Bluetooth independent access interface is connected with the second radio frequency front end module, and under the condition that the power signal on the first front end access exceeds the preset power range, the Bluetooth signal is received and sent through the second front end access, so that the problems of wireless and Bluetooth failure in the mobile terminal are effectively prevented.
New pub : Oppo Mobile - CN212811690 Radio frequency I-DRX device, radio frequency transceiving system and communication equipment	The present application provides a radio frequency L-DRX device, a radio frequency transceiving system and a communication apparatus, wherein the radio frequency L-DRX device is configured with a receiving port and a round-robin port for connecting a radio frequency transceiver and an antenna port for connecting an antenna, and the radio frequency L-DRX device includes: the first switch unit is respectively connected with the antenna port and the wheel transmitting port and used for selectively conducting a receiving passage where the antenna port is located and a transmitting passage where the wheel transmitting port is located; the first filtering unit is arranged in the receiving path or the transmitting path and is used for filtering the received radio frequency signal; the first low-noise amplifier is arranged in the receiving channel, the output end of the first low-noise amplifier is connected with the receiving port, and the first low-noise amplifier is used for amplifying the radio-frequency signals subjected to filtering processing so as to output the radio-frequency signals through the receiving port, so that the area occupied by the substrate can be saved, the integration level can be improved, and the cost can be reduced.
New pub : Radrock Tech. - CN212627891 Radio frequency front-end circuit and wireless device	The utility model discloses a radio frequency front end circuit and wireless device. The radio frequency front-end circuit comprises a radio frequency switch circuit, a power amplifier, a low noise amplifier and at least two frequency band selection inductors; a first signal end of the radio frequency switch circuit is used for being connected with an antenna, and a second signal end of the radio frequency switch circuit is used for being connected with the power amplifier and a first end of each frequency band selection inductor; and the second end of each frequency band selection inductor is connected with the low noise amplifier. The radio frequency front-end circuit can effectively reduce the number of the passing change-over switches, reduce the cost, effectively reduce the loss of radio frequency signals passing through the switches, and avoid the amplified radio frequency signals output by the low-noise amplifier from being greatly attenuated, thereby ensuring the performance of the radio frequency front-end circuit.

Q1 RF FE module noticeable patents

Assignee - Title	Abstract
<p>New Granted : SEMCO - KR10-2211745 Radio frequency pa mid device, radio frequency transceiving system and communication equipment</p>	<p>A front end module according to an embodiment of the present disclosure includes: a first antenna terminal to which a first antenna is connected; a second antenna terminal to which a second antenna is connected; a plurality of first side terminals provided on a first side and a plurality of second side terminals provided on a second side corresponding to the other side of the first side, Wherein each of the plurality of first side terminals comprises: a switch connected with a different one of the first antenna terminal and the second antenna terminal; a first filter connected with the first antenna terminal and having a passband of a first frequency band; A second filter connected with the first antenna terminal and having a passband of a second frequency band; a third filter connected with one of the plurality of second side terminals and having a passband of a third frequency band; and a fourth filter connected with another one of the plurality of second side terminals and having a passband of a third frequency band, A fourth filter having a passband of a fourth frequency band, wherein the third filter and the fourth filter may be connectable with different antenna terminals among the first antenna terminal and the second antenna terminal.</p>
<p>New Granted : Qorvo - US10931033 Multi-polarization millimeter wave (mmwave) transmitter/receiver architecture with shared power amplifiers</p>	<p>A multi-polarization millimeter wave (mmWave) transmitter/receiver (TX/RX) architecture with shared power amplifiers (PAs) is provided. This architecture provides a transceiver which uses shared PAs to reduce the number of TX and PA stages required for multi-polarization transmission in mmWave radio frequency (RF) devices. Embodiments provide an array of switching channels which selectively connect a shared TX and shared PA to two or more antennas in antenna arrays having different polarizations (e.g., a dipole antenna array and a patch antenna array). This approach provides a dual polarization or multi-polarization mmWave transceiver having a reduced number of components which results in a smaller size, improved power efficiency, and improved power heat dissipation.</p>
<p>New Granted : Intel – US10951248 Radio frequency (RF) module with shared inductor</p>	<p>Embodiments may relate to a radio frequency (RF) front-end module (FEM) with a first filter and a second filter. The RF FEM may include a termination inductor coupled to ground, and a switch that is to selectively couple the first filter and the second filter to the termination inductor</p>



Q1 PA / LNA noticeable patents

Assignee - Title	Abstract
New pub. : Qualcomm - US20210067118 Bidirectional variable gain amplification	An apparatus is disclosed for bidirectional variable gain amplification. In an example aspect, an apparatus comprises an antenna element of an antenna array and a wireless transceiver. The wireless transceiver comprises a transmit path coupled to the antenna element, a receive path coupled to the antenna element, and a phase shifter disposed in both the transmit path and the receive path. The phase shifter is configured to operate in an active mode and comprises a first bidirectional variable gain amplifier and a second bidirectional variable gain amplifier.
New pub. : Huawei - WO2021/051232 Power amplifier circuit, transmitter and network device	A power amplifier circuit, a transmitter and a network device. The power amplifier circuit comprises N input ends, N power amplifier branches (11, 12, 13, ..., 1N), a composite circuit (20), and an output end (30). The N input ends are respectively connected each of the N power amplifier branches (11, 12, 13, ..., 1N). Each power amplifier branch is connected to the composite circuit (20). The composite circuit (20) is further connected to the output end (30). Each input end is used for inputting an input signal, the N power amplifier branches (11, 12, 13, ..., 1N) and the composite circuit (20) are used for performing power amplification on the N input signals and generating an output signal, and the output end (30) is used for outputting an output signal, wherein the N power amplifier branches (11, 12, 13, ..., 1N) comprises a first power amplifier branch (11) and N-1 second power amplifier branches (12, 13, ..., 1N); the first power amplifier branch (11) operates in a Class-AB or Class-B working mode, the N-1 second power amplifier branches (12, 13, ..., 1N) operate in a Class-C working mode at different gate bias voltages, the gate bias voltages of the N-1 second power amplifier branches (12, 13, ..., 1N) are decreased sequentially, and N is a positive integer greater than 2. The power amplifier circuit has broad band and high efficiency.
New pub. : Skyworks – US20210083636 Amplifier with tunable impedance circuit	This disclosure describes amplifiers that include impedance circuits that are configured to adapt to various contexts. For example, a variable-gain amplifier can include a gain circuit configured to amplify a signal and to operate in a plurality of gain modes, and an impedance circuit coupled to the gain circuit. The impedance circuit can include an inductor and a switching-capacitive arm coupled in parallel to the inductor. The impedance circuit can be configured to operate based at least in part on a gain mode from among the plurality of gain modes.
New pub. : Murata – US20210067103 Amplifier circuit	An amplifier circuit has an amplification path including an amplifier and a bypass path configured to bypass at least the amplifier. The bypass path includes a switch coupled in series on the bypass path and another switch coupled in series between the bypass path and ground. The amplification path further includes an inductor coupled on an output side with respect to the amplifier and a switch coupled between the inductor and ground on a path between the inductor and the amplifier.
New pub. : Murata – US20210075369 Power amplifier circuit	A power amplifier circuit includes a first path and a second path between an input terminal and an output terminal, a first amplifier located in the first path operative in a first mode, a second amplifier located in the second path operative in a second mode, a first matching circuit between the first amplifier and the output terminal in the first path, a first capacitor having a first end connected to the output terminal side of the first matching circuit, and a second end, a first inductor having a first end connected to the second end of the first capacitor and a second end grounded, and a short-circuit switch connected in parallel with the first inductor. The short-circuit switch short-circuits the first and second ends of the first inductor in the first mode and is placed in an open-circuit position in the second mode.
New pub. : NXP – US20210075374 Compact three-way Doherty amplifier module	Embodiments of a method and a device are disclosed. In an embodiment, a Doherty amplifier module includes a substrate including a mounting surface, and further includes a first amplifier die, a second amplifier die, and a third amplifier die on the mounting surface. The first amplifier die is configured to amplify a first radio frequency (RF) signal along a first signal path, the second amplifier die is configured to amplify a second RF signal along a second signal path, and the third amplifier die is configured to amplify a third RF signal along a third signal path. A side of the first amplifier die including a first output terminal faces a side of the second amplifier die including a second output terminal. The second signal path is parallel to the first signal path, and the third signal path is orthogonal to the first and second signal paths.

Q1 2021 OVERVIEW

Q1 PA / LNA noticeable patents



[USXXXXXXX](#) Clickable link to PDF document

Assignee - Title	Abstract
New Granted : Qualcomm - US10944441 Receiver with broadband low-noise amplifier and filter bypass	A receiver front end is provided with a bypass mode of operation in which a received carrier-aggregated RF signal bypasses a bandpass filter to drive a broadband low-noise amplifier. The low-noise amplifier amplifies the carrier-aggregated RF signal to form an amplified RF signal.
New Granted : Qualcomm - US10965261 Power amplifier circuit	The present disclosure provides an amplifier circuit that includes one or more amplifier stages, each of the one or more amplifier stages including a complementary transistor configuration. The complementary transistor configuration includes an NMOS transistor (436) and a PMOS transistor (440). The NMOS transistor (436) is electrically coupled in parallel to the PMOS transistor (440). The amplifier circuit further includes an output amplifier stage electrically coupled to an output of the one or more amplifier stages, the output amplifier stage including a non-complementary transistor configuration including one or more NMOS transistors (452) or PMOS transistors.
New Granted : Murata - US10951252 5G NR configurable wideband RF front-end LNA	Methods and devices addressing design of reconfigurable wideband LNAs to meet stringent gain, noise figure, and linearity requirements with multiple gain modes are disclosed. The disclosed teachings can be used to reconfigure RF receiver front-end to operate in various applications imposing stringent and conflicting requirements, such as 5G NR radios. Wideband and narrowband input and output matching with gain modes using a combination of the same hardware and a switching network are also disclosed.
New Granted : NXP – US10903182 Amplifier die bond pad design and amplifier die arrangement for compact Doherty amplifier modules	Embodiments of a method and device are disclosed. In an embodiment, a Doherty amplifier module includes a substrate including a mounting surface, and a carrier amplifier die, a first peaking amplifier die, and a second peaking amplifier die on the mounting surface. The carrier amplifier die includes a first output bond pad that has a first length and a first width. The first peaking amplifier die includes a second output bond pad including a first main pad portion having a second length and a second width and including a first side pad portion having a third length and a third width. At least one of the second width or the third width is greater than the first width. The second peaking amplifier includes a third output bond pad. A first wirebond array is coupled between the third output bond pad and at least the first side pad portion.
New Granted : Skyworks - US10972055 Integrated Doherty power amplifier	Integrated Doherty power amplifiers are provided herein. In certain implementations, a Doherty power amplifier includes a carrier amplification stage that generates a carrier signal, a peaking amplification stage that generates a peaking signal, and an antenna structure that combines the carrier signal and the peaking signal. The antenna structure radiates a transmit wave in which the carrier signal and the peaking signal are combined with a phase shift.
New Granted : IC Valley Microelectronics - CN212463155 0.8-2ghz broadband low noise amplifier	The utility model relates to the technical field of low noise amplifiers, in particular to a 0.8-2GHz broadband low noise amplifier, which comprises a two-stage amplifier, wherein a device adopts a single power supply to supply power, and a drain electrode of a first-stage triode is connected with a grid electrode of a second-stage triode through a blocking capacitor and a matching circuit; RLC negative feedback is added to the first-stage grid drain; the grid width of the second-stage triode is twice that of the first-stage triode. The utility model discloses circuit structure is simple, has rationally selected the size of triode, and operating condition has optimized matching circuit, compares with traditional low noise amplifier, and this structure has the bandwidth width, and the standing wave is low, and the noise is low and advantages such as power height.

Q1 2021 OVERVIEW



[USXXXXXXX](#) Clickable link to PDF document

Q1 Acoustic wave filters noticeable patents

Assignee - Title	Abstract
New pub. : Broadcom - US20210099155 Acoustic resonator device	The present disclosure provides an acoustic resonator device, among other things. One example of the disclosed acoustic resonator device includes a substrate having a carrier layer, a first layer disposed over the carrier layer, and a piezoelectric layer disposed over the first layer. The acoustic resonator device is also disclosed to include an interdigitated metal disposed over the piezoelectric layer, where the interdigitated metal is configured to generate acoustic waves within an acoustically active region. The acoustic resonator device is further disclosed to include an acoustic wave scattering structure.
New pub. : Skyworks - US20210058057 Multilayer piezoelectric substrate	A surface acoustic wave (SAW) resonator comprises a plurality of interdigital transducer electrodes disposed on a multilayer piezoelectric substrate (MPS) including a layer of piezoelectric material having a lower surface bonded to an upper surface of a layer of a second material different from the piezoelectric material that improves the temperature stability and reliability of the SAW resonator, and a layer of dielectric material disposed on an upper surface of the interdigital transducer electrodes and MPS.
New pub. : Skyworks - US20210067136 Suppression of transverse mode spurious signals in surface acoustic wave devices utilizing a gap hammer structure	An acoustic wave device comprises a substrate including a piezoelectric material, and interdigital transducer (IDT) electrodes disposed on a surface of the substrate. The IDT electrodes have gap regions, edge regions, and center regions. A maximum width of the IDT electrodes in the gap regions is greater than the maximum width of the IDT electrodes in the edge regions, thereby achieving a velocity of an acoustic wave in the gap regions being greater than the velocity of the acoustic wave in the center regions, and the velocity of the acoustic wave in the center regions being greater than the velocity of the acoustic wave in the edge regions.
New pub. : Skyworks - US20210075400 Harmonic suppression in bulk acoustic wave duplexer	Harmonic suppression in bulk acoustic wave duplexer. In some embodiments, a filter circuit can include an input node and an output node, and a first assembly having one or more bulk acoustic wave (BAW) resonators implemented electrically between the input node and the output node, and configured to filter a signal. The filter circuit can further include a second assembly having one or more surface acoustic wave (SAW) resonators implemented electrically relative to the first assembly, and configured to suppress one or more harmonics resulting from the filtering of the signal by the first assembly.
New pub. : Skyworks - US20210083643 Gradient raised frames in film bulk acoustic resonators	Gradient raised frames in film bulk acoustic resonators. In some embodiments, a film bulk acoustic resonator device can include a substrate, first and second metal layers implemented over the substrate, a piezoelectric layer between the first and second metal layers, and a gradient raised frame implemented relative to one of the first and second metal layers and configured to improve reflection of lateral mode waves and to reduce conversion of main mode waves into lateral mode waves.
New pub. : Qorvo - US20210079515 Piezoelectric bulk layers with tilted c-axis orientation and methods for making the same	A structure includes a substrate including a wafer or a portion thereof; and a piezoelectric bulk material layer comprising a first portion deposited onto the substrate and a second portion deposited onto the first portion, the second portion comprising an outer surface having a surface roughness (Ra) of 4.5 nm or less. Methods for depositing a piezoelectric bulk material layer include depositing a first portion of bulk layer material at a first incidence angle to achieve a predetermined c-axis tilt, and depositing a second portion of the bulk material layer onto the first portion at a second incidence angle that is smaller than the first incidence angle. The second portion has a second c-axis tilt that substantially aligns with the first c-axis tilt.
New pub. : SEMCO - US20210075398 Bulk-acoustic wave resonator	A bulk-acoustic wave resonator includes: a resonator comprising a central portion in which a first electrode, a piezoelectric layer, and a second electrode are sequentially stacked on a substrate, and an extension portion disposed along a periphery of the central portion; and an insertion layer disposed below the piezoelectric layer in the extension portion to raise the piezoelectric layer. The insertion layer may have a first inclined surface formed along a side surface facing the central portion, and the first electrode may have a second inclined surface extending from a lower end of the first inclined surface of the insertion layer.



Q1 Acoustic wave filters noticeable patents

Assignee - Title	Abstract
New Granted : SEMCO - US10958239 Bulk acoustic wave resonator	A bulk acoustic wave resonator includes: support members disposed between air cavities; a resonant part including a first electrode, a piezoelectric layer, and a second electrode sequentially disposed above the air cavities and on the support members; and a wiring electrode connected either one or both of the first electrode and the second electrode, and disposed above one of the air cavities, wherein a width of an upper surface of the support members is greater than a width of a lower surface of the support members, and side surfaces of the support members connecting the upper surface and the lower surface to each other are inclined.
New Granted : Qualcomm - US10944379 Hybrid passive-on-glass (PoG) acoustic filter	An integrated radio frequency (RF) circuit combines complementary features of passive devices and acoustic filters and includes a first die, a second die, and a third die. The first die includes a substrate having one or more passive devices. The second die includes a first acoustic filter. The second die is stacked and coupled to a first surface of the first die. The third die includes a second acoustic filter. The third die is stacked and coupled to a second surface opposite the first surface of the first die.
New Granted : Murata - US10924080 Elastic wave device, high-frequency front end circuit, and communication device	An acoustic wave device includes a supporting substrate, an acoustic reflection film the supporting substrate, a piezoelectric thin film on the acoustic reflection film, and an interdigital transducer electrode the piezoelectric thin film. The acoustic reflection film includes acoustic impedance layers including therein first, second, third, and fourth low acoustic impedance layers and first, second, and third high acoustic impedance layers. The acoustic reflection film includes a first acoustic impedance layer and a second acoustic impedance layer, the first and second acoustic impedance layers each being one of the acoustic impedance layers, and the second acoustic impedance layer has an arithmetic average roughness different from that of the first acoustic impedance layer.
New Granted : Qorvo - US10931257 WLP BAW device with through-SLP vias	The present disclosure relates to a wafer-level packaged (WLP) bulk acoustic wave (BAW) device, which includes a BAW resonator, a WLP enclosure, and an interconnect. The BAW resonator includes a piezoelectric layer with an opening, a bottom electrode lead underneath the opening, and an interface structure extending over the opening and in contact with the bottom electrode lead through the opening. The WLP enclosure includes a cap, an outer wall that extends from the cap toward the piezoelectric layer to form a cavity, and a through-WLP via that extends through the cap and the outer wall and is vertically aligned with the opening of the piezoelectric layer. A portion of the interface structure is exposed to the through-WLP via. The interconnect is formed in the through-WLP via and electrically connected to the interface structure.
New Granted : Taiyo Yuden - US10938371 Acoustic wave resonator, filter, and multiplexer	An acoustic wave resonator includes: an IDT located on a piezoelectric substrate, including comb-shaped electrodes facing each other and including electrode fingers and a bus bar connecting the electrode fingers; a first silicon oxide film located on the electrode fingers in an overlap region where the electrode fingers overlap and having a film thickness in a part of edge regions, which correspond to both ends of the overlap region, equal to or less than that in a center region sandwiched between the edge regions; and a second silicon oxide film located on the electrode fingers, containing an element slowing an acoustic velocity in a silicon oxide film when being added to the silicon oxide film, having a concentration of the element greater than that in the first silicon oxide film, and having a film thickness in a part of the edge regions greater than that in the center region.
New Granted : Skyworks - US10931253 Hybrid acoustic IC filter cascaded with IC filter	Aspects of this disclosure relate to a cascaded filter circuit that includes a hybrid acoustic LC filter, a non-acoustic LC filter, and a switch configured to selectively couple the hybrid acoustic LC filter and the non-acoustic LC filter. The hybrid acoustic filter can filter a radio frequency signal. The hybrid acoustic LC filter can include an acoustic resonator, an inductor, and a capacitor. The non-acoustic LC filter includes an LC circuit. Related multiplexers, wireless communication devices, and methods are disclosed.



Q1 RF Switch / Tuner noticeable patents

Assignee - Title	Abstract
New pub. : Skyworks - US20210091808 RF signal switch	Systems and methods are provided herein that include an improved RF switch assembly. In at least one embodiment, the RF switch assembly may have an optimized topology including a common node shared by each signal path, reducing the size and cost of the RF switch assembly and providing improved performance.
New pub. : Skyworks - US20210075462 Fast antenna switching	Circuits, devices, and methods related to setting a drive power of a power amplifier to a first power level, switching an input of the power amplifier to an isolation state, switching an antenna selection state of an antenna network, and switching the input of the power amplifier to an active state.
New pub. : Murata - US20210075420 Single supply RF switch driver	A single supply RF switch driver. The single supply RF switch driver includes an inverter, where a first resistor has been integrated within the inverter, and the resistor is connected to an RF switch. In one aspect, the integration of the first resistor within the inverter allows for the elimination of a negative power supply for the inverter, while maximizing the isolation achieved in the RF switch. In another aspect, the driver is configured to have a second resistor integrated within the inverter. A third resistor is connected between the gate of the RF switch and the inverter. In an alternate aspect, the driver operates from a positive power supply and a negative power supply, thus increasing the isolation in the RF switch even further.
New pub. : Radrock Tech. – CN112235013 Radio frequency switch circuit, radio frequency front-end circuit and wireless device	The invention discloses a radio frequency switch circuit, a radio frequency front-end circuit and a wireless device. The radio frequency switch circuit is used for being connected with a radio frequency power amplifier and a radio frequency antenna, and comprises a first series radio frequency switch, a second series radio frequency switch, a third series radio frequency switch, a first parallel radio frequency switch and a second parallel radio frequency switch. The first series radio frequency switch, the second series radio frequency switch and the third series radio frequency switch are arranged between the radio frequency power amplifier and the radio frequency antenna in series; one end of the first parallel radio frequency switch is connected with a connection node between the first series radio frequency switch and the second series radio frequency switch, and the other end is connected with a grounding end; one end of the second parallel radio frequency switch is connected with a connection node between the second series radio frequency switch and the third series radio frequency switch, and the other end is connected with a grounding end. The radio frequency switch circuit can reduce the introduced insertion loss and improve the isolation between different transmitting paths while ensuring that the radio frequency switch circuit can bear enough high voltage/power.
New pub. : Oppo Mobile CN112532274 Radio frequency switch assembly and control method thereof, radio frequency test equipment and system thereof	The embodiment of the application relates to a radio frequency switch assembly and a control method thereof, radio frequency test equipment and a system thereof, wherein the control method of the radio frequency switch assembly comprises the following steps: receiving a control instruction input from the outside; switching the closed state of the paths of the first switch and the second switch according to a control instruction, wherein the radio frequency switch assembly comprises a plurality of first switches and a plurality of second switches, the first end of each first switch is respectively used for being correspondingly connected with one radio frequency point to be tested, the first end of each second switch is respectively used for being correspondingly connected with one test port, and the second ends of each first switch are respectively correspondingly connected with one second end of each second switch one by one; and acquiring the switched on-state information of the radio frequency switch assembly, and when the on-state information is not matched with the control instruction, continuously executing the step of receiving the externally input control instruction. Based on the special radio frequency switch assembly and the control method thereof, the radio frequency test process of the radio frequency equipment can be greatly simplified, and the test efficiency is improved.
New Granted : NXP - US10972091 Radio frequency switches with voltage equalization	Embodiments described herein include radio frequency (RF) switches that may provide increased power handling capability. In general, the embodiments described herein can provide this increased power handling by equalizing the voltages across transistors when the RF switch is open. Specifically, the embodiments described herein can be implemented to equalize the source-drain voltages across each field effect transistor (FET) in a FET stack that occurs when the RF switch is open and not conducting current. This equalization can be provided by using one or more compensation circuits to couple one or more gates and transistor bodies in the FET stack in a way that at least partially compensates for the effects of parasitic leakage currents in the FET stack.



Q1 RF Switch / Tuner noticeable patents

Assignee - Title	Abstract
<p>New Granted : IC Valley Microelectronics - CN212305286 Dc-40ghz broadband pin single-pole double-throw switch</p>	<p>The utility model discloses a DC40GHz broadband PIN single-pole three-throw switch comprising a radio frequency input common signal end which is connected with a series diode and is used for transmitting an RF radio frequency signal to a circuit; the three radio frequency output signal ends are respectively connected with the series diode and the parallel diode and are used for receiving the output radio frequency signals; the serial diode and the parallel diode are used for conducting an RF radio frequency signal sent by the radio frequency input common signal end to the radio frequency output signal end or conducting the RF radio frequency signal to the ground; according to the single-pole three-throw power supply, the effect of single-pole three-throw can be achieved, a structure combining series connection and parallel connection is selected, the insertion loss is low, the power capacity and the isolation degree are high, the multi-tube series connection diode and the multi-tube parallel connection diode adopt the same direct current bias, and the single-pole three-throw power supply is high in reliability and high in reliability. Saving the power of a switch.</p>
<p>New Granted : Qorvo - US10930456 Microelectromechanical systems switch die</p>	<p>A microelectromechanical systems (MEMS) switch die having an N number of radio frequency (RF) MEMS switches, each having an anchored beam with a switch contact, a gate, and a terminal contact is disclosed. Also included is a MEMS-based decoder having logic gates comprised of logic MEMS switches that are configured to decode the coded signals to determine which of the N number of RF MEMS switches to open and close, apply a higher level gate voltage to each gate of the RF MEMS switches determined to be closed, wherein the higher gate voltage electrostatically pulls the anchored beam and brings the switch contact into electrical contact with the terminal contact, and apply a lower gate voltage to each gate of the RF MEMS switches to be opened, wherein the lower gate voltage releases the anchored beam and allows the switch contact to break electrical contact with the terminal contact.</p>
<p>New Granted : Qorvo - US10897246 Radio frequency switching circuitry with reduced switching time</p>	<p>RF switching circuitry includes a plurality of FETs coupled between an input node, an output node, and a gate drive node. When a positive power supply voltage is provided at the gate drive node, the plurality of FETs turn on and provide a low impedance path between the input node and the output node. When a negative power supply voltage is provided at the gate drive node, the plurality of FETs turn off and provide a high impedance path between the input node and the output node. Switch acceleration circuitry in the RF switching circuitry includes a bypass FET and multi-level driver circuitry. The bypass FET selectively bypasses the common resistor in response to a multi-level drive signal. The multi-level driver circuitry uses a built-in gate to capacitance of the bypass FET to provide the multi-level drive signal at an overvoltage that is above the positive power supply voltage.</p>
<p>New Granted : SEMCO - US10903836 Radio-frequency switch with voltage equalization</p>	<p>A radio-frequency switch includes a first series switch including a plurality of series field-effect transistors (FETs) connected in series between a first terminal and a second terminal, a first shunt switch including a plurality of shunt FETs connected in series between the first terminal and a first ground terminal, and a first shunt gate resistor circuit including a plurality of gate resistors respectively connected to gates of the plurality of shunt FETs of the first shunt switch. Respective resistance values of the plurality of gate resistors of the first shunt gate resistor circuit successively increase in a direction away from the first ground terminal toward the first terminal.</p>
<p>New Granted : Murata / Psemi - US10886911 Stacked FET switch bias ladders</p>	<p>A positive-logic FET switch stack that does not require a negative bias voltage, exhibits high isolation and low insertion/mismatch loss, and may withstand high RF voltages. Embodiments include a FET stack comprising series-coupled positive-logic FETs (i.e., FETs not requiring a negative voltage supply to turn OFF), series-coupled on at least one end by an "end-cap" FET of a type that turns OFF when its VGS is zero volts. The one or more end-cap FETs provide a selectable capacitive DC blocking function or a resistive signal path. Embodiments include a stack of FETs of only the zero VGS type, or a mix of positive-logic and zero VGS type FETs with end-cap FETs of the zero VGS type. Some embodiments withstand high RF voltages by including combinations of series or parallel coupled resistor ladders for the FET gate resistors, drain-source resistors, body charge control resistors, and one or more AC coupling modules.</p>
<p>New Granted : Oppo Mobile - US10924139 Radio frequency circuit and electronic device</p>	<p>A radio frequency circuit includes: a first, second, and third switch, a first and second phaser circuit, and a combiner. When the first switch is configured to connect the first phase shifter circuit with the combiner and the second switch is configured to connect the second phase shifter circuit with the combiner, a transmission path for the high-frequency RF signal is cut off relative to the medium-frequency RF signal and a transmission path for the medium-frequency RF signal is cut off relative to the high-frequency RF signal, so as to perform CA of the high-frequency and medium-frequency RF signal to obtain a first aggregation signal, and the combiner performs CA on the first aggregation signal and a low-frequency signal.</p>

Q1 2021 OVERVIEW

New patent families

Assignee	Number of patent families	RFFE	PA	LNA	SAW	BAW	Switch	Tuner	Packaging
MURATA	72	36	13	23	20		1		10
SKYWORKS SOLUTIONS	27		7	2	8	4	4	1	9
QUALCOMM	18	2	4	1	7	2			7
OPPO MOBILE	13	10		7			5	2	11
GUANGDONG GUANGNAIXIN TECHNOLOGY	12				11				
RUI SHI CHUANGXIN / RADROCK TECH	10	5	5	2			3		1
ROFS MICROSYSTEM	9					9			2
SOUTH CHINA UNIVERSITY OF TECHNOLOGY	8	1	2	2		4			
TAIYO YUDEN	8	1	1		3				1
INTEL	8	2	2	1	1		1		10
RESONANT	7				7				1
SAMSUNG ELECTRONICS	7	1	3	1	2		1		2
SAMSUNG ELECTRO MECHANICS	7					7			
NXP	7		6				1		7
CHENGDU FREQUENCY ELECTRONICS	6				5				
VIVO MOBILE COMMUNICATION	6	2					3	1	
FUMAN MICROELECTRONICS GROUP	6		3	3					1
WUHAN UNIVERSITY	5					4			1
CHINA ELECTRONICS TECHNOLOGY	5	1	4		2	1			5
SUMITOMO CHEMICAL	5				5				
HUAWEI	5	2	3				1		2
XI AN KERUI SHENG INNOVATIVE TECHNOLOGY	5	4	1	2					
GUANGZHOU HUIZHI MICROELECTRONIC	5		4	1					
XI AN BORUI JIXIN ELECTRONIC TECHNOLOGY	5		2	3					
QORVO	4		1	1		2			

Q1 2021 OVERVIEW

New patent families

- In Q1 2021, **Murata** is the IP player that has been the most active. With more than **70 new published inventions**, the company has well enlarged its portfolio related to RF FE. Furthermore, **Murata** activity covers **all key RF FE components but tuner and switches**. Especially, the company filed new patent applications related to **RF FE modules**. This quarter confirms the company strategy to focus their development on **integration**. Indeed, the challenge addressed in **Murata** patents are related to transceiver circuits with high isolation from two antennas while being compatible with miniaturization.
- Other active players are **Skyworks** and **Qualcomm** that are Murata direct competitors. Contrary to Murata these two companies recent patenting activities are related to **devices**, e.g. **PA** and **Acoustic Wave Filters**, rather than RF FE modules. **Skyworks** and **Qualcomm** patenting activities related to acoustic wave filters are also very noticeable this quarter. Indeed, in addition to their high patenting activity (around 15 new published inventions) both companies have well enlarged their patent portfolio with new technologies. On one hand **Skyworks**, the main activity is related to the publication of 4 new patent families related to **BAW filters**. Such IP position is quite unusual for **Skyworks** which used to be a SAW pure player. On the other hand, **Qualcomm** (through RF 360 patenting activity) has enlarged its portfolio related to **thin film SAW**. The goal being to reach higher frequencies and operate in the 5G frequency range.
- This quarter the most noticeable activities were related to acoustic wave filters. Players like **Qorvo**, **Intel**, **SEMCO**, **Taiyo Yuden** or **Resonant** have enlarged their portfolio as well as numerous **Chinese IP players such as ROFS Microsystems, Ruishi Chuangxin / RADROCK TECH. (锐石创芯(深圳)科技有限公司) and Guangdong Guangnaixin Technology**. Such strong activity from Chinese players is not surprising but continue to attest of the strong R&D and IP efforts made to compete against well established US, Japanese and European players.
- Aside acoustic wave filters, the patenting activity is mainly related to **Power Amplifiers**. The high number of new published patent families is mainly due to the patenting activity of many different assignees.
- **Murata** and **Oppo Mobile** drive the IP activity related to **RF FE modules**. Contrary to Murata that has a strong activity related to all RF FE components, the Chinese OEM patenting activity is quite singular as it is mainly related to **RF FE module and switch** which are smaller segments of the RF FE IP landscape. **Oppo mobile** activity aims at providing module with better integration capacity thanks to the development of Pa mid or RF FE modules that include multiplexer in a single package.

Q1 2021 OVERVIEW

New granted patent families

Assignee	Number of patent families	RFFE	PA	LNA	SAW	BAW	Switch	Tuner	Packaging
MURATA	69	29	17	4	26	4	3		14
SAMSUNG ELECTRO MECHANICS	19	3	5			9	1		3
QORVO	17	1	4	1	5	2	3		3
OPPO MOBILE	15	7					11		10
VIVO MOBILE COMMUNICATION	12	6		1			5	2	2
HUAWEI	11	2	4			1	4	1	2
ROFS MICROSYSTEM	10				1	9			2
TAIYO YUDEN	9		1		3				
KYOCERA	8				7				
SOUTH CHINA UNIVERSITY OF TECHNOLOGY	7		4		1	2			2
INTEL	7	1	6	1		1	1	1	10
QUALCOMM	6	1	4	1	1	1			3
MITSUBISHI ELECTRIC	6		6						3
RUISHI CHUANGXIN / RADROCK TECH	6	3	3						
HEFEI IC VALLEY MICROELECTRONICS	5		1	1			3		
NXP	5		3				2		2
SHANGHAI SHENG JIA ELECTRONIC TECHNOLOGY	4		1		2	3			
SKYWORKS SOLUTIONS	4		2	1					3
CHENGDU GANIDE TECHNOLOGY	4		2	2					
ANALOG DEVICES	4		2	2			1		2
TOSHIBA	4		4						
ERICSSON	4		4						1
HANGZHOU DIANZI UNIVERSITY	4		4						2



New granted patent families

- In Q1 2021 **Murata** is the player that has **strengthened its IP position** the most. The company has especially enlarged the gap with its competitors on the **Acoustic Wave Filters** and **RF FE modules** segments. With **69 family newly granted** in the quarter, the company has increased its capacity to limit the freedom to operate of its competitors involved in the **SAW** and **RF FE modules**. Indeed, **Kyocera** is the second IP player with the most granted patents related to **SAW** this quarter. However, with 8 granted inventions, **Kyocera** is far from competing against Murata. Same trend is visible for the **RF FEM** as **Oppo Mobile** and **Vivo Mobile** have only 6 and 7 new granted patent families.
- Most of the **newly granted patents** are related to **power amplifier**. However, the number of newly granted patents is well balanced between players. Indeed, aside **Murata** that has more than 15 new granted inventions related to PA, all other players have around 5 new granted inventions. This is the case for major IP players such as **Qorvo**, **NXP**, **SEMCO**, **Qualcomm**, **Intel** or **Mitsubishi**. More than 50% of the patents granted in Q1 2021 are filed in China attesting of the current strong activity of Chinese players.
- In addition to its high recent patenting activity **Oppo Mobile** has also well strengthened its IP portfolio related to RF FE and related component. The company patents remain related to **integration** as most of its newly granted patents are related to RF FE. In addition, the company has 4 new granted patents related to **PAMID** devices that allow to improve the integration level while reducing the cost ([CN21258832](#), [CN212588326](#), [CN212811690](#)). The company also leads the Switching segment with 11 newly granted patents that describe switch with improved performances for carrier aggregation.
- **BAW is the most competitive segment** of the acoustic wave filter. Indeed, **Murata** is by far the leader of the **SAW** segments while **SEMCO** and **ROFS Microsystem** have around 10 new granted inventions. **ROFS** patents describing **structural improvement of FBAR** as well as multiplexers. The structural improvements include bottom electrode with 2 metal layers or including a gap as well as packaging. **SEMCO** patents also provide solutions to **improve the BAW structure**. Electrodes made of Al with Sc and piezoelectric layers with inclined surface are among the solutions described.

Expired or Abandoned patents

Assignee	Number of Dead patents	RFFE	PA	LNA	SAW	BAW	Switch	Tuner	Packaging
MURATA MANUFACTURING	67	10	2		54				16
BROADCOM	20	3	8	4		5	1		1
QUALCOMM	20	2	4	2	6		4		2
NXP	17		16				1		
PANASONIC	11		5		5		1		1
TDK EPCOS	13	2			11				4
SKYWORKS	10		8		2				1
FUJITSU	8		6		2				
RENESAS ELECTRONICS	7		7						
ERICSSON	6		6						
SEIKO EPSON	6	1	2		3				
CLARISAY	5				4				3
SAMSUNG ELECTRONICS	5		2	2	1				1
APPLE	5	2					2	1	
NOKIA	4		1		1	1		1	
CIRRUS LOGIC	4		4						
IBM	4		4						

Broadcom is the player that has lost the most capacity to hamper the freedom of operate of its competitor this quarter. Indeed, even if **Murata** and **Qualcomm** have seen 67 and 20 of their patent expired this quarter, they compensate it with a strong patenting activity and a good number of newly granted patents. Patent [US7471941](#) being the most valuable patent that has expired. Furthermore, its 4 patents related to BAW filters were among the most cited patents with a high capacity to hamper the FTO of other IP players.

Murata and **Qualcomm** have also lost numerous patents this quarter. Especially 54 Murata patents related to SAW have expired. Patents [US6720842](#), [JP3435640](#)* and [JP2002290205](#) / [JP3534080](#)* are among the most valuable that has been lost by the company.

NXP has abandoned 7 patents related to power amplifier this quarter and 3 have expired.

* The entire patent families will shortly expire as all member will be dead July 2021 and March 2022

Focus on main IP players of the quarter



	Q1 2021	SEGMENTS							
		RFFE	PA	LNA	SAW	BAW	Switch	Tuner	Packaging
New patent families (inventions)	72	36	13	23	20		1		10
Patent families newly granted	69	29	17	4	26	4	3		14
Patents expired or abandoned	67	10	2		54				16

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

- In Q1 2021, **Murata** has increased its IP leadership and blocking potential thanks to a high patenting activity in all segment of the RF FE. Indeed, the company patenting activity focuses on integration challenges (isolation, insertion loss) which explain its transversal patenting activity.
- The company focuses on **high frequency modules** in which the **losses** that may occurs in the wiring and transmission paths ([DE202020107047](#), [JP2021013055](#), [US20210091798](#), [US20210091801](#)). **Murata** patents related to RF FEM describe module with **reduced size** ([WO2021/044691](#)), and **good isolation** ([WO2021/039068](#), [WO2021/039067](#), [US20210091800](#)) .
- **Murata** patents related to **packaging** provide an **elastic wave filter** which can suppress separation of a cover member from support members (peeling) ([US20210013867](#)). The device include a support member with an inclined portion such that a width of the support member becomes narrower toward the end surface and the cover member extends from the second end surface of the support member to the inclined portion of the inner side surface ([WO2021/006156](#), [WO2021/006157](#)).
- **Murata** keeps enlarging its portfolio related to **thin film SAW**. In some inventions, the layers having different acoustic velocities are below the IDT ([US20190386639](#), [WO2019/111664](#), [WO2019/003909](#)). In others, **Murata** provides structures in which a **silicon oxide film provided on the piezoelectric substrate** so as to cover the IDT electrode ([US20190288664](#)).



	Q1 2021	SEGMENTS							
		RFFE	PA	LNA	SAW	BAW	Switch	Tuner	Packaging
New patent families (inventions)	18	2	4	1	7	2			7
Patent families newly granted	6	1	4	1	1	1			3
Patents expired or abandoned	20	2	4	2	6		4		2

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

- In Q1 2021, **Qualcomm** patenting activity is mainly focused on **SAW filter**. As usual, the IP is done by RF 360 and has a worldwide geographic coverage. Aside acoustic wave filter activity, the company has continued to enlarge and strengthen its patent portfolio related to **PA** as well as **RF FE modules**. However, the company level of IP activity is balanced by the **high number of dead patents**. In addition, **Qualcomm** has a quite small number of newly granted patent families.
- This quarter the patenting activity of **Qualcomm** was related to **thin film SAW** ([WO2021/028281](#)). The intermediate layer thickness used between the substrate and the piezoelectric layer is adjusted to adjust the required bandwidth to the desired bands ([WO2021/052836](#)). A functional layer could be added to reduce the temperature compensation layer (TW202110087). Better TCF is also addressed in patent [DE102019121082](#). In this patent, two SAW resonators are made on a common die and composed of TCF compensation layers made of SiO2. The thickness of the compensation layer being different for each stack.
- Qualcomm** recent patenting activity related to amplifier and RF FE module describe **power amplifier for mm-waves** ([US10965261](#)) based on **NMOS** and **PMOS** technology. The other noticeable patents published this quarter describe the **integration of vertical GaN varactor with HEMT** in order to provide filtering and matching circuitry for power amplifiers.
- Other patents describe PA that may be used to simplify the number of elements and thus the size of the device. On one hand the **bidirectional PA** ([WO2021/041766](#)) allows to reduce the devices size even when a large quantity of antenna elements is necessary without adversely impacting system performance or increasing cost. On the other hand, a **dual band PA** ([US20210099140](#)) is provided allowing the use of a single RF chain to amplify and transmit signals in two or more different portions of the radio spectrum, which may or may not be continuous in frequency.



	Q1 2021	SEGMENTS							
		RFFE	PA	LNA	SAW	BAW	Switch	Tuner	Packaging
New patent families (inventions)	27		7	2	8	4	4	1	9
Patent families newly granted	4		2	1					3
Patents expired or abandoned	10		8		2				1

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

- In Q1 2021, **Skyworks** most noticeable patenting activity is the one related to **BAW filter**. Indeed, this is the second time that the company shows an activity related to BAW filter in the last year confirming their recent developments. Aside BAW, the company has kept a stable patenting activity related to **PA/LNA** and **SAW filters**.
- Regarding **SAW filters**, the company Q1 patents provide **SAW with suppressed transverse spurious mode**. To do so, **Skyworks** either use a **dense film above the gap region** ([US20210067134](#)) or a **gap hammer structure** ([US20210067136](#)). In patent [US20210067127](#), the spurious signal is suppressed by playing with the dielectric film thickness is also used.
- Regarding the **BAW filter**, Skyworks patents describe BAW with special frames. In patent [US20210083643](#), a **gradient raised frame** is implemented. The gradient is relative to one of the first and second metal layers and configured to improve reflection of lateral mode waves and to reduce conversion of main mode waves into lateral mode waves. In patent [US20210075391](#), the **frame is recessed**, and the electrode has a lesser thickness in the recessed frame regions than in the central region to increase a quality factor of the FBAR. The two other patent related to BAW describe BAW and multiplexers. The filter can include BAW filter as well as SAW filters and connected. The SAW resonators are configured to suppress one or more harmonics resulting from the filtering of the signal by the BAW assembly. In patent [US20210044278](#), **Skyworks** describe BAW resonators on a common die. The BAW filters having the same resonant frequency.
- Skyworks** most noticeable Q1 patents related to PA/LNA describe **LNA on SOI substrate** ([US10944008](#)) in order to reduce the noise figure and leakage compare to NMOS et PMOS. Other patents describe **control circuit** of the amplifier. For instance, patent [US20210083636](#) describe a **tunable impedance circuit** included with an amplifier resulting in a reduction the RF FE module size and return loss. Patents [US20210091724](#), [US20210036669](#) and GB202100245 describe **biasing circuit** for amplifiers. These circuits allow to prolong battery life and/or provide a suitable transmit power level.



	Q1 2021	SEGMENTS							
		RFFE	PA	LNA	SAW	BAW	Switch	Tuner	Packaging
New patent families (inventions)	13	10		7			5	2	11
Patent families newly granted	15	7					11		10
Patents expired or abandoned	0								

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

- **Oppo Mobile** Q1 IP activity is **quite unique** as the OEM patents are related to small segments, e.g. **RF FEM and switch**. Indeed, the Chinese recent IP developments are related to the **integration of RF FE in the smart phone**. Oppo Mobile patents aim at reducing the module/device size and cost.
- For instance, patents ([CN21258832](#), [CN212588326](#), [CN212811690](#), [CN212588327](#)) describe **PAMID devices** that allow to improve the integration level while reducing the cost. Patent [CN112272030](#) describes a **RF FEM in which a multiplexer is integrated** instead of being externally hung in the radio frequency front-end module.
- Aside RF FE device with smaller size, **Oppo Mobile** has also developed **RF FE circuit** that can support the **2.4 G and 5G frequency bands** and **8*8 MIMO**. The goal being to meet the requirements of **WiFi 6** ([CN110113063](#)). In patent [CN109951209](#), a radio frequency circuit based on 3 switches which can improve the diversity of receiving and transmitting carrier aggregation signals or non-carrier aggregation signals is described.
- Patent [US10924139](#) is the only invention that has been **extended abroad China**. The disclosure provides an **RF circuit** which may improve the diversity of carrier aggregation (CA) of RF signals by the electronic device thanks to 3 switches, a combiner and 2 phase modules.

Focus on main IP transfers

No patent related to RF FE components has been transferred (reassigned) in Q1 2021

Focus on main patent litigation

**No US complaint RF FE components
has been neither filed or closed in Q1 2021**



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