

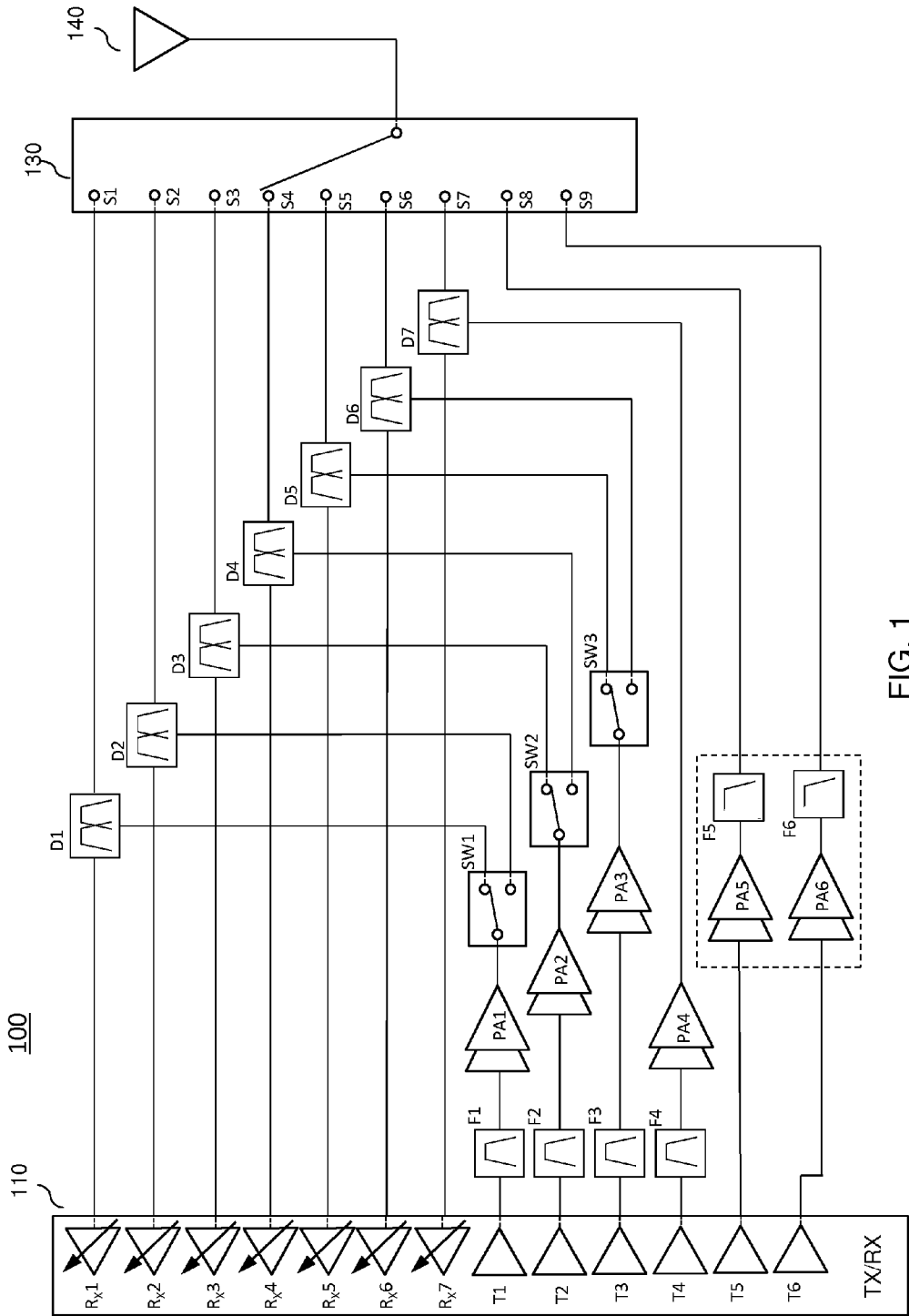


FIG. 1

200

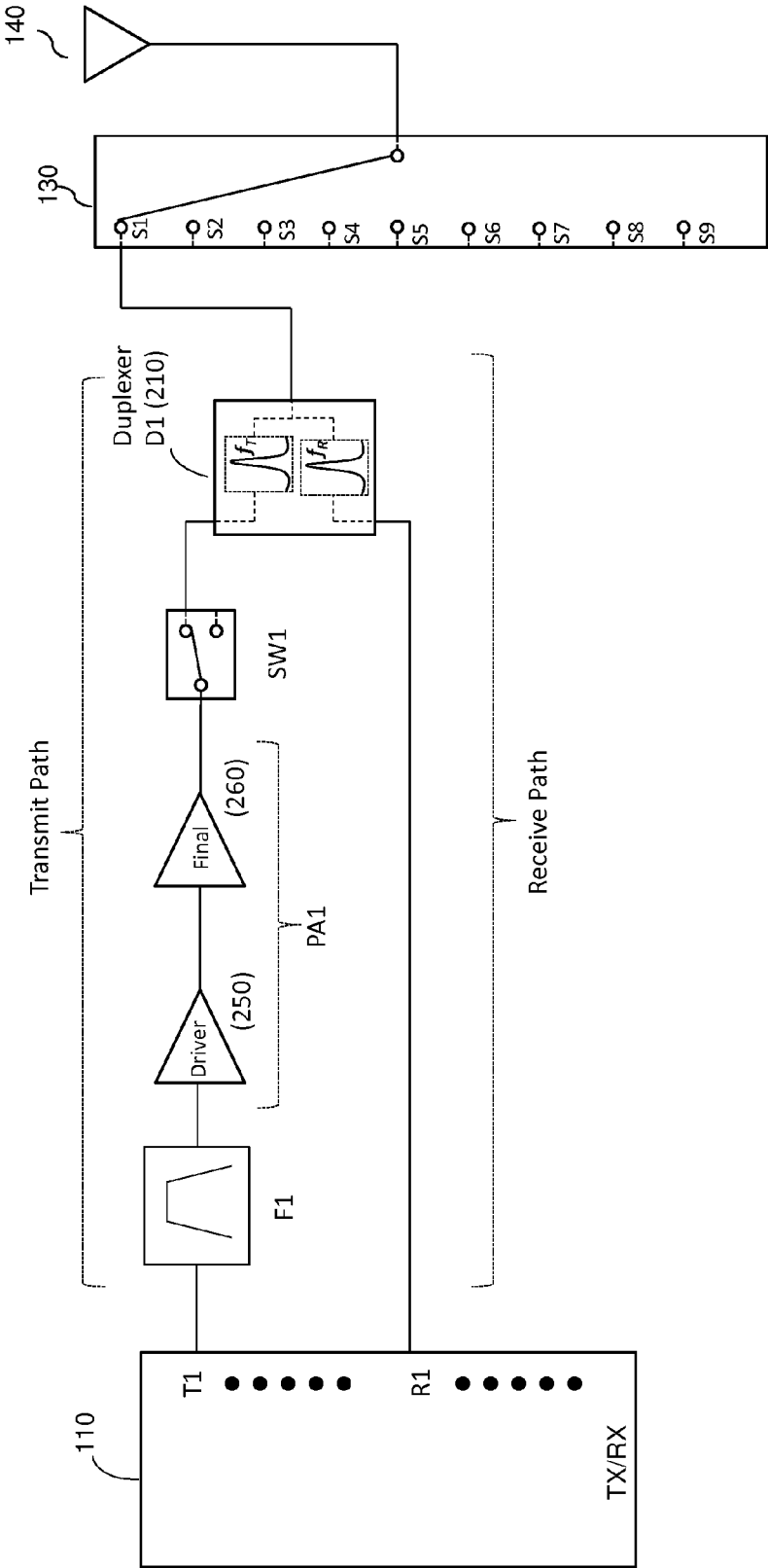


FIG. 2A

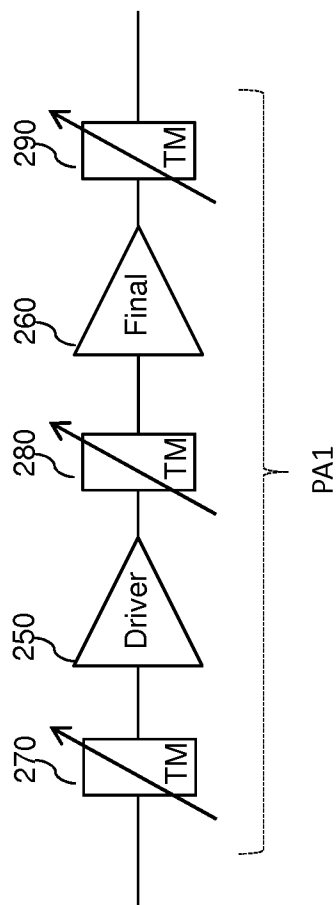


FIG. 2B

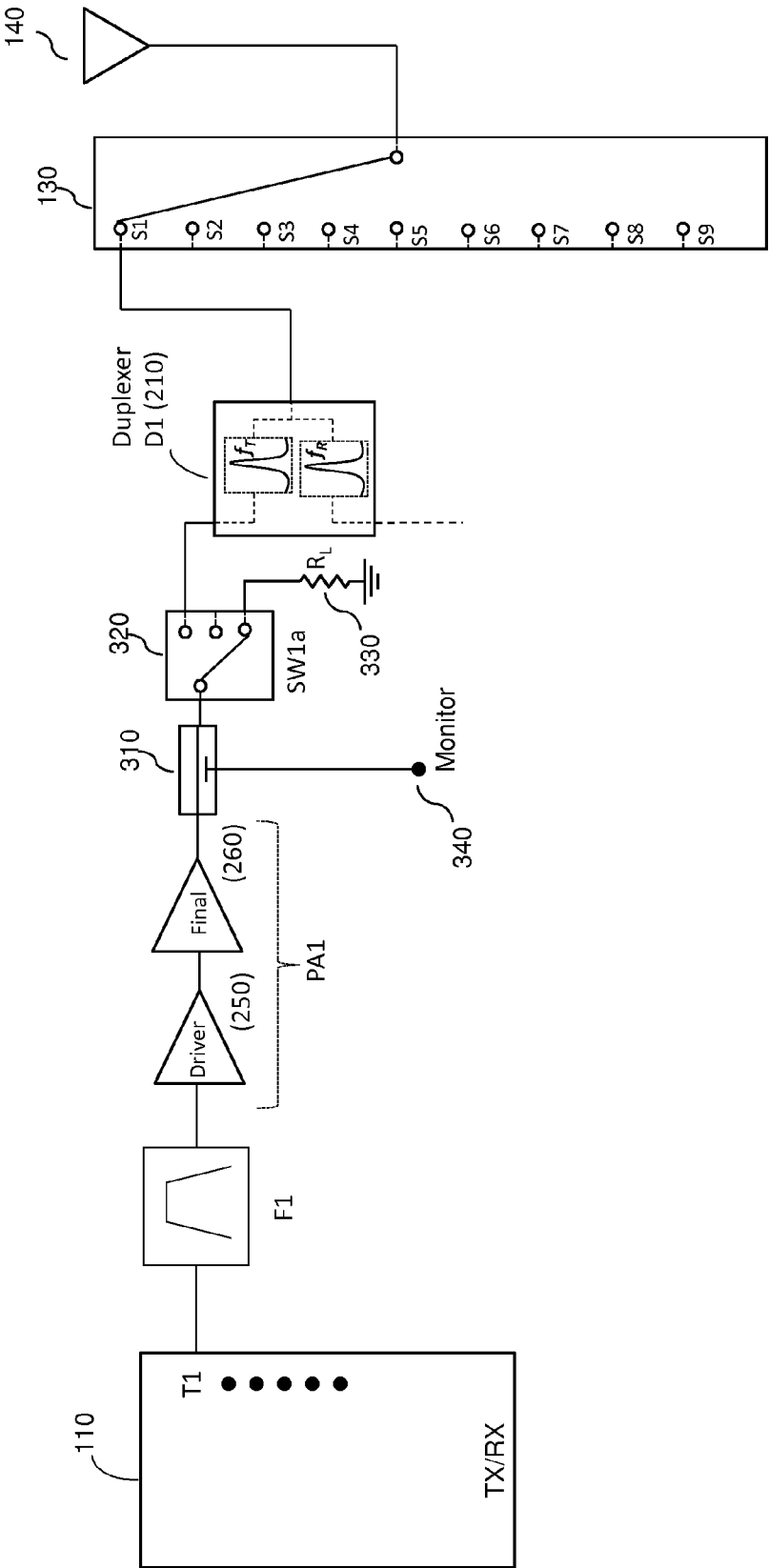


FIG. 3A

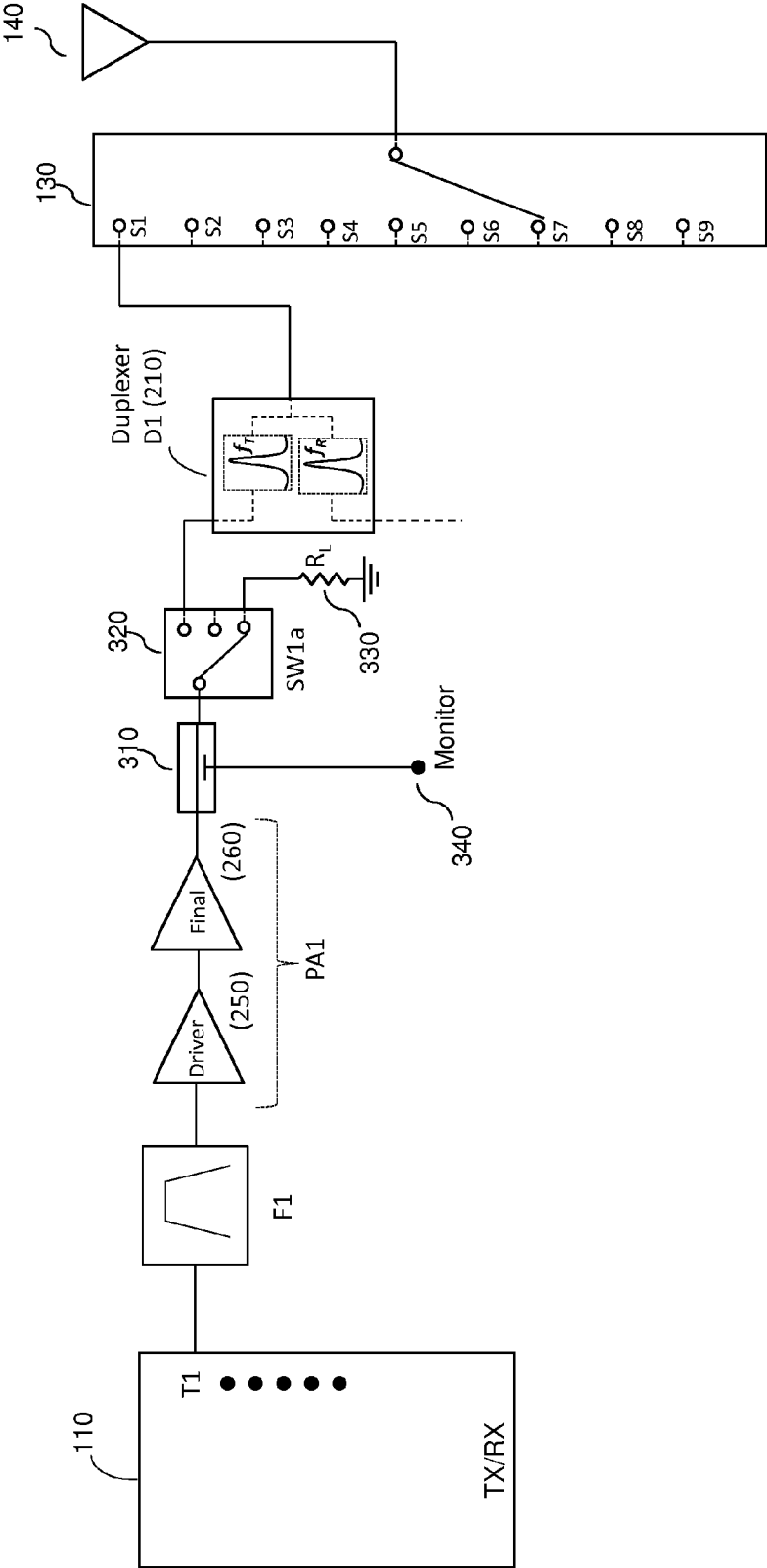


FIG. 3B

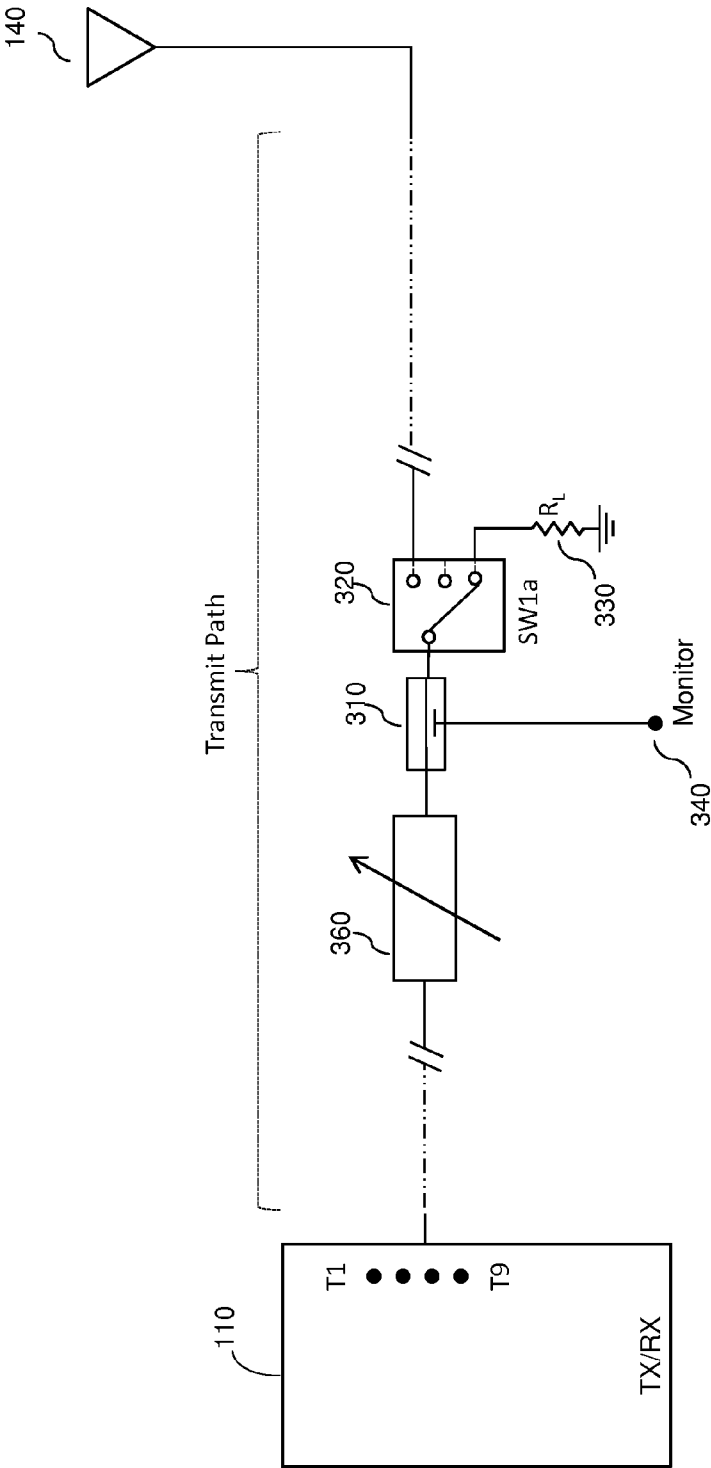


FIG. 3C

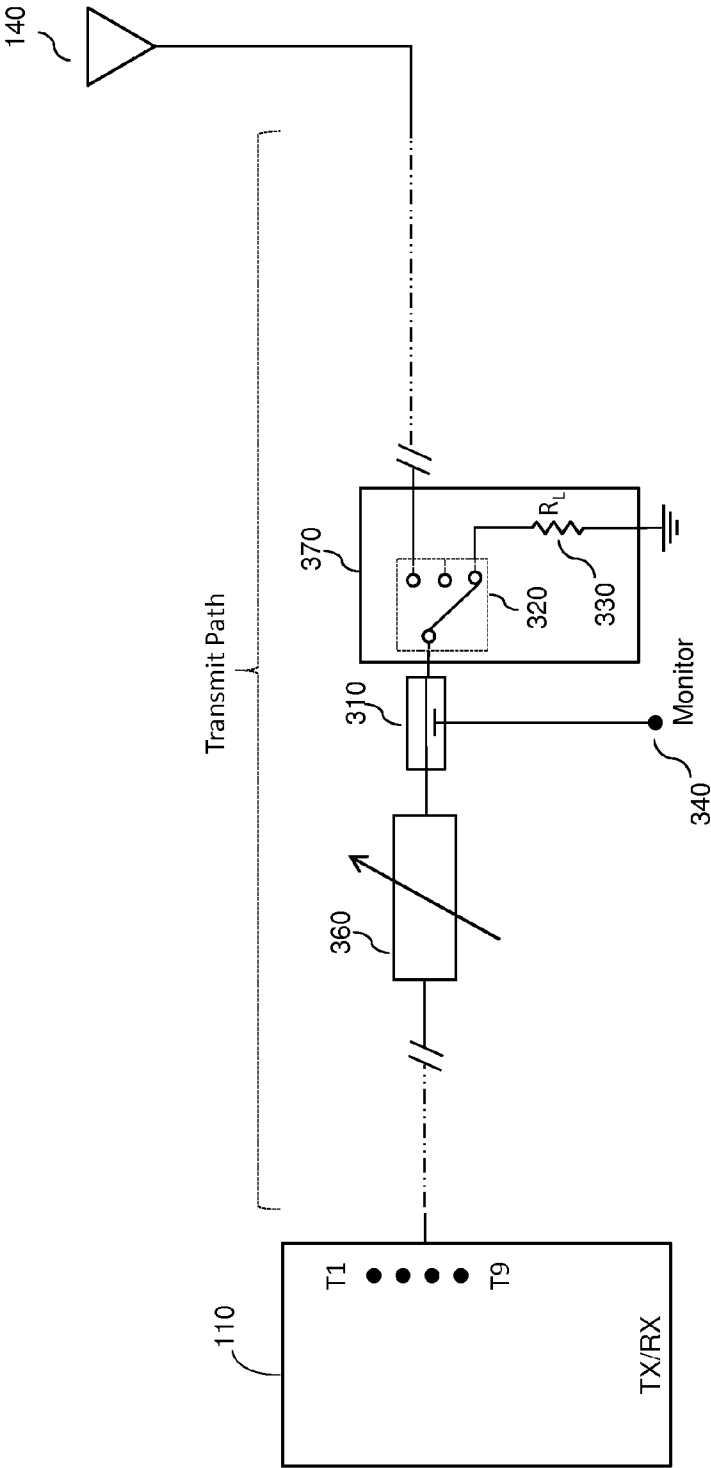


FIG. 3D

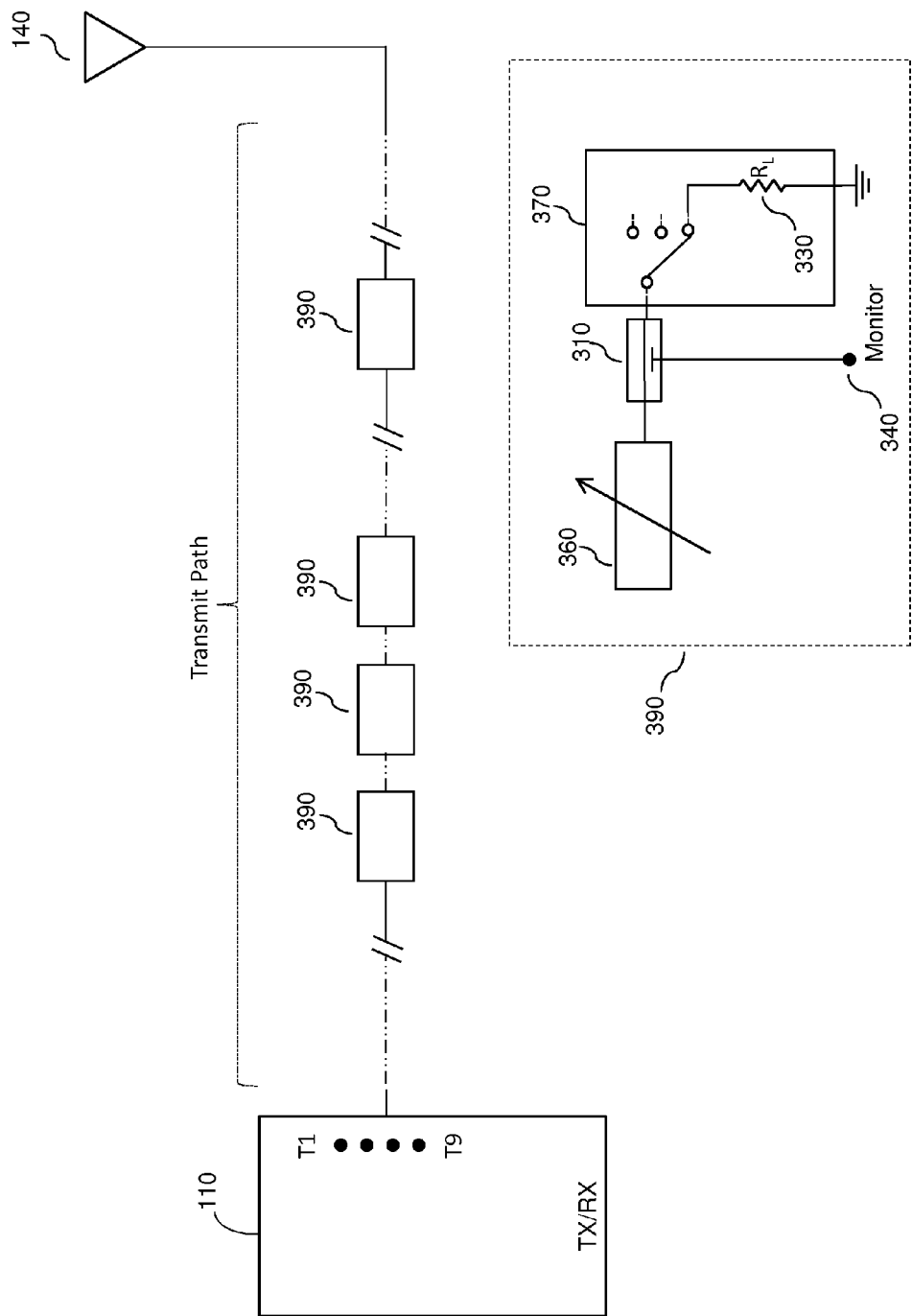


FIG. 3E

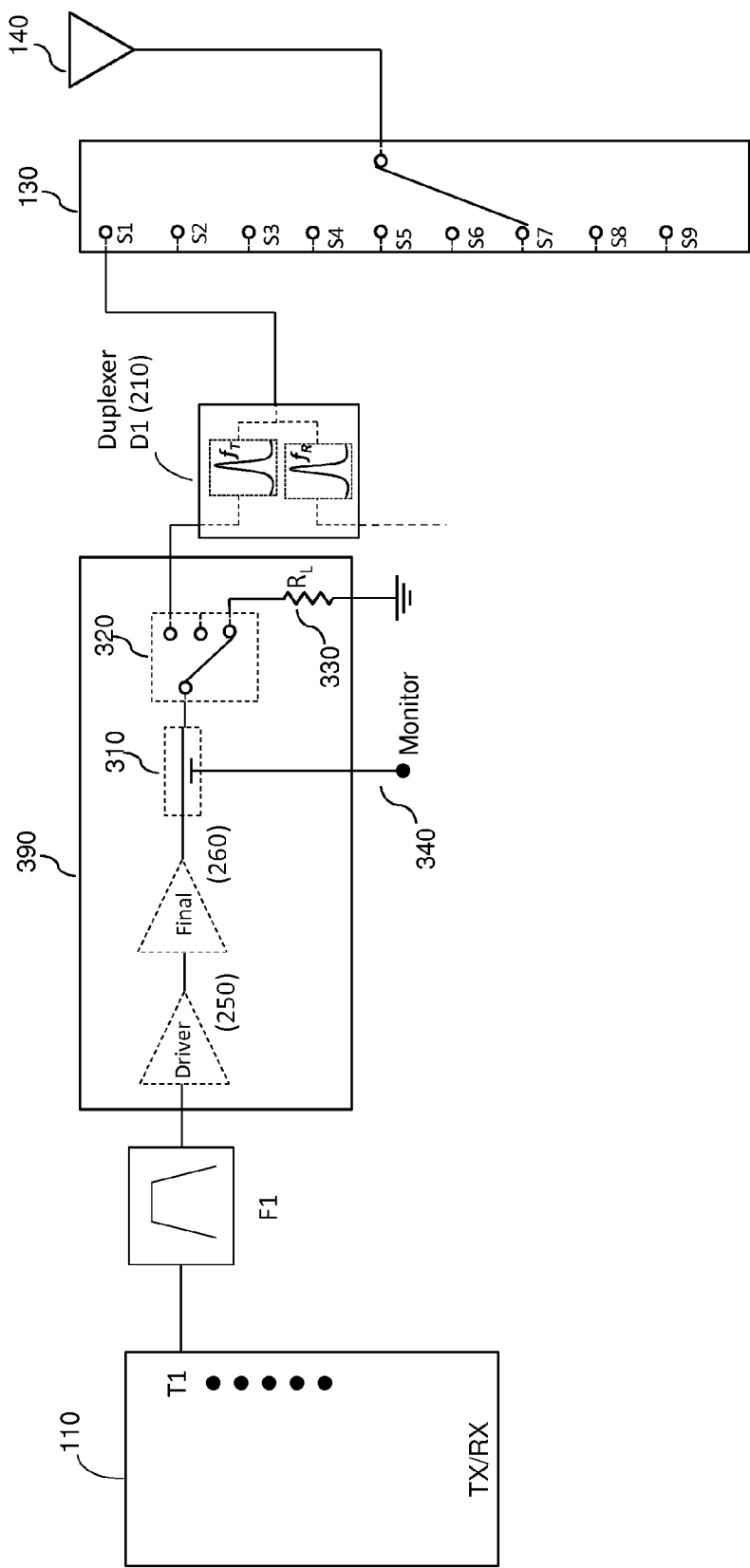


FIG. 3F

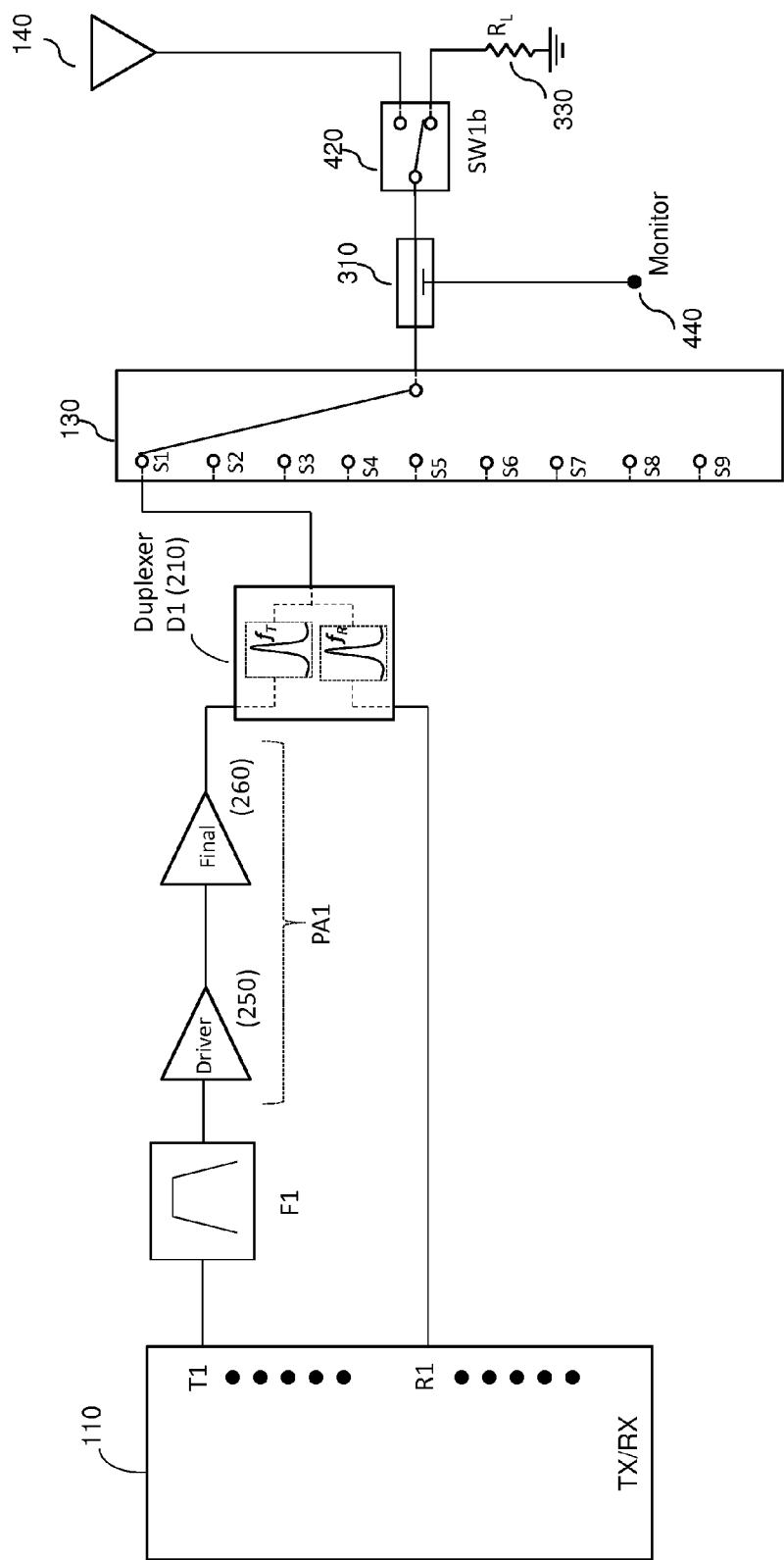


FIG. 4A

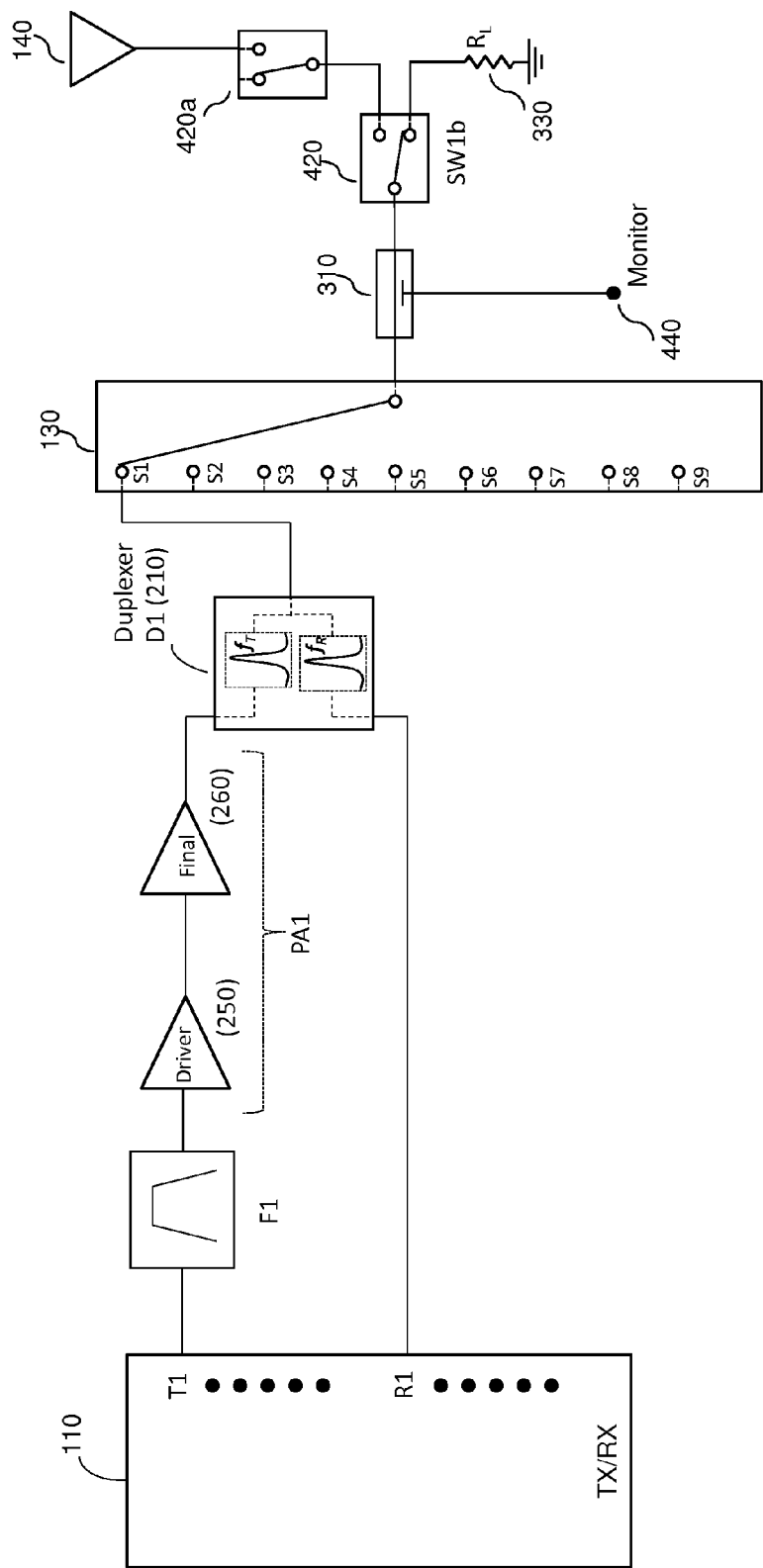


FIG. 4B

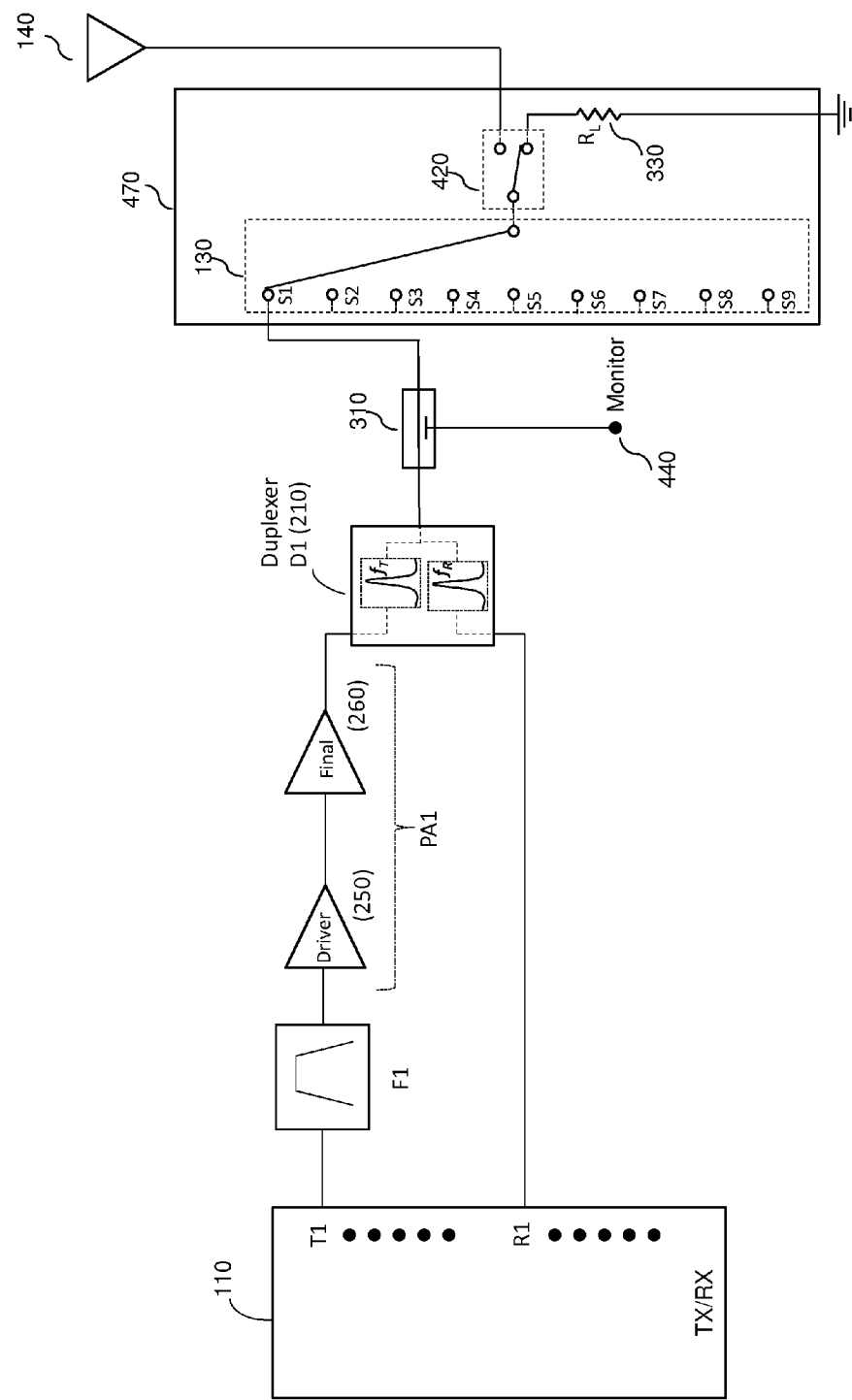


FIG. 4C

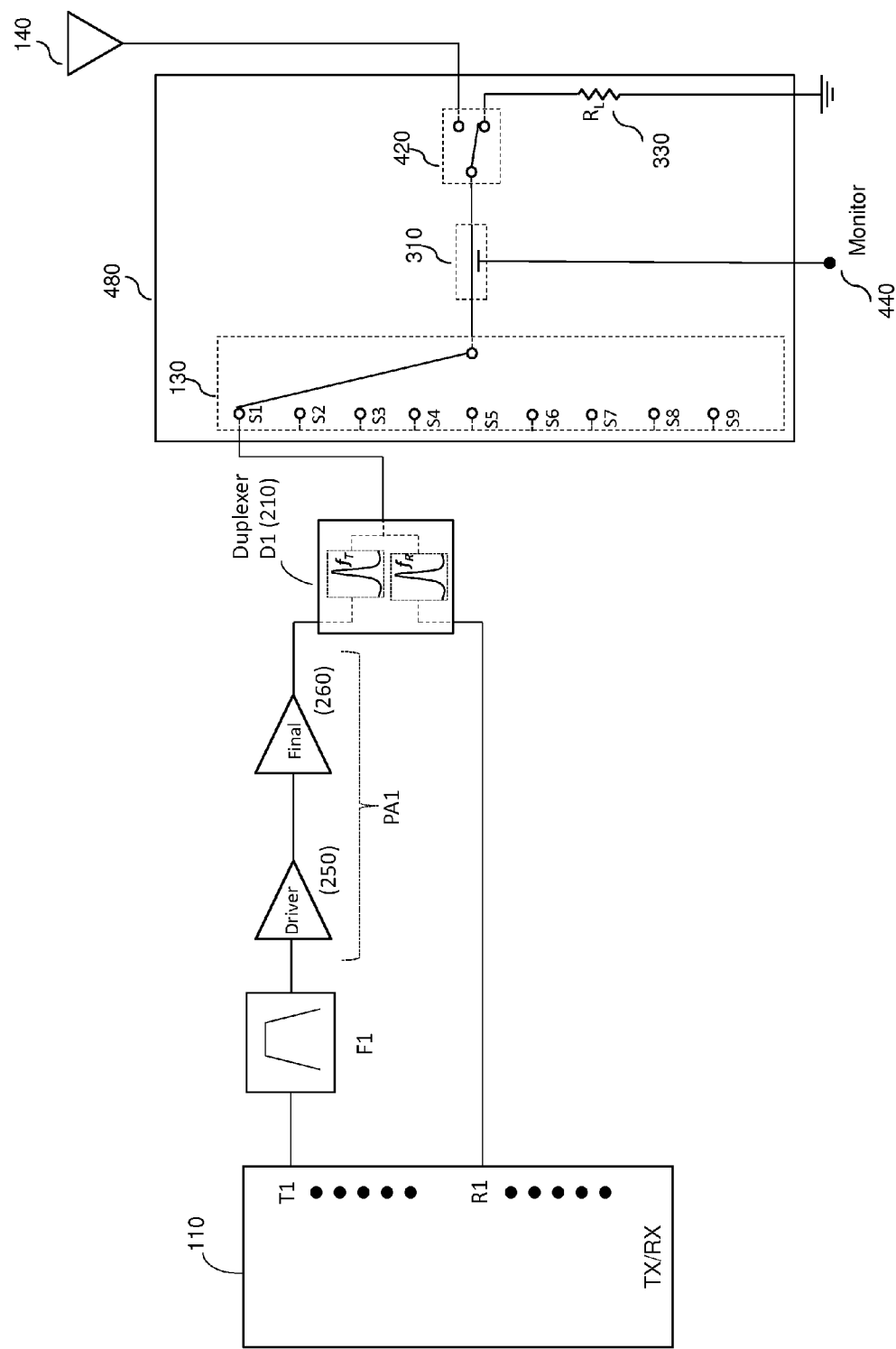


FIG. 4D

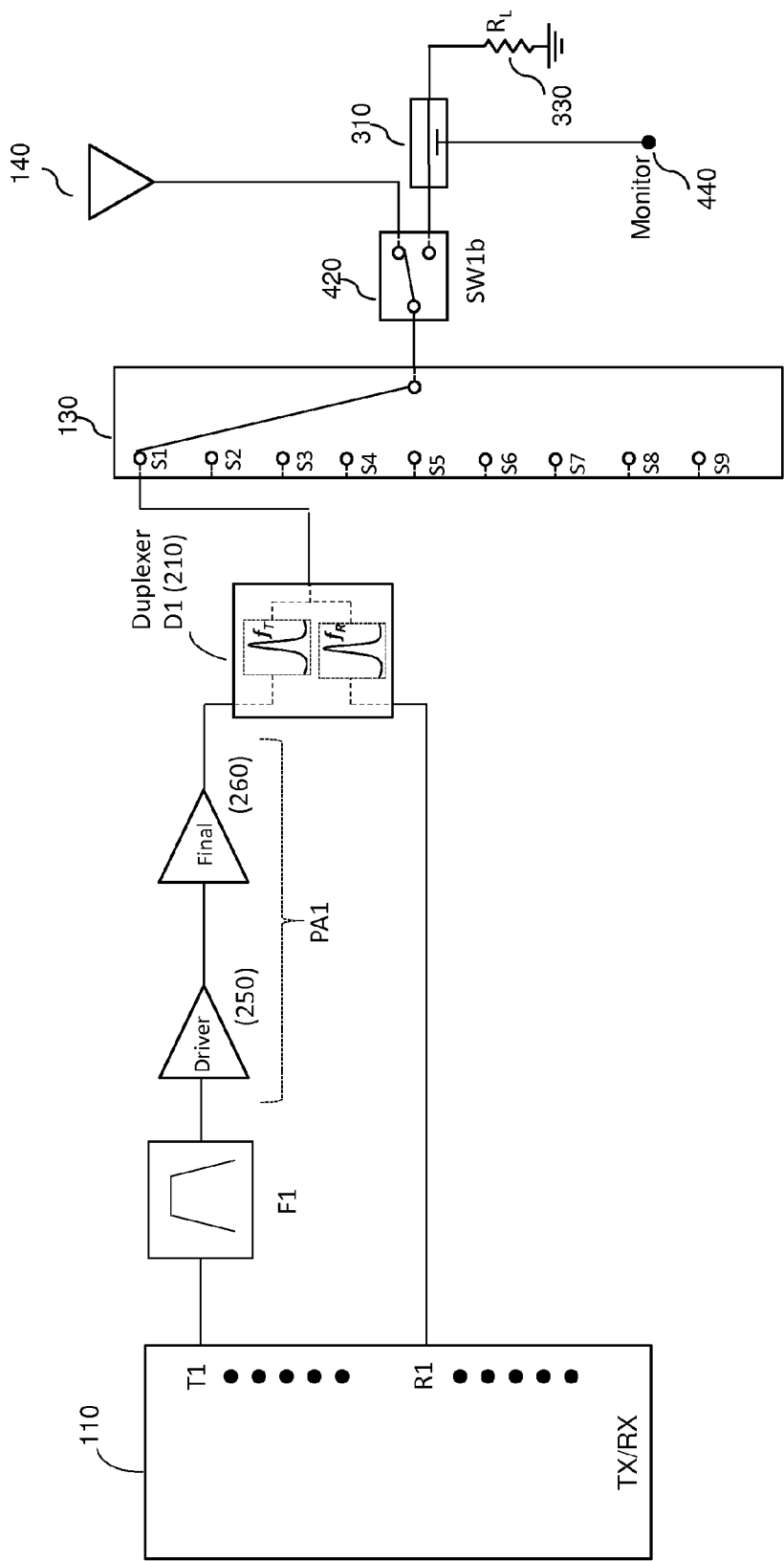


FIG. 5

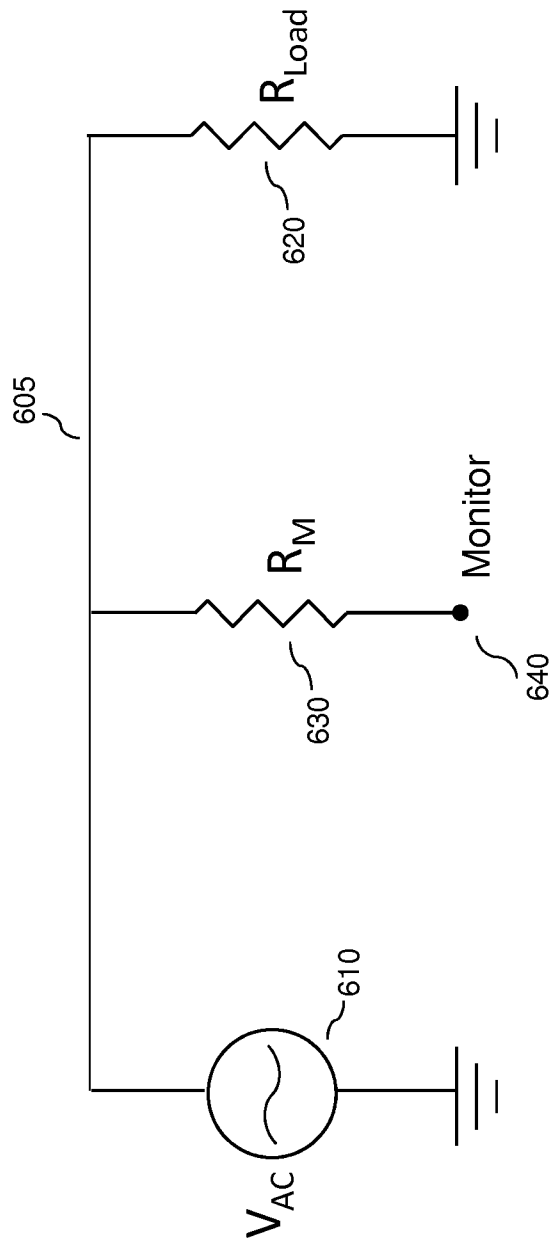


FIG. 6A

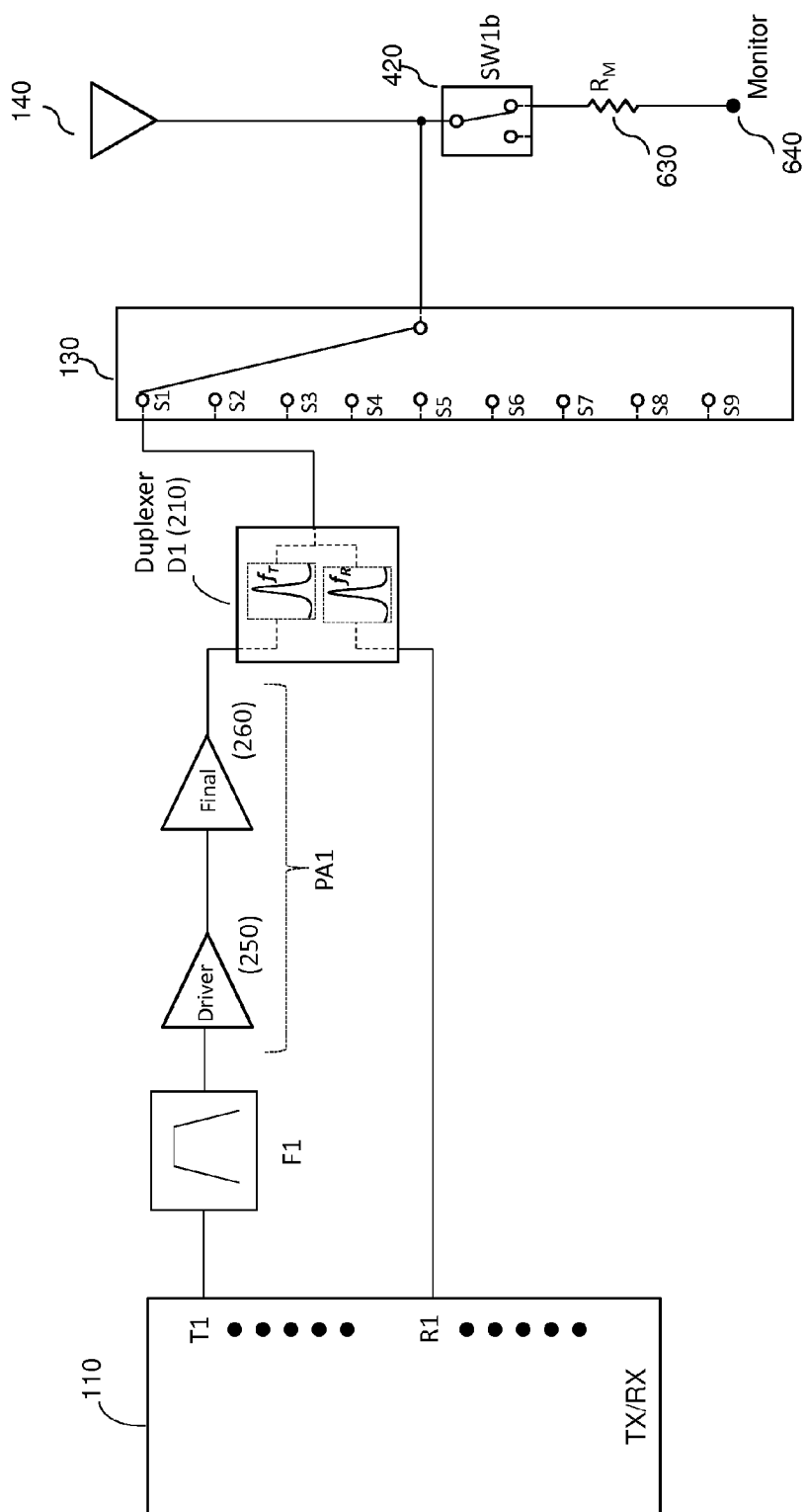


FIG. 6B

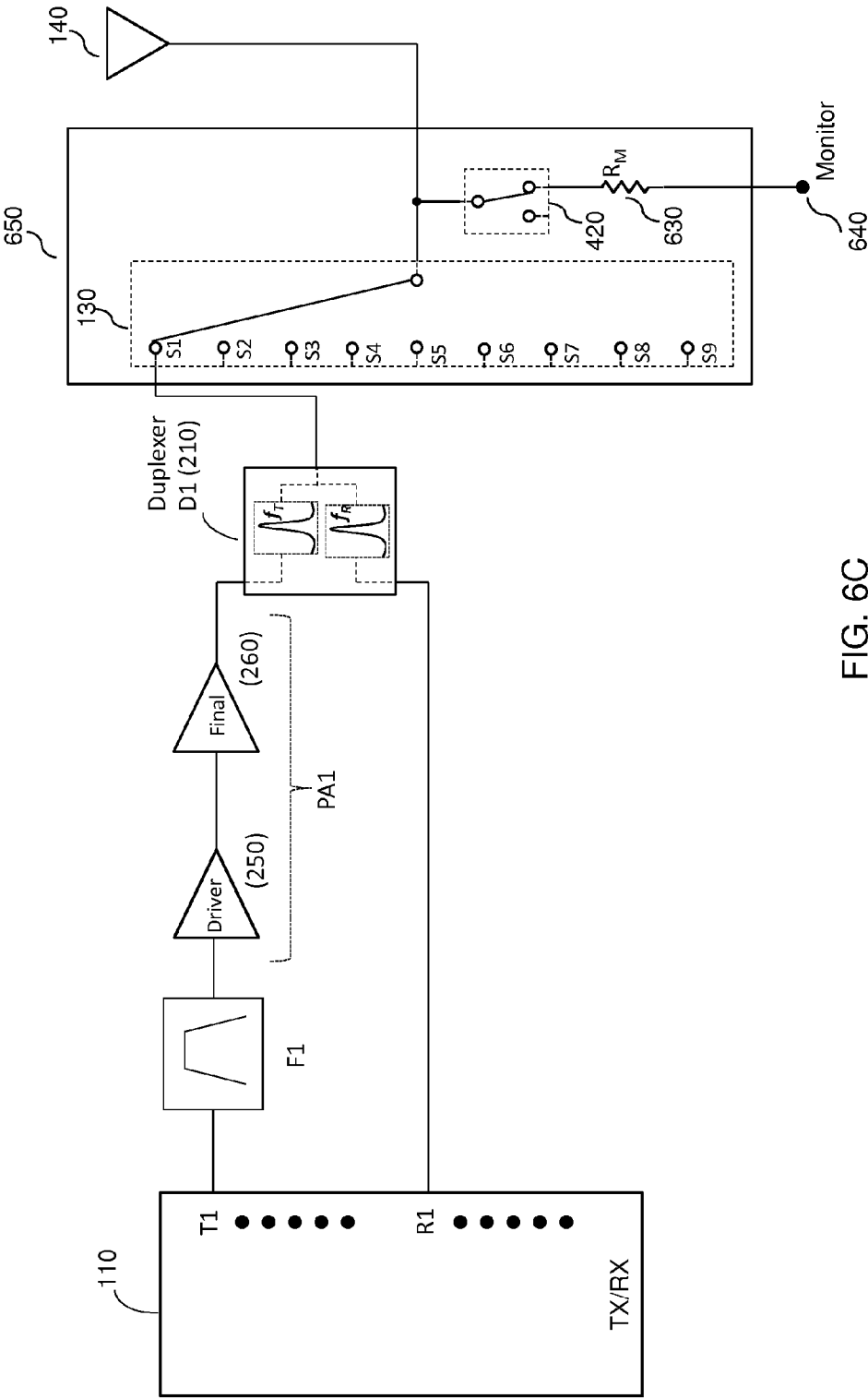


FIG. 6C

RF TRANSMIT PATH CALIBRATION VIA ON-CHIP DUMMY LOAD

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to U.S. patent application Ser. No. _____ entitled “Mismatch Detection Using Replica Circuit” (Attorney Docket No. PER-068-PAP) filed on even date herewith and incorporated herein by reference in its entirety.

[0002] The present application may be related to U.S. Pat. No. 6,804,502, issued on Oct. 12, 2004 and entitled “Switch Circuit and Method of Switching Radio Frequency Signals”, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. Pat. No. 7,910,993, issued on Mar. 22, 2011 and entitled “Method and Apparatus for use in Improving Linearity of MOSFET’s using an Accumulated Charge Sink”, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. 13/797,779 entitled “Scalable Periphery Tunable Matching Power Amplifier”, filed on Mar. 12, 2013, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to International Application No. PCT/US2009/001358, entitled “Method and Apparatus for use in digitally tuning a capacitor in an integrated circuit device”, filed on Mar. 2, 2009, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. 13/595,893, entitled “Methods and Apparatuses for Use in Tuning Reactance in a Circuit Device”, filed on Aug. 27, 2012, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. 14/042,312, filed on Sep. 30, 2013, entitled “Methods and Devices for Impedance Matching in Power Amplifier Circuits”, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. Pat. No. 7,248,120, issued on Jul. 24, 2007, entitled “Stacked Transistor Method and Apparatus”, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. 13/828,121, filed on Mar. 14, 2013, entitled “Systems and Methods for Optimizing Amplifier Operations”, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. 13/967,866 entitled “Tunable Impedance Matching Network”, filed on Aug. 15, 2013, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. 13/797,686 entitled “Variable Impedance Match and Variable Harmonic Terminations for Different Modes and Frequency Bands”, filed on Mar. 12, 2013, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. 14/042,331 entitled “Methods and Devices for Thermal Control in Power Amplifier Circuits”, filed on Sep. 30, 2013, the disclosure of which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. 13/829,946 entitled “Amplifier Dynamic Bias Adjustment for Envelope Tracking”, filed on Mar. 14, 2013, the disclosure of which is incorporated herein by reference in its entirety. The present

application may also be related to U.S. patent application Ser. No. 13/830,555 entitled “Control Systems and Methods for Power Amplifiers Operating in Envelope Tracking Mode”, filed on Mar. 14, 2013, the disclosure of which is incorporated herein in its entirety.

BACKGROUND

[0003] 1. Field

[0004] The present teachings relate to RF (radio frequency) circuits. More particularly, the present teachings relate to methods and apparatuses for calibration of an RF transmit path via on-chip dummy load.

[0005] 2. Description of Related Art

[0006] RF devices, such as cell phone transmitters, are becoming increasingly complex due to additional frequency bands, more complex modulation schemes, higher modulation bandwidths, and the introduction of efficiency improvement schemes such as envelope tracking. The transmitter lineup in a transceiver commonly employs calibration techniques to improve modulator performance, remove DC offsets, calibrate power levels, and so on. This is done at phone power up, and even periodically to remove temperature and frequency variations.

[0007] However, the full transmit path, through an associated power amplifier (PA) and even through associated filters and antenna switch(es), is usually calibrated only in an RF device production test environment, then not ever again. This is because due to local regulations, a transmitter cannot perform the task of transmitting over the air without a channel being assigned to the transmission, a task which is required for calibration of the transmit path. New transceivers are implementing a full receive path to monitor the PA output so it can make updates to track out performance shifts due to frequency, temperature, and battery voltage variations. This receive path requires the RF device (e.g. cell phone) to be in a call to carry out the closed loop updates, however, the transmission quality must meet system requirements before the closed loop corrections can be implemented.

SUMMARY

[0008] According to a first aspect of the present disclosure, a radio frequency (RF) circuit arrangement is presented, wherein the RF circuit arrangement is configured to transmit an RF signal at an output RF transmit port via one or more RF transmit paths, wherein a transmit path of the one or more transmit RF paths comprises: one or more adjustable RF devices configured during operation to affect one or more characteristics of the RF signal; and a terminating switch positioned between an adjustable RF device of the one or more adjustable RF devices and the output RF transmit port, wherein: during a first mode of operation of the RF transmit path, the terminating switch is configured to couple the RF signal to the output RF transmit port, and during a second mode of operation of the RF transmit path, the terminating switch is configured to isolate the RF signal from the output RF transmit port and terminate the RF signal into a terminating load connected to a terminating terminal of the terminating switch.

[0009] According to a second aspect of the present disclosure, a radio frequency (RF) circuit arrangement is presented, wherein the RF circuit arrangement is configured to transmit an RF signal at an output RF transmit port, the RF circuit arrangement comprising: an output switch compris-

ing a plurality of switching terminals and a common terminal, wherein the common terminal is operatively coupled to the output RF transmit port; a plurality of RF transmit paths comprising one or more adjustable RF devices and configured, during operation, to transmit the RF signal, wherein the plurality of RF transmit paths are coupled to the plurality of switching terminals; and a terminating switch positioned between an adjustable RF device of the one or more adjustable RF devices and the output RF transmit port, wherein: during a first mode of operation of the RF circuit arrangement, the terminating switch is configured to couple the RF signal to the output RF transmit port, and during a second mode of operation of the RF circuit arrangement, the terminating switch is configured to isolate the RF signal from the output RF transmit port and terminate the RF signal into a terminating load connected to a terminating terminal of the terminating switch.

[0010] According to a third aspect of the present disclosure, a monolithically integrated radio frequency (RF) circuit is presented, wherein the RF circuit comprises: an RF switch comprising a common terminal and a plurality of switching terminals, wherein during operation the switch is adapted to connect a selected switching terminal of the plurality of switching terminals to the common terminal, and a resistor connected via a first terminal of the resistor, to a terminating switching terminal of the plurality of switching terminals, wherein the RF switch and the resistor are monolithically integrated on a same integrated circuit.

[0011] According to a fourth aspect of the present disclosure, a method for calibrating a transmit path of a radio frequency (RF) front-end stage is presented, the method comprising: providing a switchable load impedance in a transmit path; during a calibration of the transmit path, terminating the transmit path at the switchable load impedance; based on the terminating, reducing an output RF signal power at an output antenna of the transmit path; based on the terminating, measuring an RF signal characteristic at the switchable load impedance; based on the measuring, adjusting an adjustable RF device of the transmit path, and based on the adjusting, calibrating the transmit path, wherein the reducing provides an output RF signal power at the output antenna of the transmit path lower than a desired RF transmission power.

[0012] According to a fifth aspect of the present disclosure, a method for calibrating a transmit path of a radio frequency (RF) front-end stage is presented, the method comprising: providing an RF front-end stage comprising one or more transmit paths, wherein each transmit path of the one or more transmit paths is adapted to be connected to a transmit port via an output RF switch; providing one or more RF switches, wherein an RF switch of the one or more RF switches is adapted to provide a series connection between two RF components of a transmit path of the plurality of transmit paths via a common terminal of the RF switch and a first switching terminal of the RF switch; selecting a transmit path of the plurality of transmit paths for transmission of an RF signal at the transmit port; configuring the output switch to connect the selected transmit path to the output port; configuring at least a subset of the one or more RF switches to provide series connections between two RF components of the selected transmit path; providing the RF signal to the selected transmit path; transmitting the RF signal based on the providing of the RF signal; calibrating the selected transmit path by performing the following steps: configuring an RF switch of the one or more RF switches to disable a series connection between

two RF components of the selected transmit path, based on the configuring, terminating the selected transmit path at a resistor load connected to a second switching terminal of the RF switch, sensing an RF signal at the resistor load, based on the sensing, adjusting an adjustable RF component of the selected transmit path, and configuring the RF switch of the one or more RF switches to provide series connection between the two RF components of the transmit path; and based on the calibrating, obtaining a desired signal characteristic of the transmitted RF signal.

BRIEF DESCRIPTION OF DRAWINGS

[0013] The accompanying drawings, which are incorporated into and constitute a part of this specification, illustrate one or more embodiments of the present disclosure and, together with the description of example embodiments, serve to explain the principles and implementations of the disclosure.

[0014] FIG. 1 shows a block diagram of a multi-band and multi-channel RF front-end stage of an RF device, as used, for example, in a cellular phone. The RF stage comprises transmit and receive paths for high frequency bands and low frequency bands.

[0015] FIG. 2A shows a transmit path and a receive path of the RF stage depicted in FIG. 1.

[0016] FIG. 2B shows a configurable power amplifier module.

[0017] FIG. 3A and FIG. 3B show exemplary embodiments according to the present disclosure of a switchable dummy load in a transmit path which can be used to monitor an RF signal in the transmit path during a calibration step. The switchable dummy load of FIG. 3A is positioned prior to an antenna switch of the RF stage.

[0018] FIG. 3C shows a relative position according to an embodiment of the present disclosure of a switchable dummy load within a transmit path of the RF front-end stage of FIG. 1.

[0019] FIG. 3D shows a monolithically integrated switchable dummy load according to an embodiment of the present disclosure.

[0020] FIG. 3E shows an exemplary embodiment according to the present disclosure of a plurality of dummy loads in a transmit path which can each be used to monitor an RF signal in the transmit path during a calibration step. Each switchable dummy load is positioned after an adjustable RF component of the transmit path.

[0021] FIG. 3F shows a monolithically integrated power amplifier module comprising an integrated switchable dummy load.

[0022] FIG. 4A shows an exemplary embodiment according to the present disclosure of a switchable dummy load in a transmit path which can be used to monitor the RF signal in the transmit path during a calibration step. The switchable dummy load of FIG. 4A is positioned after the antenna switch of the RF stage.

[0023] FIG. 4B shows the embodiment of FIG. 4A with an added switch for a higher signal isolation with respect to an antenna.

[0024] FIG. 4C and FIG. 4D show a monolithically integrated antenna switch with built-in switchable dummy load according to an embodiment of the present disclosure.

[0025] FIG. 5 shows an exemplary embodiment according to the present disclosure of a switchable dummy load in a transmit path which can be used to monitor the RF signal in

the transmit path during a calibration step. The switchable dummy load of FIG. 5 is positioned after the antenna switch of the RF stage. In the exemplary embodiment depicted in FIG. 5, a signal coupler, used to monitor the RF signal, switches in and out of the transmit path together with the dummy load.

[0026] FIG. 6A shows an equivalent AC signal circuit of a transmit path of the RF front-end stage of FIG. 1.

[0027] FIG. 6B shows an exemplary embodiment according to the present disclosure of a switchable monitor impedance which can be used to monitor a transmitted RF signal in a transmit path while transmitting.

[0028] FIG. 6C shows a monolithically integrated antenna switch with built-in switchable monitor impedance of FIG. 6B.

[0029] FIG. 7 shows an exemplary embodiment according to the present disclosure of a switch with stacked transistors.

DETAILED DESCRIPTION

[0030] Throughout this description, embodiments and variations are described for the purpose of illustrating uses and implementations of the inventive concept. The illustrative description should be understood as presenting examples of the inventive concept, rather than as limiting the scope of the concept as disclosed herein.

[0031] As used in the present disclosure, the terms “switch ON” and “activate” may be used interchangeably and can refer to making a particular circuit element electronically operational. As used in the present disclosure, the terms “switch OFF” and “deactivate” may be used interchangeably and can refer to making a particular circuit element electronically non-operational. As used in the present disclosure, the terms “amplifier” and “power amplifier” may be used interchangeably and can refer to a device that is configured to amplify a signal input to the device to produce an output signal of greater magnitude than the magnitude of the input signal.

[0032] The present disclosure describes electrical circuits in electronics devices (e.g., cell phones, radios) having a plurality of devices, such as for example, transistors (e.g., MOSFETs). Persons skilled in the art will appreciate that such electrical circuits comprising transistors can be arranged as amplifiers. As described in a previous disclosure (U.S. patent application Ser. No. 13/797,779), a plurality of such amplifiers can be arranged in a so-called “scalable periphery” (SP) architecture of amplifiers where a total number (e.g., 64) of amplifier segments are provided. Depending on the specific requirements of an application, the number of active devices (e.g., 64, 32, etc.), or a portion of the total number of amplifiers (e.g. $\frac{1}{64}$, $\frac{2}{64}$, 40% of 64, etc.), can be changed for each application. For example, in some instances, the electronic device may desire to output a certain amount of power, which in turn, may require 32 of 64 SP amplifier segments to be used. In yet another application of the electronic device, a lower amount of output power may be desired, in which case, for example, only 16 of 64 SP amplifier segments are used. According to some embodiments, the number of amplifier segments used can be inferred by a nominal desired output power as a function of the maximum output power (e.g. when all the segments are activated). For example, if 30% of the maximum output power is desired, then a portion of the total amplifier segments corresponding to 30% of the total number of segments can be enabled. The scalable periphery amplifier devices can be connected to corresponding impedance

matching circuits. The number of amplifier segments of the scalable periphery amplifier device that are turned on or turned off at a given moment can be according to a modulation applied to an input RF signal, a desired output power, a desired linearity requirement of the amplifier or any number of other requirements.

[0033] The term “amplifier” as used in the present disclosure is intended to refer to amplifiers comprising single or stacked transistors configured as amplifiers, and can be used interchangeably with the term “power amplifier (PA)”. Such terms can refer to a device that is configured to amplify a signal input to the device to produce an output signal of greater magnitude than the magnitude of the input signal. Stacked transistor amplifiers are described for example in U.S. Pat. No. 7,248,120, issued on Jul. 24, 2007, entitled “Stacked Transistor Method and Apparatus”, the disclosure of which is incorporated herein by reference in its entirety. Such amplifier and power amplifiers can be applicable to amplifiers and power amplifiers of any stages (e.g., pre-driver, driver, final), known to those skilled in the art.

[0034] As used in the present disclosure, the term “mode” can refer to a wireless standard and its attendant modulation and coding scheme or schemes. As different modes may require different modulation schemes, these may affect required channel bandwidth as well as affect the peak-to-average-ratio (PAR), also referred to as peak-to-average-power-ratio (PAPR), as well as other parameters known to the skilled person. Examples of wireless standards include Global System for Mobile Communications (GSM), code division multiple access (CDMA), Worldwide Interoperability for Microwave Access (WiMAX), Long Term Evolution (LTE), as well as other wireless standards identifiable to a person skilled in the art. Examples of modulation and coding schemes include binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), quadrature amplitude modulation (QAM), 8-QAM, 64-QAM, as well as other modulation and coding schemes identifiable to a person skilled in the art.

[0035] As used in the present disclosure, the terms “channel” and “band” are used interchangeably and can refer to a frequency range. More in particular, the terms “channel” and “band” as used herein refers to a frequency range that can be defined by a wireless standard such as, but not limited to, wideband code division multiple access (WCDMA) and long term evolution (LTE).

[0036] A more integrated RF front-end where one or more components are adjustable can be reduced in size and complexity compared to a discrete RF front-end with multiple elements that can be switched between in order to accommodate different modes and different bands. One component that can enable such integration is an amplifier that can be dynamically adjusted during operation of a cellular phone or wireless device that comprises the adjustable amplifier. An RF front-end comprising such an adjustable amplifier could not need to switch between multiple fixed amplifiers (e.g. as in many RF front-ends currently available), but could rather use a smaller number of (or even one of) the adjustable amplifiers to achieve desired performance characteristics (e.g. linearity, data throughput, multimode multiband operation, and so on). A scalable periphery tunable matching amplifier (SPTM) amplifier can serve as an adjustable amplifier. An SPTM amplifier can be adjusted during operation for different output power levels and other characteristics (e.g. different output impedances, different frequencies of opera-

tion, and so forth). Additionally, an SPTM can be adjusted to compensate for manufacturing/production tolerances of related components, such as to provide uniform performance across all production samples. An SPTM amplifier can comprise a scalable periphery amplifier whose output is connected to a tunable impedance matching network.

[0037] FIG. 1 shows a block diagram of an RF front-end stage (100) which can be used for RF transmission and reception of multiple modes and multiple frequency bands signals via a common antenna (140). In the RF front-end stage (100) of FIG. 1, a plurality of transmit and receive paths are used to transmit and receive the RF signals of the multiple modes and multiple frequency bands. An antenna switch (130) is used to switch an RF signal to be transmitted by a transmit path to the antenna, or to switch a received RF signal by the antenna to a receive path for further processing by a transceiver unit (110). In a receive mode, a received RF signal by the antenna (140) can be passed through the antenna switch (130) which connects the antenna to one of the plurality of transmit/receive paths, a duplexer unit (D1-D7) which can reject frequency bands outside a desired frequency band (e.g. reject a transmit signal band), and then fed to the transceiver unit (110) for further processing. An input component of the transceiver unit (110) for a receive path can comprise an adjustable low noise amplifier (LNA) (Rx1-Rx7) designed to amplify a received RF signal in a specified receive frequency band. Once the received signal is amplified, the transceiver unit (110) can further down convert the received amplified signal to an intermediate frequency (IF) signal used for decoding of the information (e.g. voice, data) in the received RF signal.

[0038] During a transmit mode of the RF front-end stage (100) of FIG. 1, an RF signal generated by the transceiver unit (110) and amplified (e.g. buffered) by a corresponding output stage amplifier (T1-T7) can be passed through a high band (HB) transmit path or a low band (LB) transmit path. The HB transmit path can comprise a filter (F1-F4) designed to reject frequency bands outside a desired frequency band, a power amplifier (PA1-PA4) designed to amplify the RF signal within a desired frequency band, a duplexer unit (D1-D7) which can reject frequency bands outside a desired frequency band (e.g. reject a receive signal band), the antenna switch (130) which connects the HB transmit/receive path to the antenna (140) for final transmission of the RF signal to the air. The HB transmit path can be used for transmission of higher frequency RF signals, such as used in, for example, saturated GMSK mode and linear EDGE and linear WCDMA modes, where various RF frequency ranges from 1.70 GHz to 2.10 GHz are used. For transmission of lower frequency signals (e.g. 700-900 MHz), such as used in, for example, GSM and some 3G bands, the LB transmit path can be used. The LB transmit path of the RF front-end stage of FIG. 1 can comprise a power amplifier (PA5-PA6), a low pass filter (F5-F6) designed to limit the high frequency content of the amplified RF signal, the antenna switch (130) which connects the LB transmit path to the common antenna (140) for final transmission of the RF signal to the air.

[0039] It should be noted that although the RF front-end stage (100) of FIG. 1 comprises four power amplifiers (PA1-PA4), it comprises seven different transmit paths, six of which share a same power amplifier (PA1-PA3) and a same filter (F1-F3). This can be made possible due to an adjustable feature of the power amplifiers, which as described previously can be adjusted to cater to one of several specific transmission modes and/or frequency bands. A switch (SW1-

SW3) can be used to select a duplexer fit to the corresponding transmission mode and/or frequency band. For example, PA1 can be used for transmission of a specific mode and covering two distinct channels (e.g. frequency bands), one channel using a transmission filter defined by the duplexer D1 and the other channel using a transmission filter as defined by the duplexer D2. During a transmission of the specific mode at the first channel, switch SW1 routes the RF signal to be transmitted to duplexer D1 while the PA1 is adjusted for the specific mode and (first) channel of operation (e.g. via controls sent by transceiver unit (110)). During a transmission of an RF signal corresponding to the specific mode at the second channel, switch SW1 routes the RF signal to be transmitted to duplexer D2 while the PA2 is configured (e.g. adjusted) to operate in the specific mode and (second) channel.

[0040] Although not shown in FIG. 1 and as understood by the skilled person, the various configurable elements of the RF front-end stage (100) (e.g. PA1-PA3, SW1-SW3, antenna switch 130) can be controlled via associated controlling signals by an RF signal-aware processor, such as, for example, the transceiver unit (110), and according to a desired mode of operation (e.g. transmit, receive), a desired signal mode (e.g. GMSK, EDGE, WCDMA, etc.) and a desired channel (e.g. frequency band). More information on controlling a configuration of a power amplifier according to desired operation characteristics (e.g. output power, frequency, linearity, thermal compensation, operating parameter variation, etc.) can be found, for example, in U.S. patent application Ser. No. 13/828,121, filed on Mar. 14, 2013, entitled "Systems and Methods for Optimizing Amplifier Operations", U.S. patent application Ser. No. 13/797,779 entitled "Scalable Periphery Tunable Matching Power Amplifier", filed on Mar. 12, 2013, U.S. patent application Ser. No. 13/967,866 entitled "Tunable Impedance Matching Network", filed on Aug. 15, 2013, U.S. patent application Ser. No. 13/797,686 entitled "Variable Impedance Match and Variable Harmonic Terminations for Different Modes and Frequency Bands", filed on Mar. 12, 2013, U.S. patent application Ser. No., 14/042,331 entitled "Methods and Devices for Thermal Control in Power Amplifier Circuits", filed on Sep. 30, 2013, U.S. patent application Ser. No. 13/829,946 entitled "Amplifier Dynamic Bias Adjustment for Envelope Tracking", filed on Mar. 14, 2013, and U.S. patent application Ser. No. 13/830,555 entitled "Control Systems and Methods for Power Amplifiers Operating in Envelope Tracking Mode", filed on Mar. 14, 2013, the disclosures of which are incorporated herein in their entirety.

[0041] FIG. 2A shows a configuration of the RF front-end stage (100) of FIG. 1 for a specific simultaneous activation of a transmit path and a receive path. The receive path of FIG. 2A comprises the amplifier T1 of the transceiver unit (110), the filter F1, the power amplifier PA1, the switch SW1, a transmit filter of the duplexer D1, the antenna switch (130) and the antenna (140). As shown in FIG. 2A, the power amplifier PA1 can be a module comprising one or more power amplifiers, such as, for example, a driver (250) and a final (260). According to some embodiments, one or more power amplifiers of the power amplifier module PA1 can be a scalable periphery amplifier, such as described, for example, in U.S. patent application Ser. No. 13/797,779. According to further embodiments, tunable match elements can be coupled to an input and/or output of the one or more power amplifiers such as to provide further tuning capability of the design with respect to various operating parameters, such as described in, for example, U.S. patent application Ser. No. 13/797,779,

U.S. patent application Ser. No. 13/967,866 and U.S. patent application Ser. No. 13/797,686. According to yet further embodiments, the one or more power amplifiers can comprise envelope tracking amplifiers such as to provide a wider flexibility in operation with respect to, for example, linearity and output power of the amplifier, and as described in, for example, U.S. patent application Ser. No. 13/829,946 and U.S. patent application Ser. No. 13/830,555.

[0042] FIG. 2B shows a power amplifier module PA1 which can be used in a transmit path of the RF front-end stage (100) of FIG. 1 and comprising the various embodiments described in the previous section. In an exemplary implementation, amplifiers (250, 260) can be envelope tracking (ET) amplifiers (250, 260) and can be biased via an envelope tracking power supply (not shown in the figure) under control of an envelope tracking control signal which can be generated by an RF signal-aware processor, such as, for example, the transceiver unit (110). As seen in FIG. 2B, the power amplifier module PA1 can comprise tunable matching elements (270, 280, 290) coupled to the respective input and output of constituent amplifiers (250, 260).

[0043] Given the complexity of an RF front-end stage (100) as depicted in FIG. 1, the complexity of each associated transmit path (200) as depicted in FIG. 2A and the complexity of a corresponding power amplifier (PA1) used for amplifying an RF signal for transmission, calibration of the RF signal at various points in the transmission path can become of paramount importance, as operating variables, such as battery power, component aging, operating temperature and the like can negatively impact performance of the transmission as measured, for example, by RF power level, DC content of the RF signal, linearity (e.g. frequency harmonic content, adjacent leakage channel ratio ACLR) and the like. Although such calibration is typical during a production test of the front-end stage, wherein calibration of the RF signal can be performed at various points of the transmit paths under a controlled environment and controlled input RF signals (e.g. using RF test signals of known and variable/controllable amplitude, phase, modulation, etc.), such calibration is not possible during normal (e.g. customer) usage of the RF front-end stage in a cellular device due to various regulations governing unintentional (e.g. unassigned channel) RF transmission powers which can be transmitted during such calibration. It should be noted that transceiver units, such as transceiver unit (110) depicted in FIG. 1, typically perform a calibration routine during a power up stage of the RF front-end stage (100) and even periodically during operation of the stage. However, such calibration performed by a transceiver unit is limited to the RF signal output by the transceiver unit and cannot take into account variations in a full transmit path used to transmit the RF signal. Accordingly, the subject of the present disclosure is to provide means (e.g. methods and devices) to calibrate an RF transmit path during operation of the RF front-end stage without violating the various regulations governing unintentional RF transmission powers.

[0044] It follows that according to an embodiment of the present disclosure, a switchable load impedance (e.g. a switchable dummy load) is provided to a transmission path of the RF front-end stage (100) as depicted in FIG. 3A. According to the embodiment of the present disclosure as depicted in FIG. 3A, the switchable impedance RL (330) is provided through a switch (320) which can provide an additional (e.g. alternate) termination path to the RF signal prior to the duplexer unit (210). During a calibration phase, the switch can terminate

the RF transmit path at the impedance RL (330) and can decouple (e.g. isolate) the RF signal from the remainder of the RF path which leads to the antenna switch (130). At the same time, a signal coupling device (310) inserted in the transmit path right before the switch (320), can be used to monitor (e.g. during a calibration phase) a fraction of the RF signal at that point (340) in the transmit path, the fraction being representative of the full scale RF signal at the same point of the transmit path. The RF signal detected by the signal coupling device (310) can be provided via a monitor terminal (340) for subsequent measuring by, for example, dedicated measurement circuitry or even the transceiver unit (110). During a calibration phase (e.g. RF power conducted to the load impedance RL), characteristics of the monitored RF signal (e.g. deviation from desired RF signal characteristics) can be used to further adjust components within the RF transmit path, such as, for example, a configurable power amplifier (e.g. PA1) and/or associated tunable match components as depicted in FIG. 2B, and as a consequence align/calibrate the transmit path to obtain an RF signal with the desired characteristic at the monitoring point. The signal coupling device (310) can be a directional coupler which functions by sending a fractional portion of an input power (coupling factor, for example 15-25 dB lower than a main input power) to a first coupled port, and can also send a fractional part of a reflected power to a second coupled port. The coupled power (e.g. at first/second coupled port) is typically measured with a detector, such as, for example, a diode detector, which detects the peak voltages associated with the detected powers. The person skilled in the art readily knows of various methods and devices for implementing the signal coupling device (310), such as, for example, a directional coupler (e.g. coupled line coupler or a broadside coupler). Alternatively, a simple capacitive tap can be used for signal coupling, although such tap does not provide the benefit of directivity and therefore cannot separate a forward signal from a reflected signal. During a normal operation phase of the circuit presented in FIG. 3A, the switch (320) allows coupling of the RF signal to the antenna (140) via the antenna switch (130).

[0045] In the embodiment according to the present disclosure as depicted by FIG. 3A, the switch (320) provides a level of isolation of the RF signal with respect to the antenna switch (130). This means that a small residual RF signal can be present at an input terminal (e.g. S1) of the antenna switch (130) which can be provided to the antenna for transmission to the air. According to another embodiment of the present disclosure, added isolation of the RF signal to the antenna (140) can be provided, during a calibration phase of the transmit path as depicted in FIG. 3A, by disconnecting, via the antenna switch (130), connection to the transmit path being calibrated. This is depicted in FIG. 3B, wherein the transmission path is being calibrated and the RF signal conducted into the termination load (330) is isolated from the antenna (140) via switch (320) and switch (130). For example, a typical transmitted output power for a universal mobile telecommunications system (UMTS) or a long term evolution (LTE) channel is around +24 dBm and a maximum allowed transmit power for a radio not transmitting can be around -33 dBm. Therefore, in such configuration a switch isolation requirement can be defined to be greater than 24+33 dB=57 dB, which can be provided by the combination isolation provided by the antenna switch (130) and the switch (320) as depicted in FIG. 3B. The switch (320) can provide an isolation equal to or greater than about 25 dB, and the combined isolation

provided by the antenna switch (130) and the switch (320) can be equal to or greater than about 57 dB. As used herein, an isolation can be defined by an attenuation, in dB, between an RF signal power level at a common terminal of the switch, and an RF power level at a switching terminal of the switch, when the switching terminal is not connected via the switch to the common terminal.

[0046] Such calibration scheme as provided by the embodiments depicted in FIGS. 3A and 3B and described in the previous sections of the present disclosure, can allow to feed various calibration RF signals (e.g. patterns) to an RF transmit path, at various levels of powers, as required by a calibration routine run during the calibration phase, with minimum transmitted RF power at the antenna (140), such as not to violate the various regulations governing unintentional RF transmission powers. Such calibration routine and associated calibration RF signals can be provided, for example, by the transceiver unit (110) or other dedicated signal processor.

[0047] The combination of a switchable load impedance, whose function can be provided by a combination of a switch (e.g. 320) and a terminating impedance (e.g. resistor 330), and the signal coupling device (e.g. 310), can be inserted at any point of the various transmit paths of the RF front-end stage (100) of FIG. 1. According to some embodiments of the present disclosure and as depicted in FIG. 3C, such combination can be inserted after an adjusting element (360) of a transmission path, such as to allow performing some adjustment of the RF signal as being monitored. The adjusting element (360) can be a power amplifier (PA1-PA6), a filter (F1-F6), or a duplexer (D1-D7), all of which are readily available elements of the RF front-end stage (100) depicted in FIG. 1. As previously discussed in the present disclosure, and as further explained in the various references previously mentioned, such elements can be made adjustable. For example, filters can be made adjustable by using adjustable reactive components, such as, for example, digitally tunable capacitors and digitally tunable inductors as described in the International Application No. PCT/US2009/001358 and in the U.S. patent application Ser. No. 13/595,893, some implementation of which are described in, for example, the U.S. patent application Ser. No. 13/595,893 and the U.S. patent application Ser. No. 13/967,866. Also, a power amplifier can be made adjustable by using, for example, the previously discussed configuration provided in FIG. 2B, or a scalable periphery amplifier with optional tunable matching elements coupled to its input and/or output, as described in, for example, U.S. patent application Ser. No. 13/797,779, U.S. patent application Ser. No. 14/042,312, U.S. patent application Ser. No. 13/967,866 and U.S. patent application Ser. No. 13/797,686. The adjusting element (360) of FIG. 3D can be any of the adjusting components of the power amplifier, such as, for example, any of (250, 260, 270, 280 and 290) of FIG. 2B. Furthermore, several combination switchable load impedances (310, 320) can be inserted each following one of the adjustable elements (250, 260, 270, 280 and 290) of the configuration depicted in FIG. 2B, such as depicted in FIG. 3E. In the exemplary embodiment according to the present disclosure as depicted in FIG. 3E, each of the switchable load impedances (370) can be used to terminate the transmit path at a point of the switchable load and allow to monitor via an associated RF coupling device (310) the terminated RF signal at that point. Furthermore, adjustments to an adjustable element (360) of the transmit path (e.g. placed prior to the switch 370 and the coupling device 310) by a controller can allow to

calibrate the transmit path up to the point of termination provided by the switchable load. As such, calibration of the transmit path at various points of the transmit path is provided via the plurality of the switchable load impedances.

[0048] According to an embodiment of the present disclosure, FIG. 4A depicts a configuration wherein the switchable load impedance (e.g. 420 and 330) is provided after the antenna switch (130). In the configuration depicted by FIG. 4A, the switchable load impedance is provided in a portion of the transmission path common to all the transmit paths of the RF front-end (100). This configuration allows to calibrate all transmit paths in their entirety (e.g. except the actual antenna load) using a same switchable load impedance (420, 330) and a signal coupling device (310). For example, to calibrate an RF transmit path using the configuration depicted in FIG. 4A, the switching load (330) can be first inserted into the common transmit path and consequently isolating the antenna from the transmit path, then activating a transmit path to be calibrated via the various controlling elements as depicted in the RF front-end stage of FIG. 1, such as the various switches and power amplifiers, and finally performing the calibration of the selected transmit path by feeding various calibration signals to the activated transmit path and adjusting the various adjustable elements of the selected transmit path using the feedback provided by the monitoring RF signal (e.g. at terminal 440) provided by the RF signal coupling device (310). In contrast, in order to allow calibration of all transmit paths of the RF front-end stage (100) using the configuration depicted in FIG. 3B, a same switchable load impedance (320, 330) and signal coupling device (310) must be provided for each of the transmit paths.

[0049] The embodiment according to the present disclosure as depicted in FIG. 4A can minimize the number of switchable impedance loads (420, 330) and signal coupling devices (310) required to calibrate the various transmit paths of the RF front-end stage (100) of FIG. 1. It can also allow for a higher precision of calibration, as the calibration is performed on the RF signal right at the antenna (140), as opposed to an RF signal at a point further away from the antenna (140), as measured, for example, by number of active and passive elements of the transmission path between the antenna and the calibration point. For example, the configuration according to the present disclosure and as depicted in FIG. 4A includes the duplexer (210) and antenna switch (130) as part of a calibration and tuning adjustment based on a signal provided at terminal (440).

[0050] Furthermore, and according to an embodiment of the present disclosure, isolation of the calibration RF signal into the antenna (140) can be further increased by adding more switches between the antenna and the switchable load impedance. For instance, in the embodiment depicted by FIG. 4A, a single switch (420) provides the isolation between the RF calibration signal into the terminating load (330) and the antenna (140). Further isolation can be provided by inserting another switch between the antenna (140) and the terminating load (330) as depicted in FIG. 4B.

[0051] As the RF signal coupling device (310) can affect an amplitude of the RF signal being transmitted, it may be desirable not to have the coupling device as integral part of the transmit path. It follows that according to an embodiment of the present disclosure, the RF signal coupling device (310) can be switched into the transmit path only during a calibration phase, such as depicted in FIG. 5. In the embodiment according to the present disclosure depicted in FIG. 5, the RF

signal coupling device (310) is switched into the transmit path at the same time as the terminating load (330) via the switch (420).

[0052] The various active and passive elements in the various transmit paths of the RF front-end stage (100) of FIG. 1 can be designed for a nominal working impedance of 50 Ohms. FIG. 6A shows an equivalent AC signal circuit of a transmit path of the RF front-end stage (100), comprising an AC voltage source (610) which provides a signal to a load impedance (620) over a transmit path (605) of nominal impedance (e.g. same value as the load impedance). The load impedance can represent the antenna (140) of the RF front-end stage (100), the voltage source can be the equivalent circuitual representation of a power amplifier module (PA1-PA7) of the RF front-end stage (100), and the transmit path can represent the combination of all other components in the path. The skilled person will know that providing a branch of impedance (630) sufficiently higher than the nominal transmit path impedance (e.g. >1K Ohms) can have a negligible impact on the RF signal integrity at the load (620) (e.g. antenna) of the transmit path depicted in FIG. 6A, while providing a sample of the RF signal at the end of the branch (e.g. terminal 640). Accordingly and pursuant to another embodiment of the present disclosure, FIG. 6B depicts an RF signal monitoring scheme according to an embodiment of the present disclosure which can be used during an active transmission phase of the RF front-end stage with minimal impact on the integrity of the transmitted RF signal. The RF signal sampled by the sampling resistor (630) and provided at the terminal (640) can be monitored during a transmission phase and adjustments to the various adjustable elements in a corresponding active transmit path can be made accordingly, as discussed in prior sections. The switch (420) can be provided to decouple, if needed, the sampling resistor (630) from the transmit path. If desired, and according to further embodiments of the present disclosure, the switch (420) and/or the sampling resistor (630) can be monolithically integrated with the antenna switch (130), as depicted by module (650) of FIG. 6C.

[0053] By way of further example and not limitation, the switching impedance load (330) can present a 50Ω impedance, which is a common standard in RF circuit design. Furthermore, any switch or switching circuitry of the present disclosure, such as switches (130, 320, 420, 420a) shown in the various figures of the present disclosure can be implemented using transistors, stacked transistors (FETs), diodes, or any other devices or techniques known to or which can be envisioned by a person skilled in the art. In particular, such switching circuitry can be constructed using CMOS technology and various architectures known to the skilled person, such as, for example, architecture presented in U.S. Pat. No. 7,910,993, issued on Mar. 22, 2011 and entitled “Method and Apparatus for use in Improving Linearity of MOSFET’s using an Accumulated Charge Sink”, and in U.S. Pat. No. 6,804,502, issued on Oct. 12, 2004 and entitled “Switch Circuit and Method of Switching Radio Frequency Signals”, both incorporated herein by reference in their entirety. FIG. 7 shows an exemplary embodiment of a single-pole single-throw switch with stacked transistors, which the skilled person can use as an elementary component of the various switches used in the various embodiments according to the present disclosure.

[0054] Although FETs (e.g. MOSFETs) can be used to describe transistor and stacked transistor switches used in the

various embodiments of the present disclosure, a person skilled in the art would recognize that either P-type or N-type MOSFETs may be used. The skilled person would also recognize that other types of transistors such as, for example, bipolar junction transistors (BJTs) can be used instead or in combination with the N-type or P-type MOSFETs. Furthermore, a person skilled in the art will also appreciate the advantage of stacking more than two transistors, such as three, four, five or more, provide on the voltage handling performance of the switch. This can for example be achieved when using non bulk-silicon technology, such as insulated silicon on sapphire (SOS) technology and silicon on insulated (SOI) technology. In general, the various switches used in the various embodiments of the present disclosure, including when monolithically integrated with the dummy load and other components (e.g. as discussed later), can be constructed using CMOS, silicon germanium (SiGe), gallium arsenide (GaAs), gallium nitride (GaN), bipolar transistors, or any other viable semiconductor technology and architecture known, including micro-electro-mechanical (MEM) modules. Additionally, different device sizes and types can be used within a stacked transistor switch such as to accommodate various current handling capabilities of the switch.

[0055] According to the various embodiments of the switchable impedance load, a switch configured to terminate a transmit path at a calibration point with a load equivalent to what the transmit path sees at the calibration point during normal operation (e.g. RF signal transmission), is inserted at the calibration point of the transmit path of an RF front-end stage. The switch is coupled to the terminating load, and the terminating load may be external to the switch or internal (e.g. monolithically integrated with the switch), as depicted by the various figures of the present disclosure. A configuration with an external terminating load to the switch can provide the flexibility of easier power handling as larger size resistors can be used for enhanced power dissipation.

[0056] According to an embodiment of the present disclosure, the terminating load of the switchable impedance load can be monolithically integrated with the switch, such as to provide a more compact profile of the assembly. Such monolithic integration of the switch and the terminating load is depicted in FIG. 3D, wherein the switchable impedance load module (370) comprises the switch (320) and the terminating load (330). Although not shown in the FIG. 3D, according to a further embodiment of the present disclosure, the RF signal coupling device (310) may also be monolithically integrated within the module (370). The skilled person knows of various circuitries adapted to function as the RF signal coupling device, such as, for example, a directional coupler or a capacitive coupler.

[0057] According to a further embodiment of the present disclosure, the switchable impedance load can be monolithically integrated within a power amplifier, such as, for example, a power amplifier (SP1, . . . , SP6) of the RF front-end stage (100) of FIG. 1. Accordingly, FIG. 3F depicts such embodiment according to the present disclosure, wherein the RF signal coupling device (310), the switch (320) and the terminating load impedance (330) are monolithically integrated in a power amplifier module (390), which further comprises power amplifier stages (250) and (260). As previously mentioned, more than one such switchable impedance load can be provided, for example following an adjustable element of the amplifier stage (250, 260) (e.g. as depicted in FIG. 2B). According to further embodiments of the present disclosure,

the terminating load (330) of the amplifier module (390) can be provided external to the amplifier module (390), such as to provide more flexibility in size (e.g. power dissipation) of the terminating load (330).

[0058] According to another exemplary embodiment of the present disclosure, the antenna switch (130) of the RF front-end stage (110) and the switchable impedance load (420, 330) can be monolithically integrated, as depicted by module (470) of FIG. 4B. In the exemplary embodiment presented in FIG. 4C, the RF signal coupling device is placed in front of the antenna switch (130), and thus the monitor signal detected at terminal (440) of FIG. 4C does not include an effect of the switch (130) on the transmit path terminated at the switched load (330). Accordingly, a further exemplary embodiment of the present disclosure can comprise the RF signal coupling device (310) monolithically integrated within the antenna switch (130), as depicted by module (480) of FIG. 4D.

[0059] The examples set forth above are provided to give those of ordinary skill in the art a complete disclosure and description of how to make and use the embodiments of the present disclosure, and are not intended to limit the scope of what the inventors regard as their disclosure. Modifications of the above described modes for carrying out the disclosure may be used by persons of skill in the art, and are intended to be within the scope of the following claims. All patents and publications mentioned in the specification may be indicative of the levels of skill of those skilled in the art to which the disclosure pertains. All references cited in this disclosure are incorporated by reference to the same extent as if each reference had been incorporated by reference in its entirety individually.

[0060] It is to be understood that the disclosure is not limited to particular methods or systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting. As used in this specification and the appended claims, the singular forms “a”, “an”, and “the” include plural referents unless the content clearly dictates otherwise. The term “plurality” includes two or more referents unless the content clearly dictates otherwise. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the disclosure pertains.

[0061] A number of embodiments of the disclosure have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the present disclosure. Accordingly, other embodiments are within the scope of the following claims.

1. A radio frequency (RF) circuitual arrangement configured to transmit an RF signal at an output RF transmit port via one or more RF transmit paths, wherein a transmit path of the one or more transmit RF paths comprises:

one or more adjustable RF devices configured during operation to affect one or more characteristics of the RF signal; and

a terminating switch positioned between an adjustable RF device of the one or more adjustable RF devices and the output RF transmit port,

wherein:

during a first mode of operation of the RF transmit path, the terminating switch is configured to couple the RF signal to the output RF transmit port, and

during a second mode of operation of the RF transmit path, the terminating switch is configured to isolate the RF signal from the output RF transmit port and terminate the RF signal into a terminating load connected to a terminating terminal of the terminating switch.

2. The RF circuitual arrangement of claim 1, further comprising an output switch, wherein the output switch is configured to couple a selected RF transmit path of the plurality of RF transmit paths to the output RF transmit port and isolate a remaining RF transmit paths of the plurality of RF transmit paths from the output RF transmit port.

3. The RF circuitual arrangement of claim 1, wherein an isolation provided by the terminating switch with respect to the output RF transmit port during the second mode of operation is equal to or greater than about 25 dB.

4. The RF circuitual arrangement of claim 2, wherein a combined isolation provided by the terminating switch and the output switch during the second mode of operation of the RF transmit path of the plurality of RF transmit paths with respect to the output RF transmit port is equal to or greater than about 57 dB when the output switch isolates the transmit path from the output RF transmit port.

5. The RF circuitual arrangement of claim 1, wherein during the first mode of operation of the RF transmit path the terminating switch connects the RF signal at a common terminal of the terminating switch to a switching terminal of the terminating switch such as to provide a low resistance conduction path to the output RF transmit port, and wherein during the second mode of operation of the RF transmit path the terminating switch connects the RF signal at the common terminal of the terminating switch to the terminating terminal.

6. The RF circuitual arrangement of claim 4, further comprising an RF coupling device operatively coupled to the transmit path of the plurality of transmit paths at a coupling point between the terminating switch and the adjustable RF device, wherein the RF coupling device is configured to sense an RF signal at the coupling point.

7. The RF circuitual arrangement of claim 6, further comprising a controller unit configured to select a mode of operation of the RF transmit path and adjust the one or more adjustable RF devices based on a characteristic of the one or more characteristics of a sensed RF signal during the second mode of operation, wherein the mode of operation comprises the first mode of operation and the second mode of operation.

8. The RF circuitual arrangement of claim 7, wherein the controller unit is further configured to control the output switch.

9. The RF circuitual arrangement of claim 7, wherein the second mode of operation is a calibration mode used to calibrate the selected transmit path and wherein the sensed RF signal is based on an RF test signal of one or more RF test signals suitable for detecting the characteristic of the one or more characteristics of the sensed RF signal.

10. The RF circuitual arrangement of claim 9, wherein the controller unit is further configured to generate the one or more RF test signals, and to select, during the calibration mode, the RF test signal of the one or more RF test signals.

11. The RF circuitual arrangement of claim 9, wherein an adjustment of the one or more adjustable RF devices during the calibration mode of the selected transmit path provides a desired operating characteristic of the one or more adjustable RF devices for the first mode of operation, wherein the desired operating characteristic is in correspondence of a

desired characteristic of the one or more characteristics of the RF signal during the first mode of operation.

12. The RF circuitual arrangement of claim **9**, wherein during the second mode of operation the controller unit is further configured to control the output switch to isolate the RF transmit path from the output RF transmit port.

13. The RF circuitual arrangement of claim **9**, wherein the characteristic of the sensed RF signal comprises one or more of: a) an amplitude, b) a power level, c) a DC content, d) linearity, e) a phase shift, f) a harmonic frequency content, and g) an adjacent channel leakage ratio (ACLR) of the sensed RF signal.

14. A radio frequency (RF) circuitual arrangement configured to transmit an RF signal at an output RF transmit port, the RF circuitual arrangement comprising:

an output switch comprising a plurality of switching terminals and a common terminal, wherein the common terminal is operatively coupled to the output RF transmit port;

a plurality of RF transmit paths comprising one or more adjustable RF devices and configured, during operation, to transmit the RF signal, wherein the plurality of RF transmit paths are coupled to the plurality of switching terminals; and

a terminating switch positioned between an adjustable RF device of the one or more adjustable RF devices and the output RF transmit port,

wherein:

during a first mode of operation of the RF circuitual arrangement, the terminating switch is configured to couple the RF signal to the output RF transmit port, and

during a second mode of operation of the RF circuitual arrangement, the terminating switch is configured to isolate the RF signal from the output RF transmit port and terminate the RF signal into a terminating load connected to a terminating terminal of the terminating switch.

15. The RF circuitual arrangement of claim **14**, wherein an isolation provided by the terminating switch during the second mode of operation with respect to the output transmit port is equal to or greater than about 25 dB.

16. The RF circuitual arrangement of claim **14**, wherein during the first mode of operation the output switch is configured to couple the RF signal to the output RF transmit port, and during the second mode of operation the output switch is configured to isolate the RF signal from the RF transmit port.

17. The RF circuitual arrangement of claim **16**, wherein a combined isolation provided by the terminating switch and the output switch with respect to the output RF transmit port during the second mode of operation is equal to or greater than about 57 dB.

18. The RF circuitual arrangement of claim **14**, wherein the terminating switch is positioned between the common terminal of the output switch and the output RF transmit port.

19. The RF circuitual arrangement of claim **18**, further comprising an RF coupling device operatively coupled to the terminating switch at a coupling point, wherein the RF coupling device is configured to sense an RF signal at the coupling point.

20. The RF circuitual arrangement of claim **19**, wherein the coupling point is positioned between the terminating terminal of the terminating switch and the terminating load.

21. The RF circuitual arrangement of claim **19**, wherein the coupling point is positioned between the common terminal of the output switch and the common terminal of the terminating switch.

22. The RF circuitual arrangement of claim **18**, further comprising an isolation switch positioned between the terminating switch and the output RF transmit port.

23. The RF circuitual arrangement of claim **22**, wherein the terminating switch and the isolation switch combined provide an isolation with respect to the output RF transmit port equal to or greater than about 57 dB.

24. A monolithically integrated radio frequency (RF) circuit comprising:

an RF switch comprising a common terminal and a plurality of switching terminals, wherein during operation the switch is adapted to connect a selected switching terminal of the plurality of switching terminals to the common terminal, and

a resistor connected via a first terminal of the resistor, to a terminating switching terminal of the plurality of switching terminals, wherein the RF switch and the resistor are monolithically integrated on a same integrated circuit.

25. The monolithically integrated RF circuit of claim **24**, further comprising one or more RF devices comprising of: a) an RF power amplifier, and b) an RF filter network.

26. The monolithically integrated RF circuit of claim **25**, wherein an RF device of the one or more RF devices is adjustable.

27. An RF circuitual arrangement comprising the monolithically integrated RF circuit of claim **24**.

28. The RF circuitual arrangement of claim **27**, wherein a second terminal of the resistor is connected to one of: a) ground, and b) a measuring device.

29. The monolithically integrated RF circuit of claim **24**, wherein the monolithically integrated RF circuit is fabricated using a technology comprising one of: a) silicon on sapphire, b) silicon on insulator, and c) bulk-silicon.

30. A method for calibrating a transmit path of a radio frequency (RF) front-end stage, the method comprising:

providing a switchable load impedance in a transmit path; during a calibration of the transmit path, terminating the transmit path at the switchable load impedance;

based on the terminating, reducing an output RF signal power at an output antenna of the transmit path;

based on the terminating, measuring an RF signal characteristic at the switchable load impedance;

based on the measuring, adjusting an adjustable RF device of the transmit path, and

based on the adjusting, calibrating the transmit path,

wherein the reducing provides an output RF signal power at the output antenna of the transmit path lower than a desired RF transmission power.

31. The method of claim **30**, wherein the desired RF transmission power is a locally regulated unintentional RF transmission power.

32. The method of claim **30**, wherein the reducing provides an output RF signal power at the output antenna of at least 57 dB below an output RF signal power at the output antenna when the transmit path is not terminated at the switchable load impedance.

33. The method of claim **32**, wherein the terminating further comprises switching an antenna switch such as further reducing the output RF signal power at the output antenna.

34. A method for calibrating a transmit path of a radio frequency (RF) front-end stage, the method comprising:

providing an RF front-end stage comprising one or more transmit paths, wherein each transmit path of the one or more transmit paths is adapted to be connected to a transmit port via an output RF switch;

providing one or more RF switches, wherein an RF switch of the one or more RF switches is adapted to provide a series connection between two RF components of a transmit path of the plurality of transmit paths via a common terminal of the RF switch and a first switching terminal of the RF switch;

selecting a transmit path of the plurality of transmit paths for transmission of an RF signal at the transmit port;

configuring the output switch to connect the selected transmit path to the output port;

configuring at least a subset of the one or more RF switches to provide series connections between two RF components of the selected transmit path;

providing the RF signal to the selected transmit path;

transmitting the RF signal based on the providing of the RF signal;

calibrating the selected transmit path by performing the following steps:

- i) configuring an RF switch of the one or more RF switches to disable a series connection between two RF components of the selected transmit path,
 - ii) based on the configuring, terminating the selected transmit path at a resistor load connected to a second switching terminal of the RF switch,
 - iii) sensing an RF signal at the resistor load,
 - iv) based on the sensing, adjusting an adjustable RF component of the selected transmit path, and
 - v) configuring the RF switch of the one or more RF switches to provide series connection between the two RF components of the transmit path; and
- based on the calibrating, obtaining a desired signal characteristic of the transmitted RF signal.

35. The method of claim **34**, further comprising maintaining the desired signal characteristic by repeating the calibrating of the selected transmit path.

36. The method of claim **34**, wherein the desired signal characteristic comprises one or more of: a) an amplitude, b) a power level, c) a DC content, d) linearity, e) a phase shift, f) a harmonic frequency content, and g) an adjacent channel leakage ratio (ACLR) of the transmitted RF signal.

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