MSM89x7 RF Software Overview

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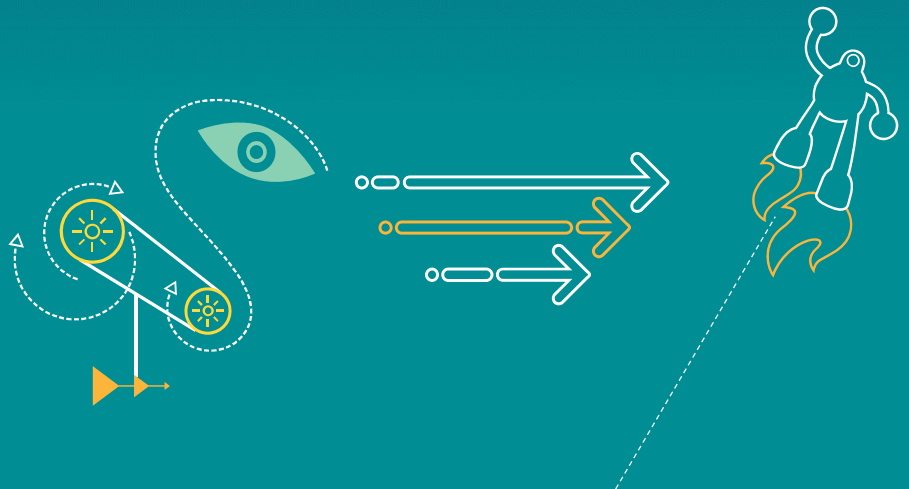

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Revision History

Revision	Date	Description
A	October 2015	Initial release
B	December 2015	Numerous changes were made to this document; it should be read in its entirety
C	February 2016	Updated slide 10 and 18

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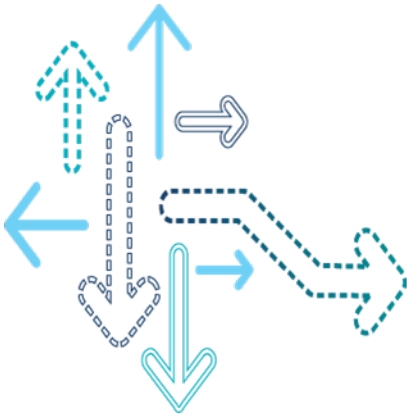
MSM89x7 Introduction



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MSM89x7 Introduction

Core PMIC/Codec

PM8937

Wi-Fi

WCN 3615
WCN3660B
WCN 3680B

12x14 mm2

MSM8937/MSM8917

Interface PMIC

PMI8937

PMI8952

Codec option

WCD 9326

WSA option

WSA 8810

RF transceiver

LTE

WTR 2965

CA

WTR 2965

GPS (for APQ)

WGR 7640

RF

LB/MB/GSM PA + AS

QFE 4320

HB PA

QPA 2340

Antenna tuners

QFE 2550

Antenna switch

QFE 1040

GSM/HB PA +AS

QPA 4373

LB/MB PA

QFE 430X

APT

QFE 2101

NFC

NQ 210

NFC + eSE

NQ 220

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MSM89x7 Introduction (cont.)

Features		MSM89x7 – February 16, 2016 CS
Process		28 nm LP
Package		12x14 mm^2 (non-PoP)
CPU		▪ For performance 4xA53 at 1.4 GHz, 512 KB L2 ▪ For power 4xA53 at 1.1 GHz, 512 KB L2
Memory		1x32 bit LPDDR3 800 MHz
Modem + Nav		▪ MPSS.JO LTE Cat 4, 2x10 carrier aggregation (CA) ▪ Gen8C Lite – GPS/Glonass/Beidou/Galileo
Apps DSP		Hexagon™ processor v56 256 KB 691 MHz
GPU	GPU	Adreno 505, 450 MHz
	APIs	OpenGL ES 3.1+, CL2.0f, 2D, DX12, and AEP
Display	Resolution	SDE515 – 1900x1200 60 fps UI + 1080p30, UBWC
	Interface	Dual DSI 4 lanes
Camera	Performance	▪ Dual ISP at 600+ MPps, 8 MP + 8 MP ▪ 21 MP at 30 zero shutter lag (ZSL), WNR, enhanced AF, LTM, JPEG, and PDAF
	Interface	CSI2, 4+4 lanes and DPHY1.1

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MSM89x7 Introduction (cont.)

Features		MSM89x7 – February 16, 2016 CS
Video	Decode	1080p30 H.264, HEVC
	Encode	1080p30 H.264
	Encode and decode	720p30 decode + 720p30 encode
Audio	Analog	Integrated 112+ dB, -90 dB, upsell with WCD93xx
	Interface	I2S, SLIMbus
	Audio	HD audio playback (192 KHz)
	Voice	Fluence™ v6, EVS at 32 KHz
Sensor		ADSP-based
Storage		eMMC 5.1, SD 3.0 (SDCC)
Peripherals		1x USB 2.0, 8x BLSP, I2S, SLIMbus
Security		SecureMSM™ ARM, StudioAccess with CPZ for GPU/DSP, Certicom, CRI, and safe switch
Bluetooth/WLAN/FM		802.11 b/g/n with WCN3615; 802.11 ac with WCN3680B
PMIC		PM8937 + PMI8952/PMI8937

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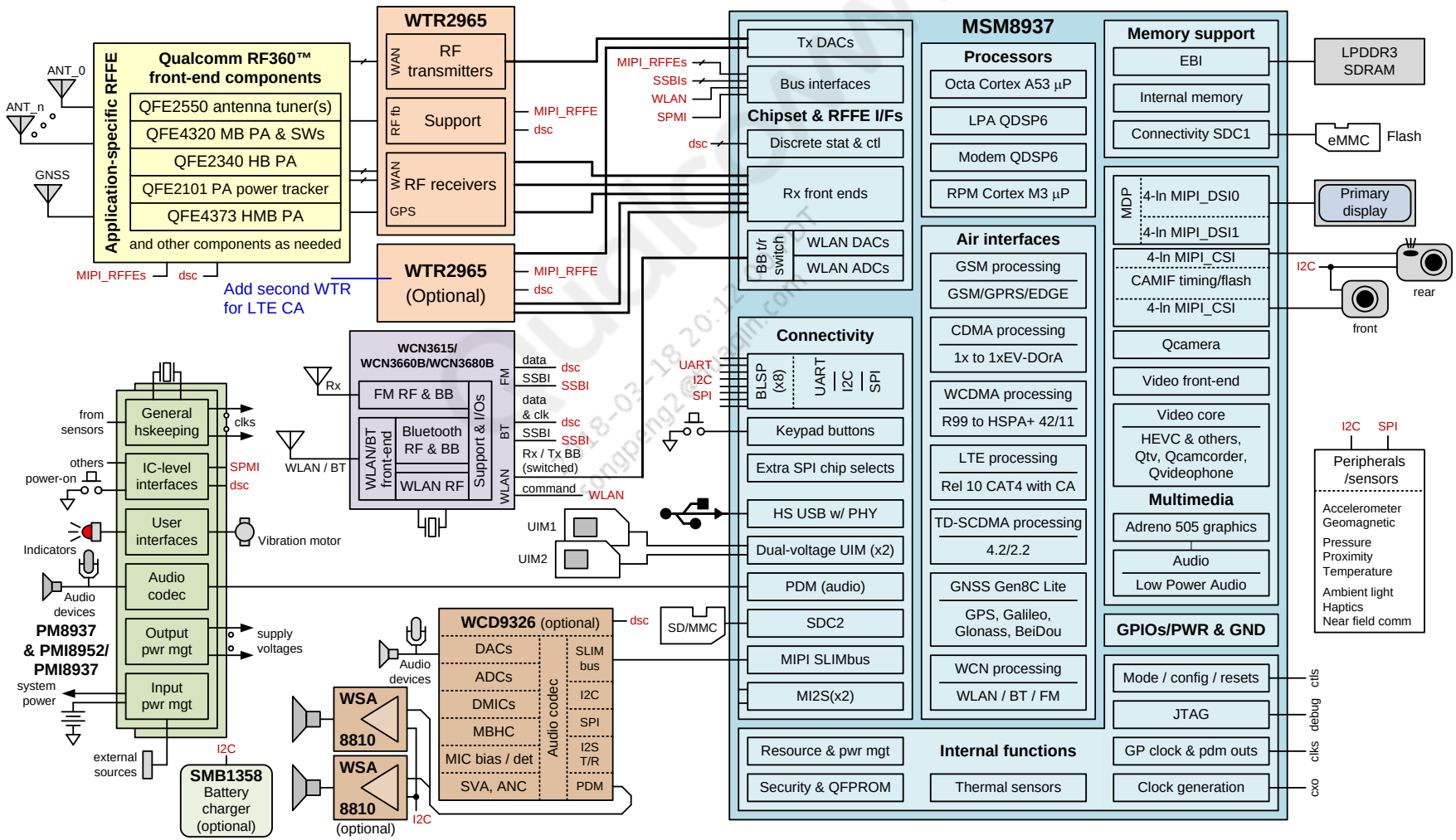
MSM8937 Functional Block Diagram



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Modem – RF Features

- Supports high performance applications worldwide using various wireless networks, e.g.:
  - GERAN MSC 33 (GSM/GPRS/EDGE)
  - cdma2000 1X, 1x Advanced, and 1xEV-DOrA
  - WCDMA Rel 99 to Rel 9
  - TD-SCDMA with 4.2 Mbps downlink and 2.2 Mbps uplink options
  - LTE Cat 4, including 2x10 MHz DL CA (MSM89x7, two WTR2965 ICs)
- DC-HSPA+
- Support for dual SIM dual standby (DSDS)
- No closed loop tuner via FBRx
- Support for APT, APT + DPD (no support for ET)
- MPSS.JO.1.2 supports RF driver for WTR2965 RFICs
- Support for Qualcomm Technologies, Inc. (QTI) RF Frontend (RFFE) devices QFE2340, QFE4320, QFE4373, QFE430x, QFE2550, QFE2101, and QFE1040
- Inter-band CA through ICI is not supported
- SAWLESS feature for GSM and TD-SCDMA is not supported

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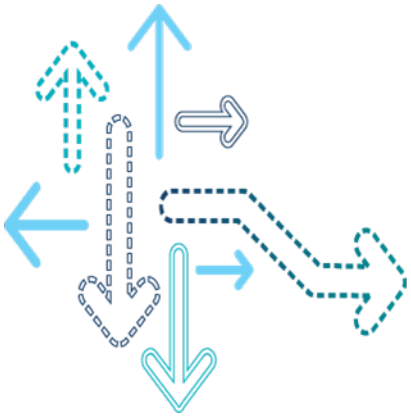
WTR2965 Introduction



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WTR2965 Band Support

Band name	LTE-FDD	LTE-TDD	WCDMA	TD-SCDMA	CDMA	GSM
IMT (2100)	B1	—	B1	—	BC6	—
PCS (1900)	B2	—	B2	—	BC1	1900
DCS (1800)	B3	—	B3	—	—	1800
AWS	B4	—	B4	—	BC15	—
CELL (850)	B5	—	B5	—	BC0	850
JCELL (800)	B6	—	B6	—	—	—
IMT-E (2600)	B7	—	—	—	—	—
EGSM (950)	B8	—	B8	—	—	900
J1700	B9	—	B9	—	—	—
EAWS	B10	—	—	—	—	—
PDC (1500)	B11	—	—	—	—	—
700 lower A-C	B12	—	—	—	—	—
700 upper C	B13	—	—	—	—	—
700 upper D	B14	—	—	—	—	—
700 lower B-C	B17	—	—	—	—	—
B18	B18	—	—	—	—	—
B19	B19	—	—	—	—	—
EU800	B20	—	—	—	—	—
PDC	B21	—	—	—	—	—
S-band	B23	—	—	—	—	—

Band name	LTE-FDD	LTE-TDD	WCDMA	TD-SCDMA	CDMA	GSM
B24	B24	—	—	—	—	—
PCS+G	B25	—	—	—	BC14	—
B26	B26	—	—	—	—	—
US 800	B27	—	—	—	—	—
700 APAC	B28	—	—	—	—	—
FLO	B29	—	—	—	—	—
WCS	B30	—	—	—	—	—
B32	B32	—	—	—	—	—
B33	—	B33	—	—	—	—
B34	—	—	—	B34	—	—
B35	—	B35	—	—	—	—
B36	—	B36	—	—	—	—
B37	—	B37	—	—	—	—
B38	—	B38	—	—	—	—
B39	—	B39	—	B39	—	—
B40	—	B40	—	B40	—	—
B41/B41-XGP	—	B41/B41-XGP	—	—	—	—
B44	—	B44	—	—	—	—
KPCS	—	—	—	—	BC4	—
Sec 800	—	—	—	—	BC10	—

Note: WTR2965 supports 3GPP2 CDMA 1X to DOrA, 3GPP WCDMA Rel 99 to DC-HSPA+, 3GPP GSM to EDGE, and TD-SCDMA (highlighted in orange). WTR2965 adds 3GPP LTE FDD and TDD (highlighted in green). The air interface features supported by the chipset depend on the modem IC, while the RFFE and the WTR2965 transceiver IC define the chipset's operating bands.

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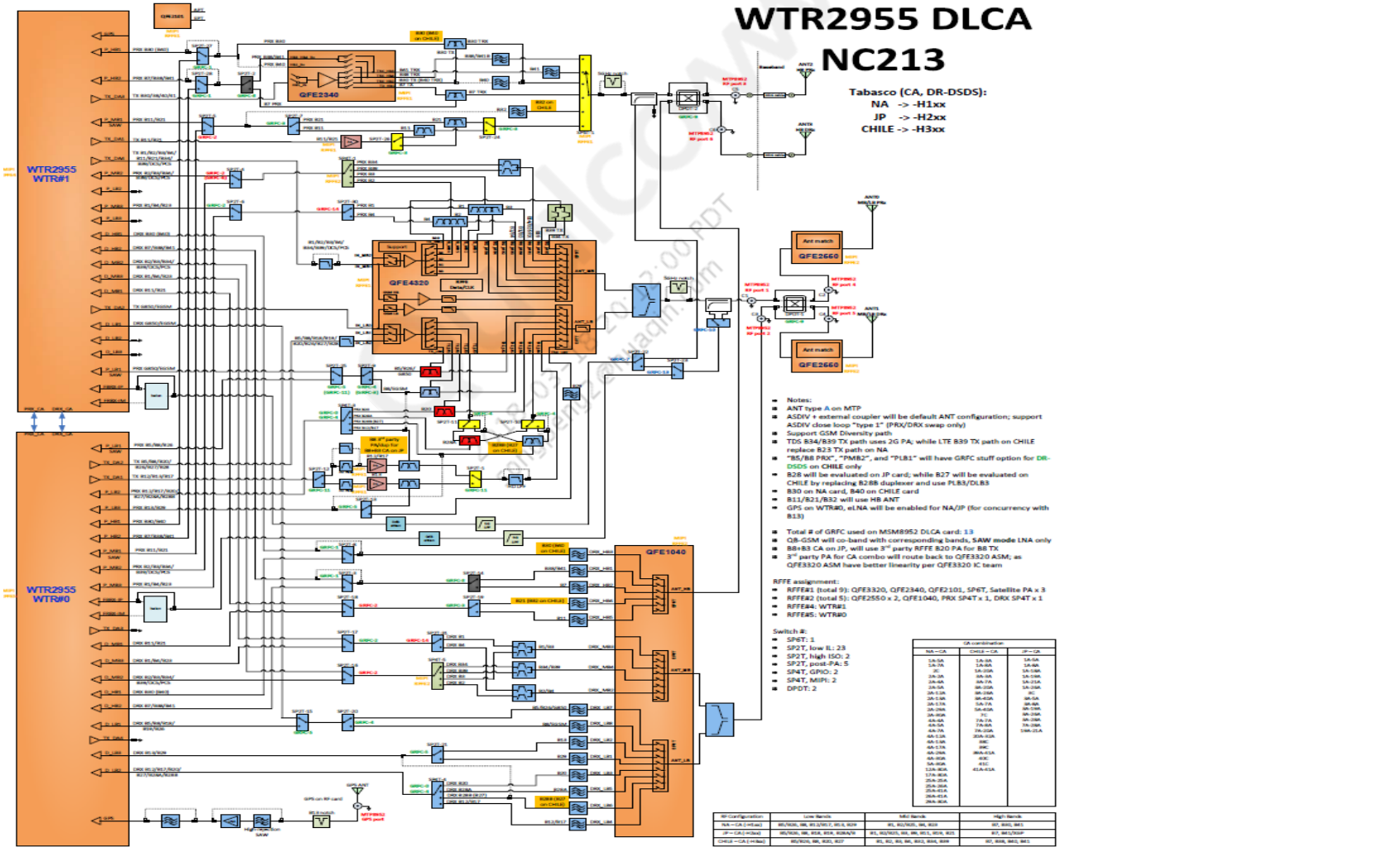
CHILE/JP/NA CA Reference Design



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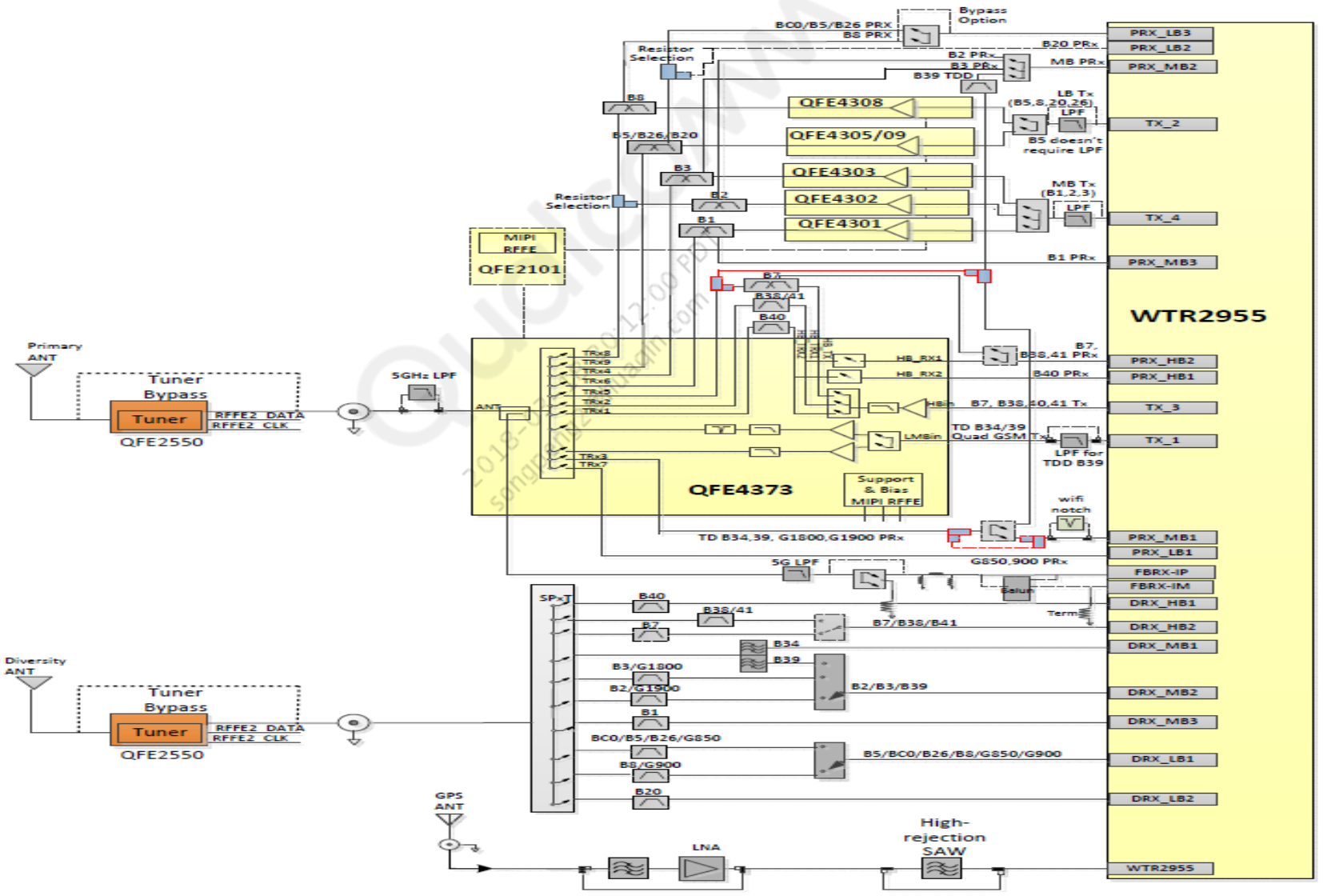
CHILE Non-CA Reference Design



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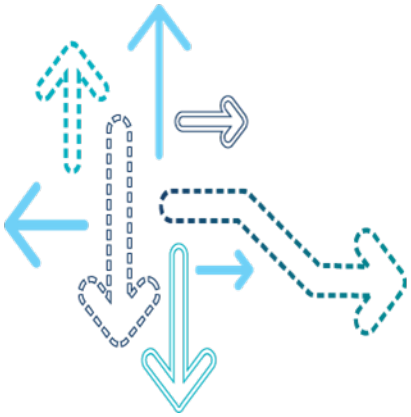
RF Software Overview



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RF Software Overview

- MPSS.JO.1.2 RF software is derived from MPSS.JO.1.1
- RF software provides services to the higher layer clients such as L1
- Supports Factory Test Mode (FTM) for development, testing, calibration, and nonsignaling support
- Controls RF devices for band or frequency selection, e.g., tuning, RF gain control
- Programs RF-related MSM™ blocks, e.g., Rx front, RxAGC, TxAGC
- Manages current consumption of RF devices on standby
- Applies algorithms for Tx power and temperature and frequency compensation
- Manages the RFC-CCS events; the RFC-CCS task queues and event tasks data such as requirements to merge tasks into single issue sequence

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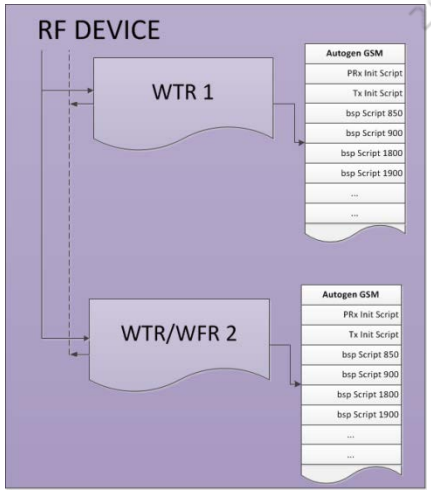
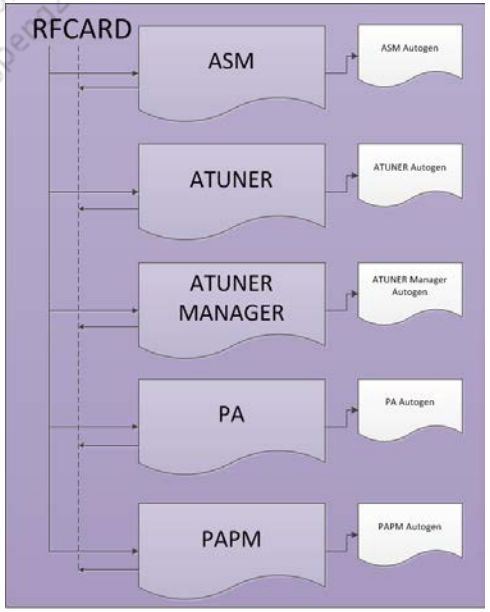
RF Software Overview (cont.)

- Depending on the command from L1, RF software can extract data, perform calculations, generate scripts, and create RFC-CCS events to program all the related RF devices.
- RF software has RF card block and RF device block, two internal blocks that extract and program device-specific settings.
- The scripts generated are packaged into a structure format called an RFC-CCS event. The RFC event is populated into the Radio Frequency Link Manager (RFLM) data manager for later extraction during a firmware→RFLM call flow.





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RFC Configuration

Card name	RF_HWID	Bands supported (POR)	RF360	SKU
WTR2965_CHILE_CA_4320	18	▪ GSM – GSM850, EGSM, DCS, PCS ▪ cdma2000 – BC0 ▪ WCDMA – B1, B2, B5, B8 ▪ TD-SCDMA – B34, B39 ▪ LTE – B1, B2, B3, B5, B7, B8, B20, B27, B28, B38, B40 ▪ LTE DL CA – 1A-3A	WTR2965 + QFE2101 + QFE2340 + QFE4320 + QFE1040 + QFE2550	India, SEA, ATAM, Eastern EU, EU, CT, CU, and CMCC
WTR2965_NA_CA_4320	19	▪ GSM – GSM850, EGSM, DCS, PCS ▪ cdma2000 – BC0, BC1, BC10, BC14, BC15 ▪ WCDMA – B1, B2, B4, B5, B8 ▪ LTE – B2, B4, B5, B7, B12, B13, B17, B25, B26, B29, B30, B41 ▪ LTE DL CA – 2A-12A, 2A-5A, 25A-26A, 17A-30A, 12A-30A, 5A-30A, 4A-29A, 4A-30A, 4A-17A, 2A-30A, 4A-13A, 4A-12A, 4A-5A, 2A-29A, 2A-17A, 2A-13A, 2A-4A, 4A-4A, 25A-25A, 29A-30A	WTR2965 + QFE2101 + QFE2340 + QFE4320 + QFE1040 + QFE2550	Verizon, AT&T, Sprint, MetroPCS, Leap, Cellular South, US Cellular, and Canada
WTR2965_JP_CA_4320	20	▪ GSM – GSM850, EGSM, DCS, PCS ▪ cdma2000 – BC0, BC1, BC6, BC10 ▪ WCDMA – B1, B3, B5, B6, B8, B9, B11, B19 ▪ LTE – B1, B3, B5, B8, B11, B18, B19, B21, B26, B28, B41, B41 XGP ▪ LTE DL CA – 1A-8A, 3A-8A	WTR2965 + QFE2101 + QFE2340 + QFE4320 + QFE1040 + QFE2550	KDDI SBM, DCM
WTR2965_Non_CA_4373	TBD	▪ GSM – GSM850, EGSM, DCS, PCS ▪ cdma2000 – BC0 ▪ WCDMA – B1, B2, B5, B8 ▪ LTE – B1, B3, B7, B38, B39, B40, B41 ▪ TD-SCDMA – B34, B39	WTR2965 + QFE2101 + QFE4373 + QFE430X + QFE1040 + QFE2550	CT, CU, and CMCC

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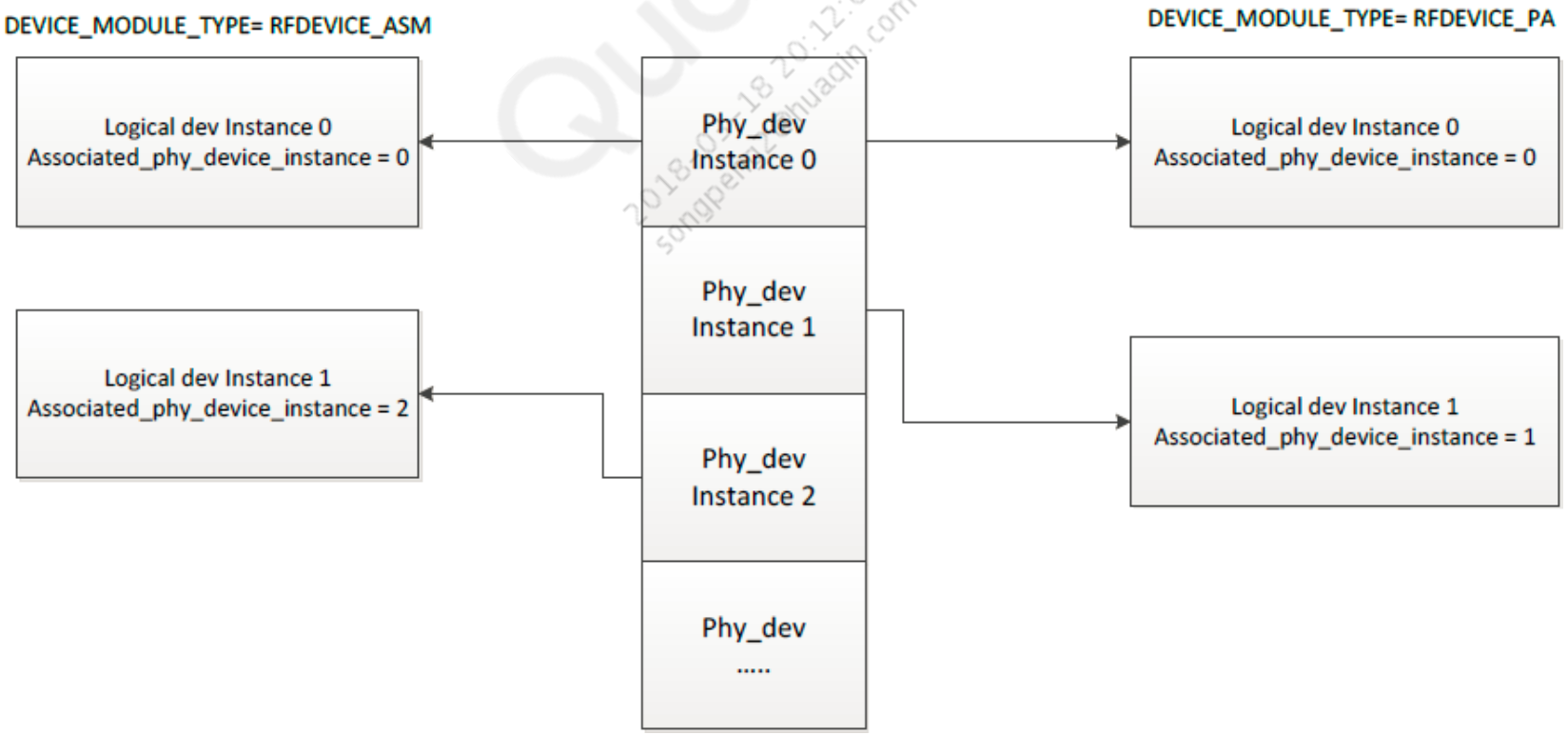
RFC Association Between Physical and Logical Device Lists

- To optimize the efficiency of the RFC code, physical and logical device lists are added into the RFC code structure to separate the concept of physical and logical devices, e.g., QFE2340 contains PA and ASM.
- One physical device can be associated with one or more logical devices based on functionality.



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Physical and Logical Device Structure Information from RFC

- Physical device structure definition

```
/*Physical Device Structure to store physical device info from RFC*/
typedef struct
{
  rfdevice_id_enum_type rf_device_id; /*PHY_DEVICE_NAME
  uint8 phy_dev_instance; /* PHY_DEVICE_INSTANCE*/
  uint32 alternate_part_idx; /* Alternate Part Index Num */
  rfdevice_comm_proto_enum_type rf_device_comm_protocol;
  uint32 bus[RFC_MAX_SLAVES_PER_DEVICE]; /*PHY_DEVICE_C
  uint32 manufacturer_id;
  uint32 product_id;
  uint32 product_rev;
  uint32 default_usid_range_start;
  uint32 default_usid_range_end;
  uint32 assigned_usid;
  uint32 group_id;
  boolean init_required;
  uint32 associated_dac;
} rfc_phy_device_info_type;
```

```
{ /*Device: QFE3320_EPT */
  QFE3320, /* PHY_DEVICE_NAME */
  3, /* PHY_DEVICE_INSTANCE */
  RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INS
  RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL *
  {    0,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
  0x0217, /* PHY_DEVICE_MANUFACTURER_ID */
  0x26, /* PHY_DEVICE_PRODUCT_ID */
  0, /* PHY_DEVICE_PRODUCT_REV */
  0xC, /* DEFAULT USID RANGE START */
  0xC, /* DEFAULT USID RANGE END */
  0x02, /* PHY_DEVICE_ASSIGNED_USID */
  0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
  TRUE, /* INIT */
  RFC_INVALID_PARAM, /* ASSOCIATED_DAC */
}, /* END - Device: QFE3320_EPT */
```

- Logical device structure definition

```
/*Logical Device Structure to store logical device info from RFC*/

typedef struct
{
  rfdevice_type_enum_type rf_device_type; /*DEVICE_MODULE_TYPE*/
  rfdevice_id_enum_type rf_device_id; /*LOGICAL_DEVICE_NAME*/
  uint32 rf_asic_id; /*DEVICE_MODULE_TYPE_INSTANCE*/
  uint8 associated_phy_dev_instance; /* ASSOCIATED PHY_DEVICE_INS
} rfc_logical_device_info_type;
```

```
{ /*Device: QFE3320_GSM */
  RFDEVICE_PA, /* DEVICE_MODULE_TYPE */
  QFE3320_GSM, /* DEVICE_MODULE_NAME */
  2, /* DEVICE_MODULE_TYPE_INSTANCE */
  3, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
}, /* END - Device: QFE3320_GSM */

{ /*Device: QFE3320_TDD */
  RFDEVICE_PA, /* DEVICE_MODULE_TYPE */
  QFE3320_TDD, /* DEVICE_MODULE_NAME */
  3, /* DEVICE_MODULE_TYPE_INSTANCE */
  3, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
}, /* END - Device: QFE3320_TDD */

{ /*Device: QFE3320_TX */
  RFDEVICE_ASM, /* DEVICE_MODULE_TYPE */
  QFE3320_TX, /* DEVICE_MODULE_NAME */
  0, /* DEVICE_MODULE_TYPE_INSTANCE */
  3, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
}, /* END - Device: QFE3320_TX */

{ /*Device: QFE3320_LB */
  RFDEVICE_ASM, /* DEVICE_MODULE_TYPE */
  QFE3320_LB, /* DEVICE_MODULE_NAME */
  1, /* DEVICE_MODULE_TYPE_INSTANCE */
  3, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
}, /* END - Device: QFE3320_LB */
```

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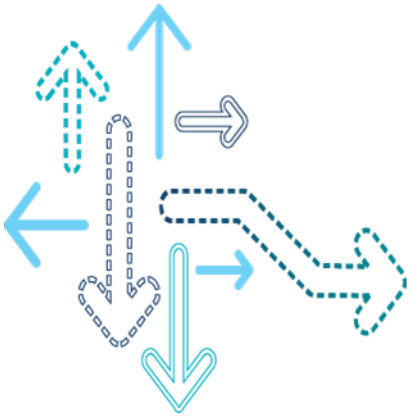
RFLM Overview



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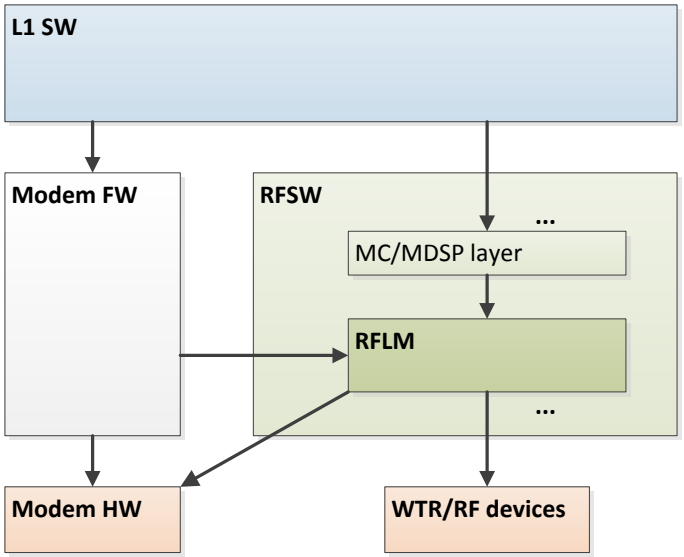
RFLM

- RFLM is the new name of FED+ with Rx/Tx link managers added; RFLM is the same as DPM 2.0.
  - It is a driver layer to handle low-level RF devices, WTR, and digital baseband controls.
  - CCS interface (of dedicated RF control CCS) is entirely in RFLM
  - Interacts with MC/mDSP layer for configurations and mode changes
  - Provides abstraction of RF-related controls to the modem firmware; controls include:
    - Digital Rx/Tx frontend configuration
    - DTR configuration via RxLM/TxLM
    - RF tuning
    - Tx power
    - LNA control
    - Antenna tuner control, antenna switch diversity (ASDiv) control



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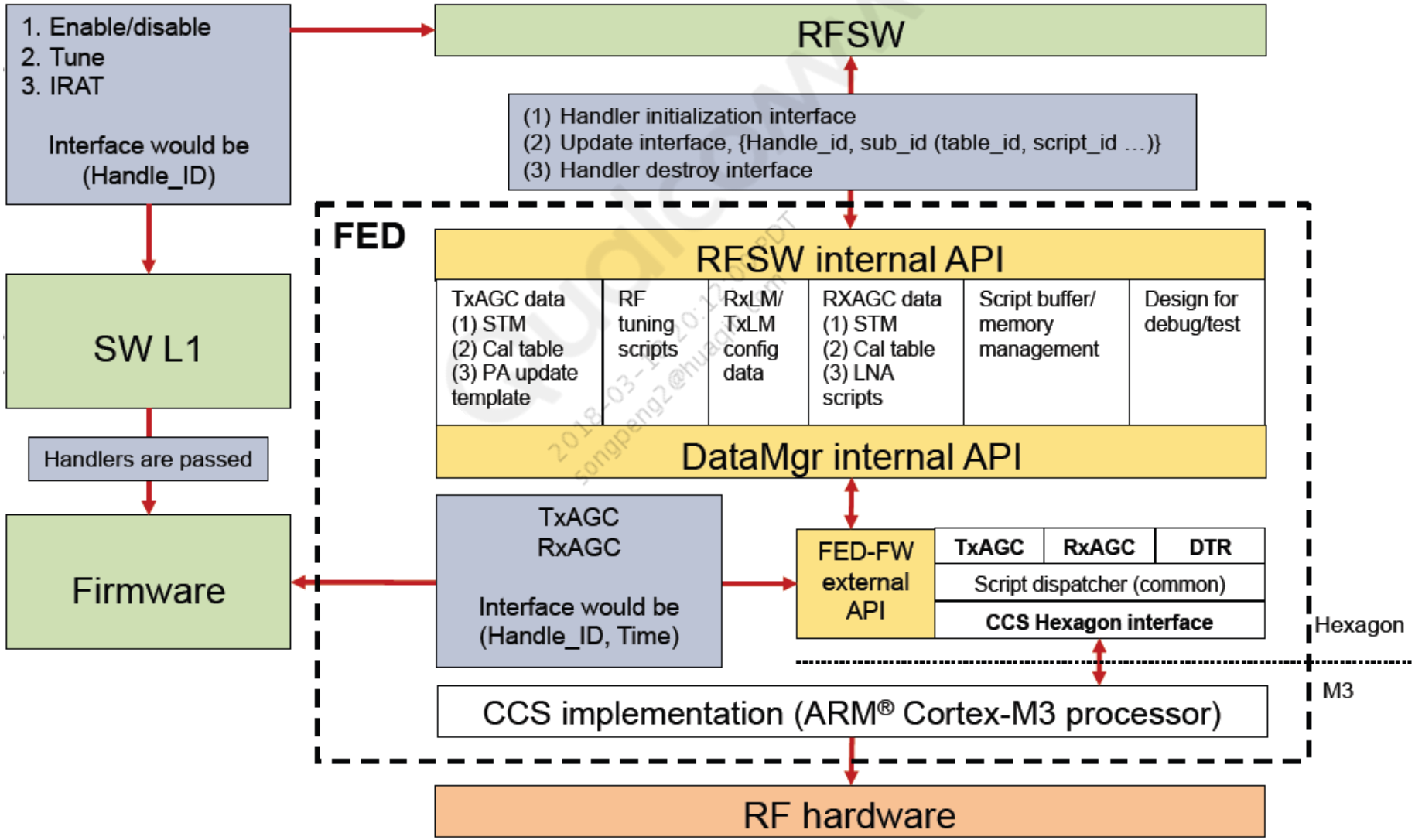
RFLM/FED Software Architecture



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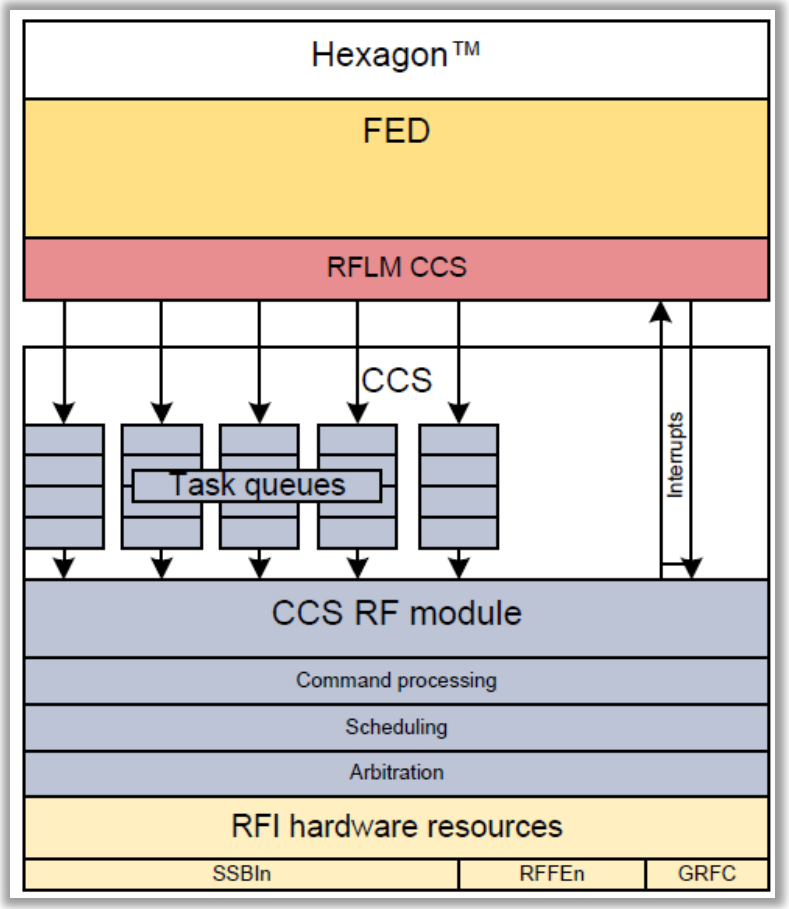
CCS Block Diagram/RF Interface

- RFLM/FED
  - Programs all RF devices
  - Interfaces with
    - RF-MC – Populates the CCS scripts for various events
    - Firmware – Instructs FED on when to execute the scripts
  - CCS
    - Aliases – RFC, RFC-CCS, and RF-CCS
    - All CCS transactions pass via this layer
  - Data Manager (DM)
    - A service provided as part of RFLM
    - Currently used by common TxAGC, RxAGC, and technology modules (to store CCS scripts for technology-specific events)
  - Digital Transceiver (DTR)
    - All hardware I/O read/writes are performed through this layer



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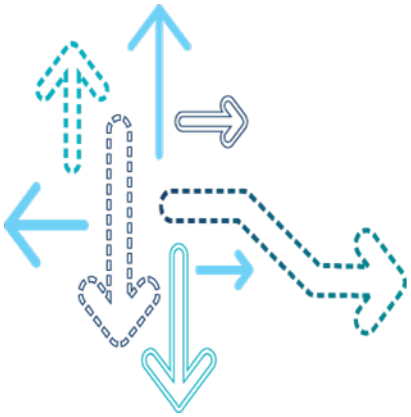
WTR Execution Engine (WXE)



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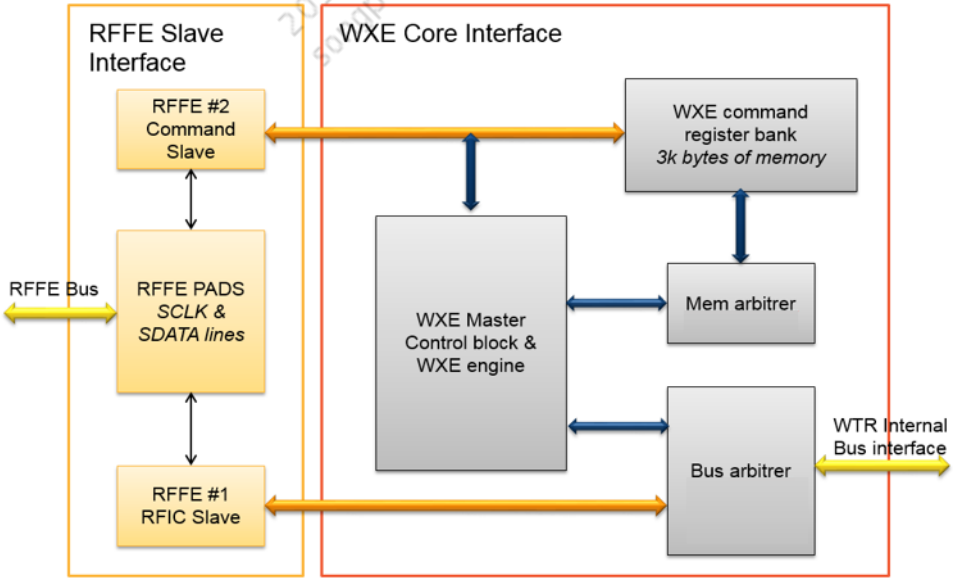
WXE

- RFFE serial interface, along with the WTR2965 WXE-based command/data architecture, can provide an improved way of data handling on RF ICs.
- The Burst mode capability of this interface also increases the throughput of the interface, when large numbers of writes have to be executed. By using an internal memory and several WXE engines, software/firmware can preload the commands into the memory bank and trigger the command executions with single writes to simplify the programming interface and meet stringent timelines.



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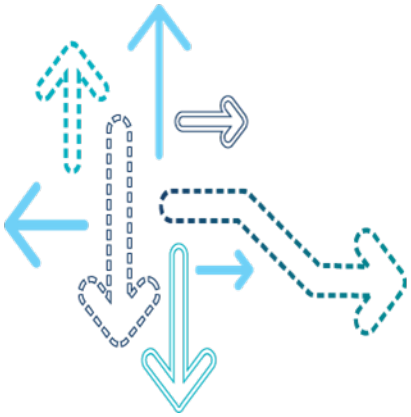
Feedback Receiver (FBRx)



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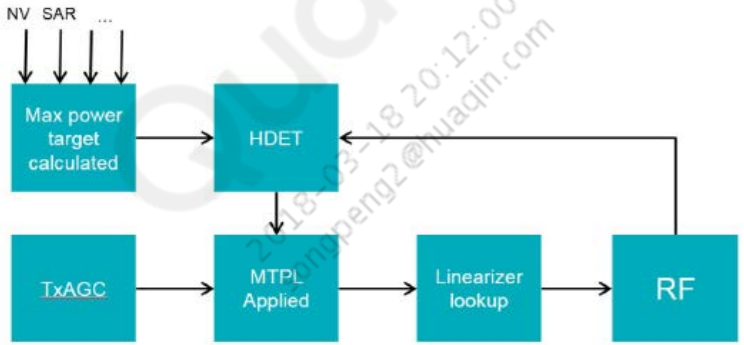
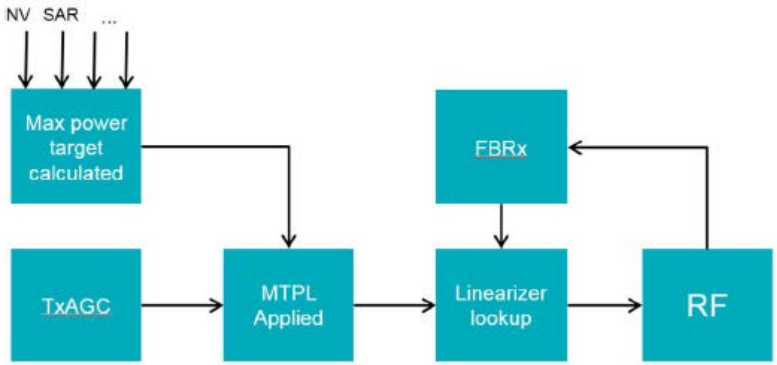
FBRx Overview

- In legacy chipsets with HDET, MTPL is adjusted to transmit more or less power to compensate for temperature/frequency variation. With FBRx, the linearizer is adjusted based on FBRx.
- FBRx is used for HDET read, which remains a 16-bit value (0-65535).
- Power control – Legacy



- Power control – FBRx



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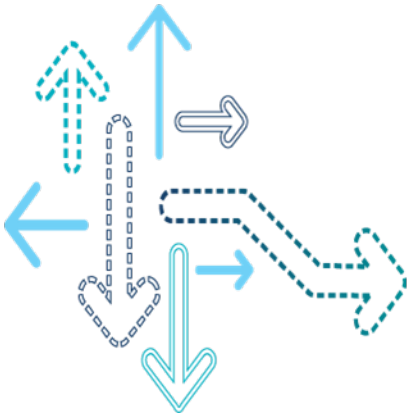
MSM89x7 RFFE



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MSM89x7 RFFE Bus

- RFFE is a serial bus to interface RF components following the MIPI standard.
- The MSM89x7 modem supports five RFFE channels.
- Multiple peripherals can be connected to each bus; transactions can be broadcasted to multiple slave devices.
- Devices must meet the requirements specified in *RFFE Vendor Specification* (80-N7876-1).

MIPI bus	MSM8937 GPIO
RFFE1_CLK	GPIO_100
RFFE1_DATA	GPIO_101
RFFE2_CLK	GPIO_102
RFFE2_DATA	GPIO_103
RFFE3_CLK	GPIO_104
RFFE3_DATA	GPIO_106
RFFE4_CLK	GPIO_122
RFFE4_DATA	GPIO_123
RFFE5_CLK	GPIO_120
RFFE5_DATA	GPIO_121

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MSM89x7 – RFFE Signal Definition in RFC

- MSM89x7 RFFE signal definition in RFC
  - rfc_msm89x7_signal_info[ ] of rfc_msm_signal_info_ag.c

```
{  RFC_RFFE1_CLK          ,  70   ,  RFC_GRFC_NUM_NA,  RFC_RFFE  ,  1,  DAL_GPIO_INPUT
{  RFC_RFFE1_DATA         ,  71   ,  RFC_GRFC_NUM_NA,  RFC_RFFE  ,  1,  DAL_GPIO_INPUT
{  RFC_RFFE2_CLK          ,  72   ,  RFC_GRFC_NUM_NA,  RFC_RFFE  ,  1,  DAL_GPIO_OUTPUT
{  RFC_RFFE2_DATA         ,  73   ,  RFC_GRFC_NUM_NA,  RFC_RFFE  ,  1,  DAL_GPIO_OUTPUT
{  RFC_RFFE3_CLK          ,  74   ,  RFC_GRFC_NUM_NA,  RFC_RFFE  ,  2,  DAL_GPIO_OUTPUT
{  RFC_RFFE3_DATA         ,  76   ,  RFC_GRFC_NUM_NA,  RFC_RFFE  ,  2,  DAL_GPIO_OUTPUT
{  RFC_RFFE5_CLK          ,  103  ,  RFC_GRFC_NUM_NA,  RFC_RFFE  ,  2,  DAL_GPIO_OUTPUT
{  RFC_RFFE5_DATA         ,  104  ,  RFC_GRFC_NUM_NA,  RFC_RFFE  ,  2,  DAL_GPIO_OUTPUT
{  RFC_GPDATA_CHAN0       ,  100  ,  RFC_GRFC_NUM_NA,  RFC_GPIO  ,  1,  DAL_GPIO_OUTPUT
{  RFC_GPDATA_CHAN0       ,  99   ,  RFC_GRFC_NUM_NA,  RFC_GPIO  ,  1,  DAL_GPIO_OUTPUT
```

- WTR2965 and QFE devices to RFFE signal mapping
  - rfc_wtr2965_non_ca_phy_devices_list[ ] of rfc_wtr2965_non_ca_cmn_ag.cpp

```
rfc_phy_device_info_type rfc_wtr2955_non_ca_phy_devices_list[] =
{
  { /*Device: WTR2955 */
    WTR2955, /* PHY_DEVICE_NAME */
    0, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {    4,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x0217, /* PHY_DEVICE_MANUFACTURER_ID */
    0xCA, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0x01, /* DEFAULT USID RANGE START */
    0x01, /* DEFAULT USID RANGE END */
    0x01, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    FALSE, /* INIT */
    RFC_TX_MODEM_CHAIN_0, /* ASSOCIATED_DAC */
  }, /* END - Device: WTR2955 */

  { /*Device: QFE2101 */
    QFE2101, /* PHY_DEVICE_NAME */
    1, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {    0,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x217, /* PHY_DEVICE_MANUFACTURER_ID */
    0x31, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0x4, /* DEFAULT USID RANGE START */
    0x4, /* DEFAULT USID RANGE END */
    0x4, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    TRUE, /* INIT */
    RFC_INVALID_PARAM, /* ASSOCIATED_DAC */
  }, /* END - Device: QFE2101 */
```

RF device	RFFE			
	RFFE1	RFFE2	RFFE4	RFFE5
WTR2965#0	—	—	—	✓
WTR2965#1	—	—	✓	—
QFE4320	✓	—	—	—
QFE2340	✓	—	—	—
QFE1040	—	✓	—	—
QFE2550	—	✓	—	—
QFE2101	✓	—	—	—

Note: The snippets of RFC code are ported from the MPSS.TA product line. The RFC snippets will be updated in the upcoming releases.

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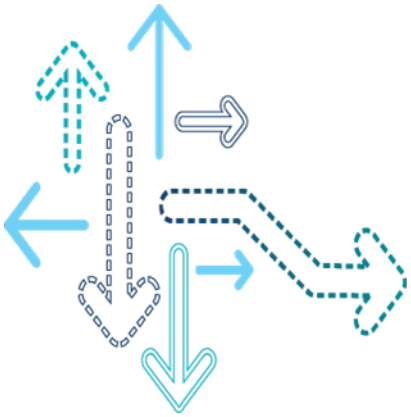
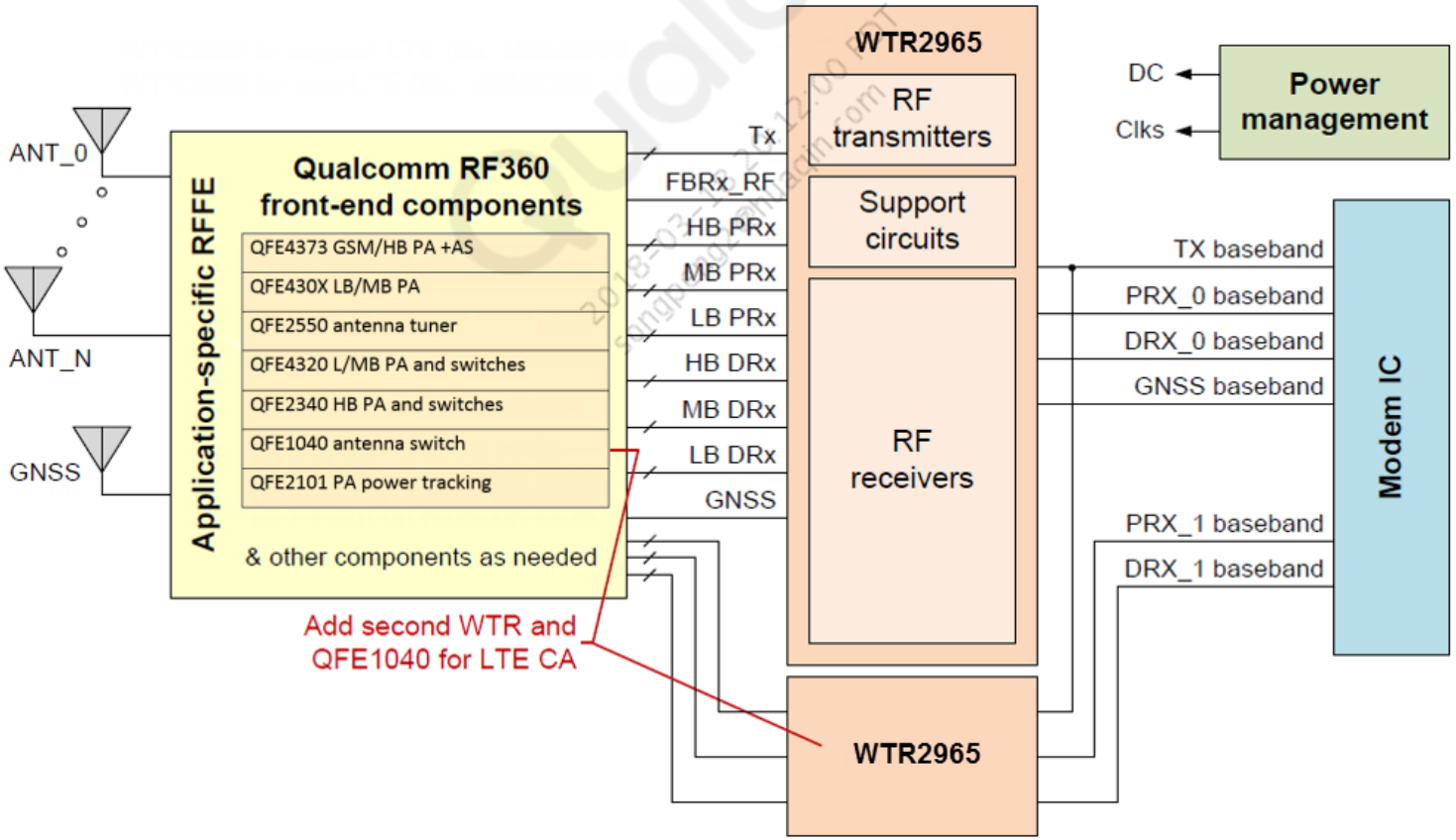
MSM89x7 Qualcomm RF360™



MSM89x7 – Qualcomm RF360™

- MSM89x7 features the Qualcomm RF360 frontend solution. Qualcomm RF360 is a multimode, multiband frontend that includes power amplifier (PA), PA power tracking, antenna switch, and antenna tuner Ics—the first genuine global RF solution for LTE products.



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QFE Device Information in RFC

- OEMs must list the QFE devices in rfc_<RF card>phy_devices_list; remove the QFE devices from this list if unused.
- This is an example of QFE devices information in a WTR2955 non-CA RF card.

```
rfc_phy_device_info_type rfc_wtr2955_non_ca_phy_devices_list[] =
{
  { /*Device: WTR2955 */
    WTR2955, /* PHY_DEVICE_NAME */
    0, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {     4,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x0217, /* PHY_DEVICE_MANUFACTURER_ID */
    0xCA, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0x01, /* DEFAULT USID RANGE START */
    0x01, /* DEFAULT USID RANGE END */
    0x01, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    FALSE, /* INIT */
    RFC_TX_MODEM_CHAIN_0, /* ASSOCIATED_DAC */
  }, /* END - Device: WTR2955 */

  { /*Device: QFE2101 */
    QFE2101, /* PHY_DEVICE_NAME */
    1, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {     0,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x217, /* PHY_DEVICE_MANUFACTURER_ID */
    0x31, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0x4, /* DEFAULT USID RANGE START */
    0x4, /* DEFAULT USID RANGE END */
    0x4, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    TRUE, /* INIT */
    RFC_INVALID_PARAM, /* ASSOCIATED_DAC */
  }, /* END - Device: QFE2101 */

  { /*Device: QFE2340 */
    QFE2340, /* PHY_DEVICE_NAME */
    2, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {     0,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x0217, /* PHY_DEVICE_MANUFACTURER_ID */
    0x21, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0x0F, /* DEFAULT USID RANGE START */
    0x0F, /* DEFAULT USID RANGE END */
    0x0F, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    FALSE, /* INIT */
    RFC_INVALID_PARAM, /* ASSOCIATED_DAC */
  }, /* END - Device: QFE2340 */

  { /*Device: QFE3320 */
    QFE3320, /* PHY_DEVICE_NAME */
    3, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {     0,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x0217, /* PHY_DEVICE_MANUFACTURER_ID */
    0x26, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0xC, /* DEFAULT USID RANGE START */
    0xC, /* DEFAULT USID RANGE END */
    0x02, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    TRUE, /* INIT */
    RFC_INVALID_PARAM, /* ASSOCIATED_DAC */
  }, /* END - Device: QFE3320 */
```

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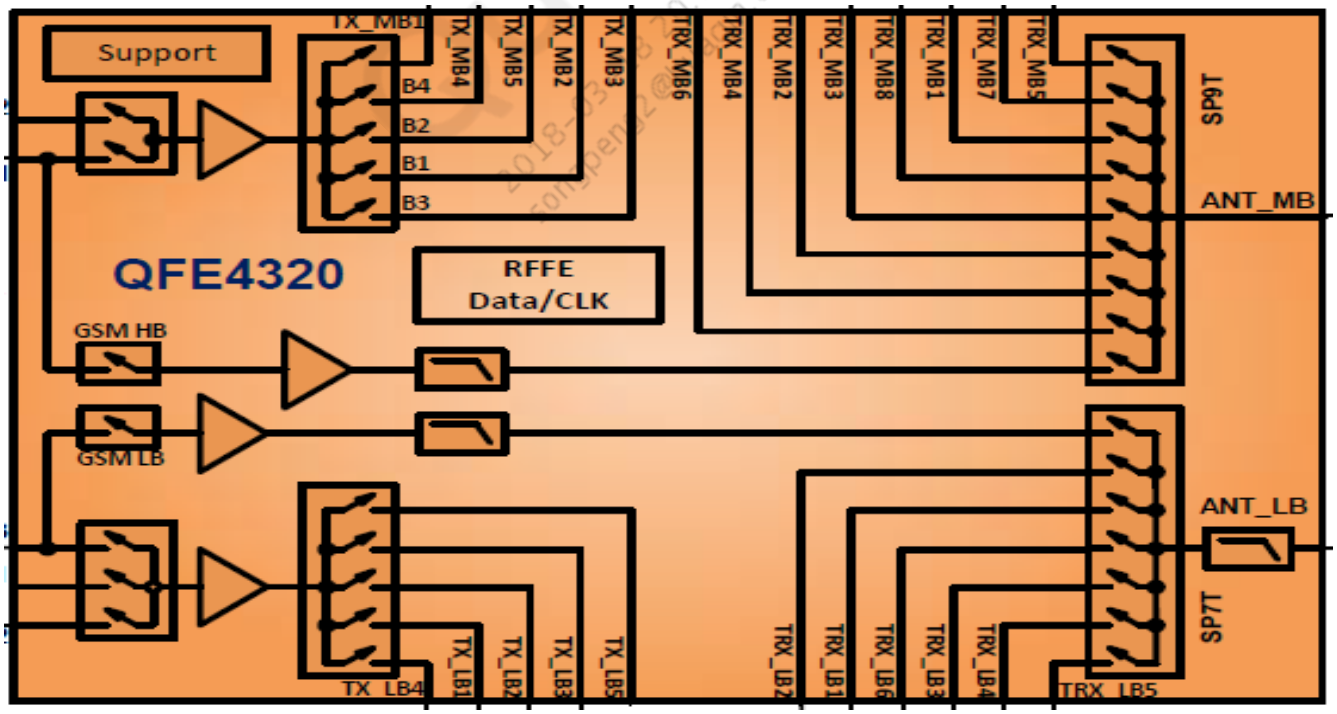
QFE4320

- QFE4320 is a multimode, multiband PA with integrated low band and mid band antenna switches
  - Small PCB footprint
  - Supports APT + DPD (does not support ET)
  - Multiband antenna switch – Nine ports for mid bands and seven ports for low band



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QFE4320 Software Implementation

- This is an example of configuring QFE4320 as PA for WCDMA B1 in a non-CA RF card.

```
rfc_device_info_type rf_card_wtr2955_na_ca_4320_tx_on_rfm_device_5_wcdma_b1_device_info =
{
  RFC_ENCODED_REVISION,
  RFC_TX_MODEM_CHAIN_0,   /* Modem Chain */
  0,   /* NV Container */
  0,   /* Antenna */
  7,  /* NUM_DEVICES_TO_CONFIGURE */
  {
    {
      RFDEVICE_TRANSCEIVER,
      WTR2955,  /* NAME */
      1,  /* DEVICE_MODULE_TYPE_INSTANCE */
      0,  /* PHY_PATH_NUM */
      {
        0 /*Warning: Not specified*/,  /* INTF_REV */
        (int)WTR2955_WCDMA_TX_BAND1_THMLB4,  /* PORT */
        ( RFDEVICE_PA_LUT_MAPPING_VALID | WTR2955_LP_LUT_TYPE << RFDEVICE_PA_STATE_0_BSHFT | WTR2955
        FALSE,  /* TXAGC_LUT */
        WTR2955_FBRX_LOW_ATTN_MODE,  /* FBRX_ATTN_STATE */
        0,  /* Array Filler */
      },
    },
    {
      RFDEVICE_PA,
      QFE4320_EPT,  /* NAME */
      1,  /* DEVICE_MODULE_TYPE_INSTANCE */
      0 /*Warning: Not specified*/,  /* PHY_PATH_NUM */
      {
        0  /* Orig setting:  */,  /* INTF_REV */
        (0x217 << 22)/*mfg_id*/ | (0x44 << 14)/*prd_id*/ | (QFE4320_EPT_WCDMA_BAND1_PORT_TX_PORT_10)
        0,  /* Array Filler */
        0,  /* Array Filler */
        0,  /* Array Filler */
        0,  /* Array Filler */
      },
    },
```

```
rfc_phy_device_info_type rfc_wtr2955_na_ca_4320_phy_devices_list[] =
{
  { /*Device: WTR2955 */
    WTR2955, /* PHY_DEVICE_NAME */
    0, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {    4,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x217, /* PHY_DEVICE_MANUFACTURER_ID */
    0xCA, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0x1, /* DEFAULT USID RANGE START */
    0x1, /* DEFAULT USID RANGE END */
    0x1, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    FALSE, /* INIT */
    RFC_TX_MODEM_CHAIN_0, /* ASSOCIATED_DAC */
  }, /* END - Device: WTR2955 */

  { /*Device: QFE2101 */
    QFE2101, /* PHY_DEVICE_NAME */
    1, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {    0,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x217, /* PHY_DEVICE_MANUFACTURER_ID */
    0x31, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0x4, /* DEFAULT USID RANGE START */
    0x4, /* DEFAULT USID RANGE END */
    0x4, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    TRUE, /* INIT */
    RFC_INVALID_PARAM, /* ASSOCIATED_DAC */
  }, /* END - Device: QFE2101 */

  { /*Device: QFE4320 */
    QFE4320, /* PHY_DEVICE_NAME */
    2, /* PHY_DEVICE_INSTANCE */
    RFC_NO_ALTERNATE_PART, /* PHY_DEVICE_ALT_PART_NUM_OF_INSTANCE */
    RFDEVICE_COMM_PROTO_RFFE, /* PHY_DEVICE_COMM_PROTOCOL */
    {    0,0 /* 0 not specified */,}, /* PHY_DEVICE_COMM_BUS */
    0x217, /* PHY_DEVICE_MANUFACTURER_ID */
    0x44, /* PHY_DEVICE_PRODUCT_ID */
    0, /* PHY_DEVICE_PRODUCT_REV */
    0xC, /* DEFAULT USID RANGE START */
    0xC, /* DEFAULT USID RANGE END */
    0xC, /* PHY_DEVICE_ASSIGNED_USID */
    0 /*Warning: Not specified*/, /* RFFE_GROUP_ID */
    FALSE, /* INIT */
    RFC_INVALID_PARAM, /* ASSOCIATED_DAC */
  }, /* END - Device: QFE4320 */
```

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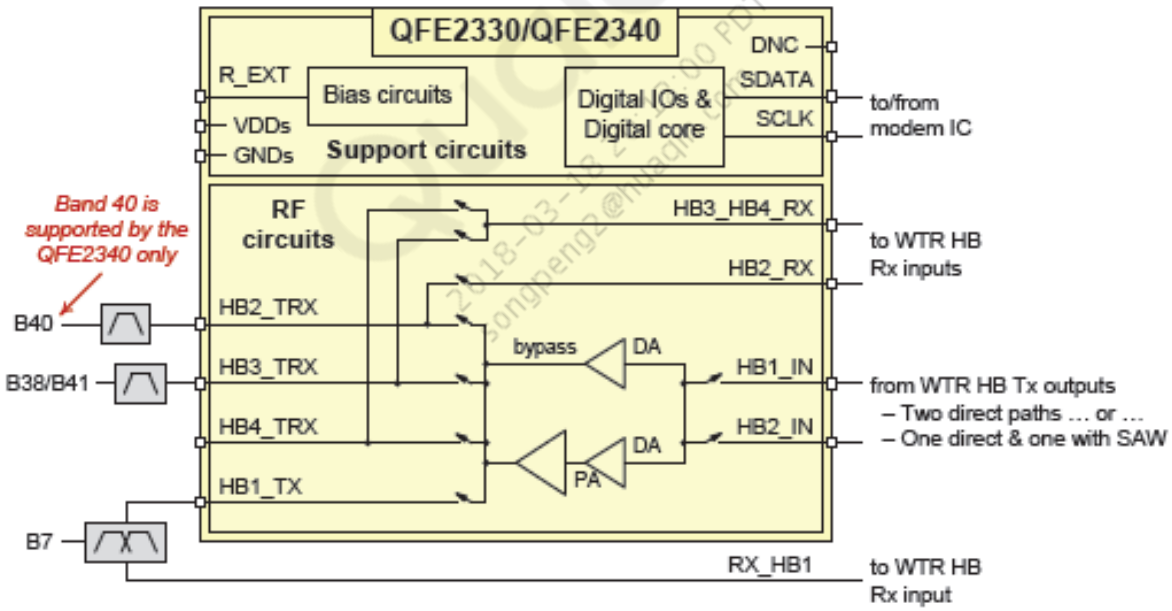
QFE2340

- QFE2340 is a high band multimode PA with integrated switches
  - Supports B7, B38, B40, B41, and B41-XGP
  - Supports APT + DPD



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QFE2340 Software Implementation

- QFE2340 logical list
  - rfc_wtr2965_non_ca_logical_devices_list[] in rfc_wtr2965_non_ca_cmn_ag.cpp
- Example – Configure QFE2340 as PA or LTE B38 in non-CA RF card

```
rfc_device_info_type rf_card_wtr2955_non_ca_tx0_lte_b38_device_info =
{
  RFC_ENCODED_REVISION,
  RFC_TX_MODEM_CHAIN_0,    /* Modem Chain */
  0,    /* NV Container */
  RFC_INVALID_PARAM /* Warning: Not Specified */,    /* Antenna */
  7,  /* NUM_DEVICES_TO_CONFIGURE */
  {
    {
      RFDEVICE_TRANSCEIVER,
      WTR2955,  /* NAME */
      0,  /* DEVICE_MODULE_TYPE_INSTANCE */
      0,  /* PHY_PATH_NUM */
      {
        0 /*Warning: Not specified*/,  /* INTF_REV */
        (int)WTR2955_LTETDD_TX_BAND38_THMLB3,  /* PORT */
        ( RFDEVICE_PA_LUT_MAPPING_VALID | WTR2955_LP_LUT_TYPE << RFDEVICE_PA_STATE_0_BSHFT |
        FALSE,  /* TXAGC_LUT */
        WTR2955_FBRX_LOW_ATTN_MODE,  /* FBRX_ATTN_STATE */
        0,  /* Array Filler */
      },
    },
    {
      RFDEVICE_PA,
      QFE2340,  /* NAME */
      0,  /* DEVICE_MODULE_TYPE_INSTANCE */
      0 /*Warning: Not specified*/,  /* PHY_PATH_NUM */
      {
        0  /* Orig setting:  */,  /* INTF_REV */
        (0x0217 << 22)/*mfg_id*/ | (0x21 << 14)/*prd_id*/ | (1)/*port_num*/,  /* PORT_NUM */
        0,  /* Array Filler */
        0,  /* Array Filler */
        0,  /* Array Filler */
        0,  /* Array Filler */
      },
    },
```

```
{ /*Device: QFE2340 */
  RFDEVICE_PA, /* DEVICE_MODULE_TYPE */
  QFE2340, /* DEVICE_MODULE_NAME */
  0, /* DEVICE_MODULE_TYPE_INSTANCE */
  2, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
}, /* END - Device: QFE2340 */

{ /*Device: QFE2340 */
  RFDEVICE_ASM, /* DEVICE_MODULE_TYPE */
  QFE2340, /* DEVICE_MODULE_NAME */
  3, /* DEVICE_MODULE_TYPE_INSTANCE */
  2, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
}, /* END - Device: QFE2340 */
```

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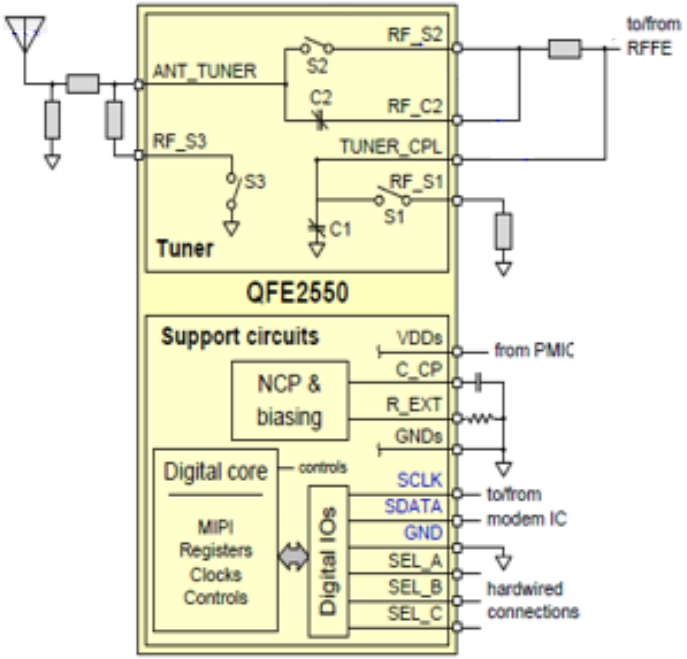
QFE2550

- The antenna tuner software feature enables QTI customers to control antenna matching, using either closed or open loop technique to improve antenna efficiency.
- Predetermined look-up tables (LUTs) of tuner settings (capacitors/ switches configuration) are stored in data files (tune codes) for each band of operation.
- Up to nine different scenarios and eight subbands per band per technology are supported.
- Two LUTs, Tx_Rx and Rx. are supported per band for both FDD and TDD.
- QFE2550 interface supports MIPI only; there is no SSBI option.



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QFE2550 Software Implementation

- QFE2550 logical list
  - rfc_wtr2965_non_ca_logical_devices_list[] in rfc_wtr2965_non_ca_cmn_ag.cpp
- Example – Configure QFE2520 as primary path antenna tuner for WCDMA B2 in non-CA card

```
rfc_device_info_type rf_card_wtr2955_non_ca_rx0_wcdma_b2_device_info =
{
  RFC_ENCODED_REVISION,
  RFC_RX_MODEM_CHAIN_0,    /* Modem Chain */
  0,    /* NV Container */
  RFC_INVALID_PARAM /* Warning: Not Specified */,    /* Antenna */
  3,  /* NUM_DEVICES_TO_CONFIGURE */
  {
    {
      RFDEVICE_TRANSCEIVER,
      WTR2955,    /* NAME */
      0,   /* DEVICE_MODULE_TYPE_INSTANCE */
      0,   /* PHY_PATH_NUM */
      {
        0 /*Warning: Not specified*/,   /* INTF_REV */
        (int)WTR2955_WCDMA_PRXLGY1_BAND2_PMB2,   /* PORT */
        ( RFDEVICE_PA_LUT_MAPPING_INVALID ),   /* RF_ASIC_BAND_AGC_LUT_MAPPING */
        FALSE,   /* TXAGC_LUT */
        WTR2955_FBRX_ATTN_DEFAULT,   /* FBRX_ATTN_STATE */
        0,   /* Array Filler */
      },
    },
    {
      RFDEVICE_ASM,
      QFE3320_MB,   /* NAME */
      2,   /* DEVICE_MODULE_TYPE_INSTANCE */
      0 /*Warning: Not specified*/,   /* PHY_PATH_NUM */
      {
        0   /* Orig setting:  */,   /* INTF_REV */
        (0x0217 << 22)/*mfg_id*/ | (0x26 << 14)/*prd_id*/ | (6)/*port_num*/,   /* PORT_NUM */
        0,   /* Array Filler */
        0,   /* Array Filler */
        0,   /* Array Filler */
        0,   /* Array Filler */
      },
    },
    {
      RFDEVICE_TUNER,
      QFE2520,   /* NAME */
      0,    /* DEVICE_MODULE_TYPE_INSTANCE */
      0 /*Warning: Not specified*/,   /* PHY_PATH_NUM */
      {
        0   /* Orig setting:  */,   /* INTF_REV */
        0   /* Orig setting:  */,   /* DISTORION_CONFIG */
        0,   /* Array Filler */
        0,   /* Array Filler */
        0,   /* Array Filler */
        0,   /* Array Filler */
      },
```

```
{ /*Device: QFE2520 */
  RFDEVICE_TUNER, /* DEVICE_MODULE_TYPE */
  QFE2520, /* DEVICE_MODULE_NAME */
  0, /* DEVICE_MODULE_TYPE_INSTANCE */
  7, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
}, /* END - Device: QFE2520 */
```

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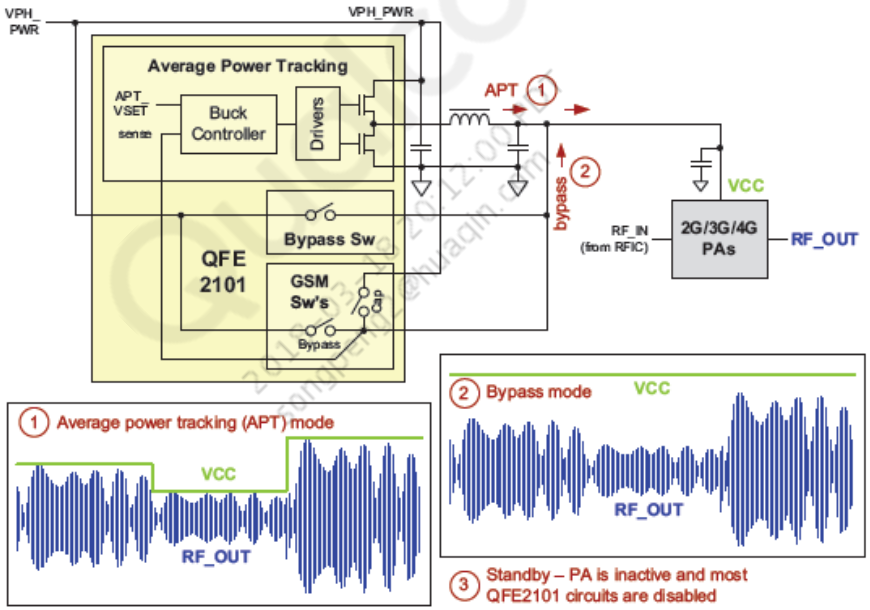
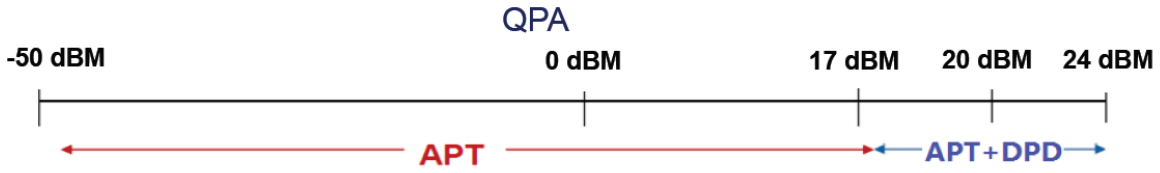
QFE2101 – PA Power Management Overview

- QFE2101 supports bypass and APT
  - Bypass mode – Fixed Vcc PA bias value
  - APT mode – PA bias value can be adjusted based on the Tx output power



- PA Operation mode



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QFE2101 Software Implementation

- QFE2101 logical list
  - rfc_wtr2965_non_ca_logical_devices_list[] in rfc_wtr2965_non_ca_cmn_ag.cpp
- Example – Configure QFE2101 as PA power tracker for LTE B38 in non-CA card

```
rfc_device_info_type rf_card_wtr2955_non_ca_tx0_lte_b38_device_info =
{
  RFC_ENCODED_REVISION,
  RFC_TX_MODEM_CHAIN_0,    /* Modem Chain */
  0,    /* NV Container */
  RFC_INVALID_PARAM /* Warning: Not Specified */,    /* Antenna */
  7,  /* NUM_DEVICES_TO_CONFIGURE */
  {
    {
      RFDEVICE_TRANSCEIVER,
      WTR2955,  /* NAME */
      0,  /* DEVICE_MODULE_TYPE_INSTANCE */
      0,  /* PHY_PATH_NUM */
      {
        0 /*Warning: Not specified*/,  /* INTF_REV */
        (int)WTR2955_LTETDD_TX_BAND38_THMLB3,  /* PORT */
        ( RFDEVICE_PA_LUT_MAPPING_VALID | WTR2955_LP_LUT_TYPE << RFDEVICE_
        FALSE,  /* TXAGC_LUT */
        WTR2955_FBRX_LOW_ATTN_MODE,  /* FBRX_ATTN_STATE */
        0,  /* Array Filler */
      },
    },
  {
    RFDEVICE_PAPM,
    QFE2101,  /* NAME */
    0,  /* DEVICE_MODULE_TYPE_INSTANCE */
    0 /*Warning: Not specified*/,  /* PHY_PATH_NUM */
    {
      0  /* Orig setting:  */,  /* INTF_REV */
      (0x217 << 22)/*mfg_id*/ | (0x31 << 14)/*prd_id*/ | (25)/*port_num*/,  /* PORT_NUM */
      0,  /* Array Filler */
      0,  /* Array Filler */
      0,  /* Array Filler */
      0,  /* Array Filler */
    },
  },
```

```
rfc_logical_device_info_type rfc_wtr2955_non_ca_logical_devices_list[] =
{
  { /*Device: WTR2955 */
    RFDEVICE_TRANSCEIVER, /* DEVICE_MODULE_TYPE */
    WTR2955, /* DEVICE_MODULE_NAME */
    0, /* DEVICE_MODULE_TYPE_INSTANCE */
    0, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
  }, /* END - Device: WTR2955 */

  { /*Device: QFE2101 */
    RFDEVICE_PAPM, /* DEVICE_MODULE_TYPE */
    QFE2101, /* DEVICE_MODULE_NAME */
    0, /* DEVICE_MODULE_TYPE_INSTANCE */
    1, /* ASSOCIATED_PHY_DEVICE_INSTANCE */
  }, /* END - Device: QFE2101 */
```

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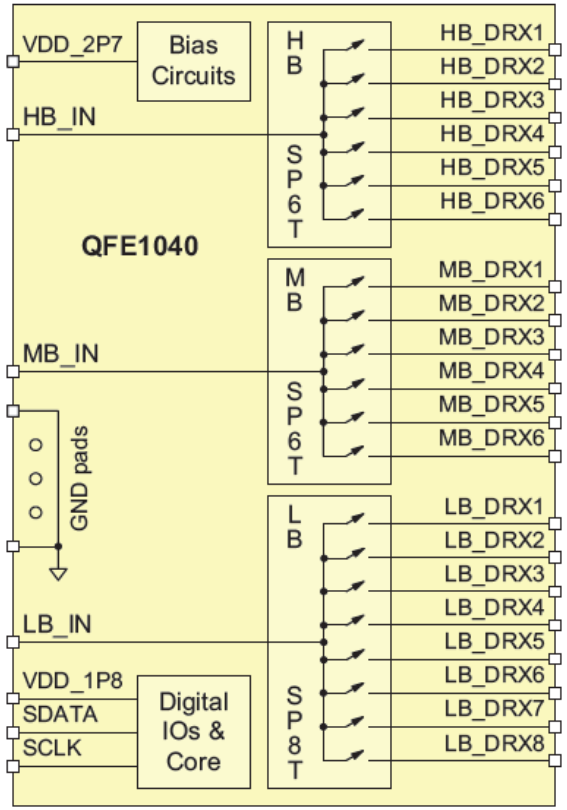
QFE1040

- QFE1040 is a diversity antenna switch device with three separate single-pole switches, each dedicated to a specific range of frequencies.
  - SP8T low band switch
  - SP6T mid band switch
  - SP6T high band switch

Band [1, 2]	Band designator			Air interface support							
					3GPP2		3GPP				
	GSM	3GPP2	3GPP	GSM	1x/DOrA	DOrB	WCDMA	DC-HSPA+	FDD LTE	TDD LTE	TD-SCDMA
IMT (2100)	–	6	1	–	X	X	X	X	X	–	–
PCS (1900)	G1900	1	2	X	X	X	X	X	X	–	–
DCS (1800)	G1800	–	3	X	–	–	X	X	X	–	–
AWS	–	15	4	–	X	X	X	X	X	–	–
CELL (850)	G850	0	5	X	X	X	X	X	X	–	–
IMT-E (2600)	–	–	7	–	–	–	–	–	X	–	–
EGSM (900)	G900	–	8	X	–	–	X	X	X	–	–
700 lower B-C	–	–	17	–	–	–	–	–	X	–	–
E800	–	–	20	–	–	–	–	–	X	–	–
E1900	–	–	25	–	–	–	X	X	X	–	–
B34	–	–	34	–	–	–	X	X	–	–	X
B38	–	–	–	–	–	–	–	–	–	X	–
B39	–	–	39	–	–	–	X	X	–	–	X
B40	–	–	–	–	–	–	–	–	–	X	X
B41 and XGP	–	–	–	–	–	–	–	–	–	X	–

1. QFE1040 supports either B3 (for EU) or B4 (for NA) but not both.
2. Band colors: • = low bands; • = mid bands; • = high bands.



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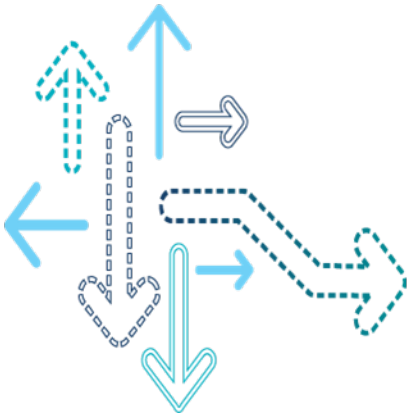
MPSS.JO.1.2 RF Calibration Overview



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RF Calibration Overview

- QTI leverages calibration methods from MPSS.JO.1.2 for RF calibration in MSM89x7 + WTR2965 to perform the following tasks:
  - Internal device calibration
  - XO calibration
  - Wideband calibration (ESC calibration V4 for wideband calibration)
    - CDMA
    - WCDMA
    - TD-SCDMA
    - LTE
  - FBRx calibration
  - 2G GSM calibration

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RF Calibration Overview (cont.)

- MPSS releases include:
  - Test tree – \modem_proc\rftarget_feero\xtt\etc
  - Static QCN – \modem_proc\rftarget_feero\qcn
  - DLL – \modem_proc\rffactory\qdart
  - NV definition – \modem_proc\rfnv\etc
  - Bias file – \modem_proc\rftarget_feero\xtt\etc\RFCalInput
  - Reference QCN – \modem_proc\rftarget_feero\common\
- Use the XTT/DLL/static QCN from the latest AMSS release
- Use the XTT that matches your RF configuration as shown in \modem_proc\rftarget_feero\common\xtt\etc

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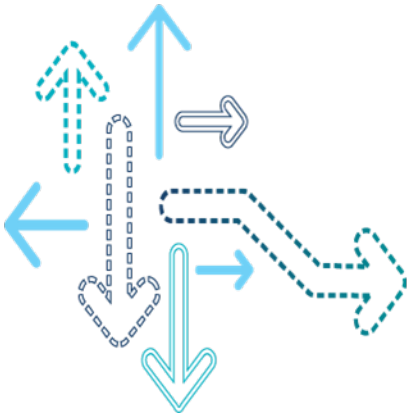
FAQs



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FAQs

Q. Can the static NV items be modified?

A. It is not recommended to modify the static NVs. Discuss with QTI before modifying these items.

Q. Does each new MPSS require a fresh RF calibration?

A. RF calibration requirements are listed in the software release notes.

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References

Documents	
Qualcomm Technologies, Inc.	
RFFE Vendor Specification	80-N7876-1
Chile Non-CA Reference Schematic Using WTR2965 And Qualcomm RF360	80-NP237-42
WTR2965/WTR2655 Wafer-level RF Transceiver Design Guidelines/Training Slides	80-NP237-5
MSM8937 Device Specification	80-P2468-1

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Acronyms	
Term	**Definition**
CA	Carrier Aggregation
DM	Data Manager
DTR	Digital Transceiver
FTM	Factory Test Mode
FBRx	Feedback Receiver
RFFE	RF Frontend
RFLM	Radio Frequency Link Manager
WXE	WTR Execution Engine

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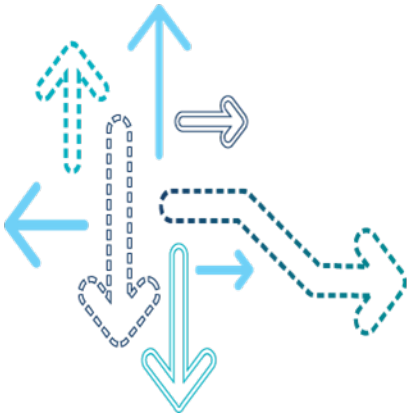
Questions?

https://createpoint.qti.qualcomm.com



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