BP30

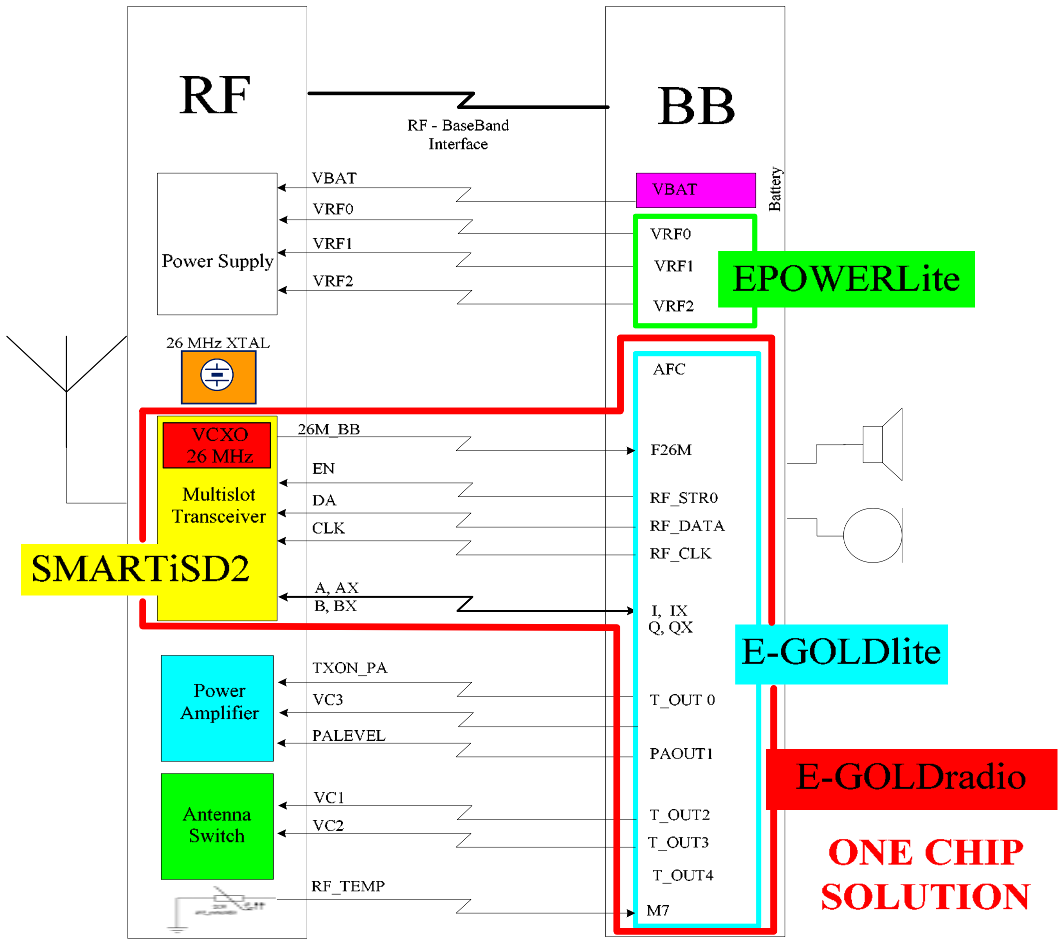
E-GOLDradio RF-BB Interface

L1 Group

Paolo Buoncompagno

Block Diagram RF-BB Interface

BP30 Platform = E-GOLDradio + EPOWERLite

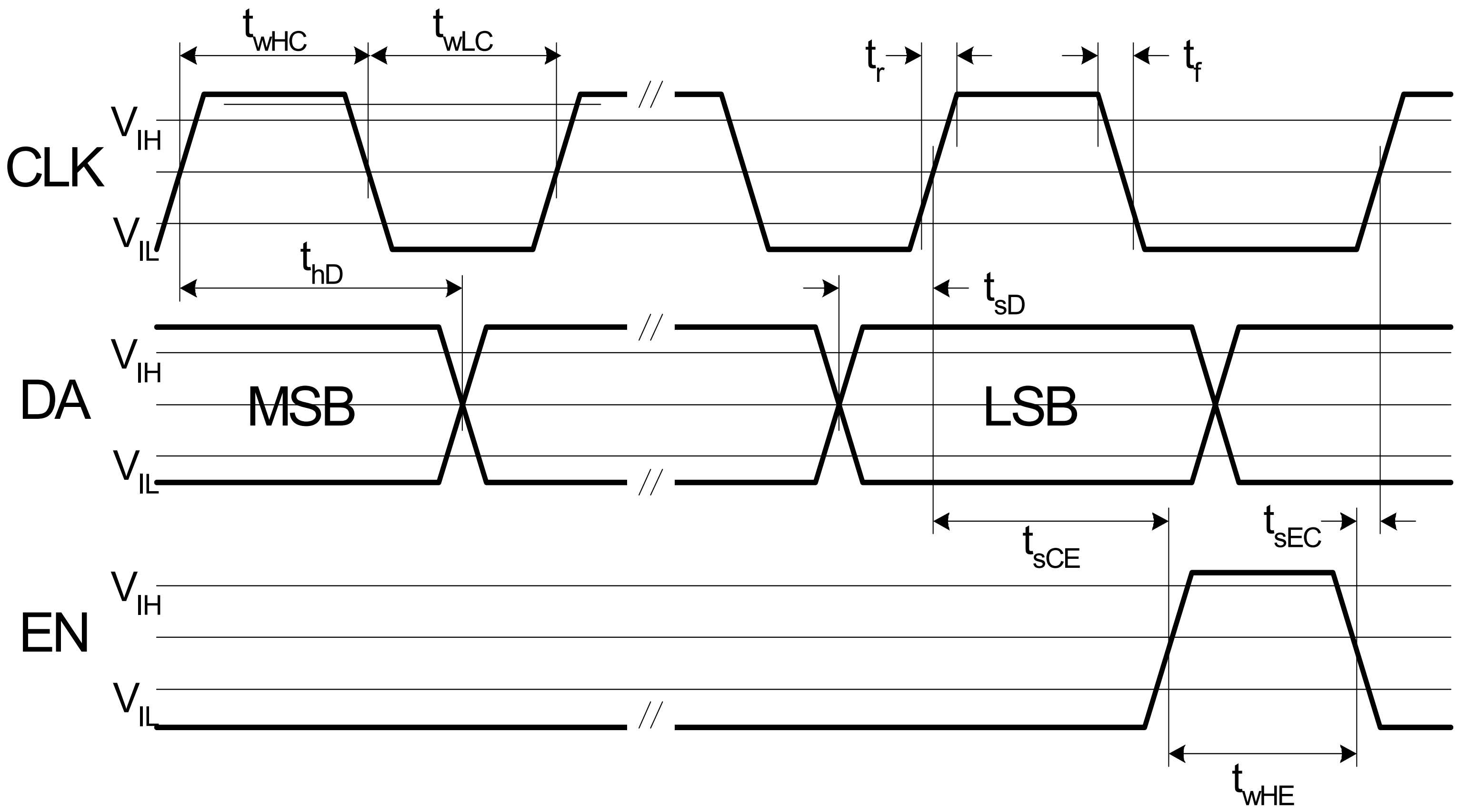


3 wire serial bus

- The 3 wire bus is used to transmit the telegrams, which are necessary to program the internal 3W control registers of the radio:
  – Channelword1 Register (REG0);
  – Channelword2 Register (REG1);
  – RX/TX Register (REG2).

- The bus consists of three signals:
  – EN (RF_STR0)
  – DA (RF_DATA)
  – CLK (RF_CLK)

Timing of the electrical signal on the 3 wire serial interface



Channelword1 register - REG0

Bit no LSB	**Value**	**Bit name**	**Function**
0	0	UMTS_GSM	GSM=0 / UMTS=1
1…3	000	Add0/1/2	REG#0 – CHANNELWORD1
4	0	F0	Frac.Channelword Part#1 bit 0
5…22		F1…F18	Frac.Channelword Part#1 bit 1…18
23 MSB		F19	Frac.Channelword Part#1 bit 19

Channelword2 register – REG1

Bit no LSB	Value	Bit name	Function
0	0	UMTS_GSM	GSM=0 / UMTS=1
1…3	001	Add0/1/2	REG#1 – CHANNELWORD2
4	0	F20	Frac.Channelword Part#2 bit 20
5	0	F21	Frac.Channelword Part#2 bit 21
6	0	F22	Frac.Channelword Part#2 bit 22
7…14		Chx x = 0…7	Integer Channelword Bit 0…7
15		ON0	SMARTi Power Mode: 00=All off, 10=XAMP ONLY, 01=PLL ON + XAMP ONLY, 11=ALL ON
16		ON1	
17		MFO	Set Level of MFO pin
18		TRX	RX TX Switch RX = 0 / TX = 1
19,20		BSWx x = 0,1	Bandselect: 00 = 850, 10 = 900, 01= 1800, 11 = 1900 MHz
21		IDA	0 = off, 1 = on
22		IDA_SLOW	= 0/1 Set Over sampling Ratio of IDA ADC = 6/3
23 MSB			

RX/TX Register - REG2

Bit no LSB	**Value**	**Bit name**	**Function**
0	0	UMTS_GSM	GSM=0 / UMTS=1
1	0	add0	
2	1	add1	REG#2 – TX/RX WORD
3	0	add2	
4		RXGAIN	LNA Gain 0 = Low / 1 = High
5,6,7,8		RXCORRx x = 0..3	RX Gain Correction from -6dB (0000) to +7 dB (1111)
9,10		TXPWRx x = 0,1	TX Power Attenuation 00 = 0dB / 10 = -0.7dB / 01 = -1.4dB / 11=-2.1dB
11,12		RXCMx x = 0,1	RX-Out Common Mode Level 00 = 0.95V / 10=1.25V / 01=1.35V / 11=1.425V
13		RSGS	Reference Gain Step 0/1 = 0/+6dB
14		OGS	Overall Gain Step 0/1 = 0/+6dB
15			

Programming of the Fractional-N SIGMA-DELTA Synthesizer

- The frequency of the internal VCO is controlled by two 24 bit registers i.e. Frac.Channelword Part#1 for the lower 20 bits (F19-F0) of the fractional part (**NF**) and Frac.Channelword Part#2 for the 3 MSBs (F22-F20) of the fractional part (NF) and 8 bits (CH7-CH0) of the integer part (**NI**) of the divide ratio. Both values form the fractional channel word **CW**:

$$CW = NI \bullet NF$$

- The internal VCO frequency (fVCO) is given by:

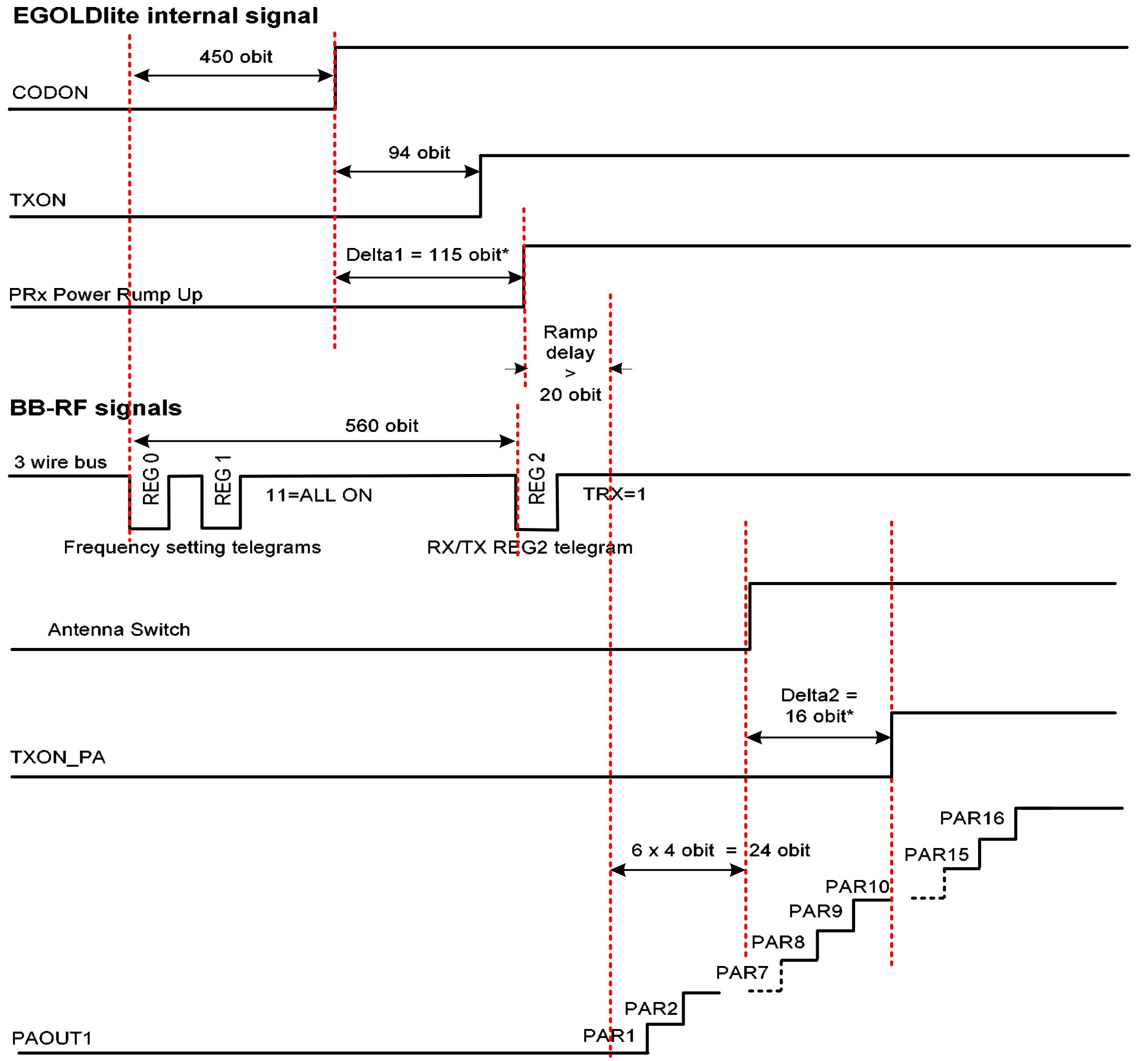
$$f_{VCO} = \left(NI + \frac{NF}{MOD} \right) \bullet f_{PD}$$

- Respectively the phase detector frequency fPD is 26 MHz (FSYS) and

$$MOD = 2^{Aw} = 2^{23} = 8388608$$

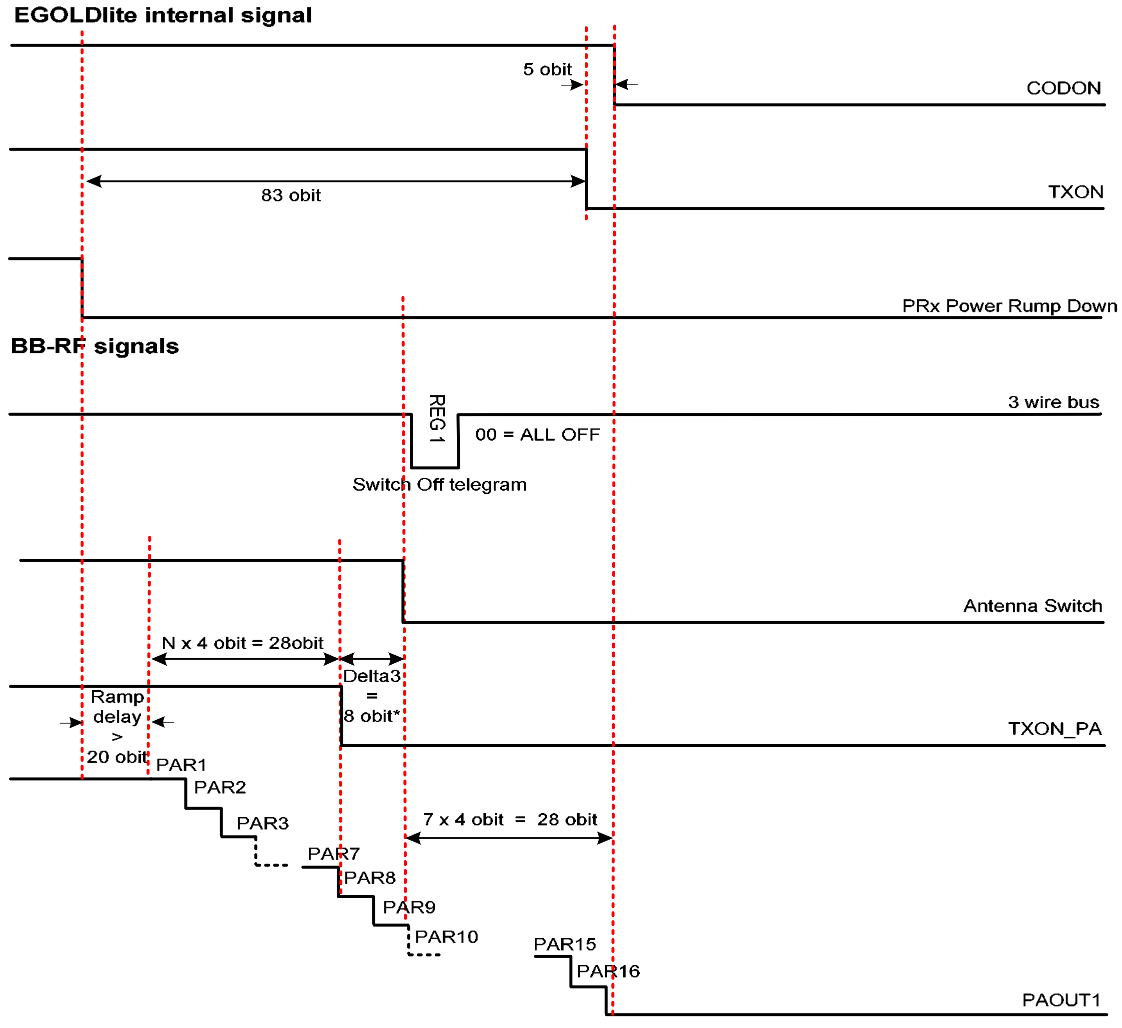
confidential

Active Signals in TX ON Group



TIME SCALE: octalbit (1 obit = 1/8 bit = 0,46 μs)
All timing values marked with * are PA dependent, see Annex 1.

Active Signals in TX OFF Group



TIME SCALE: octalbit (1 obit = 1/8 bit = 0,46 µs)
All timing values marked with * are PA dependent, see Annex 1.

Power Ramping and Calibration 1

- The applied max power level PACT[16], that sets the output RF power during the useful part of the burst, is the result of a default level value plus all compensation values:

PACT[16] = Default_Level_BAND[16]

+ eep_static.rf_adjcomp.pa_offset[x][x]

+ eep_static.rf_comp.pa_ch_comp[x][RF_get_ch_comp_index]

+ eep_static.rf_comp.pa_temp_comp

+ gsm.pl_vcc_offset

the [x][x] above indicates the band and the power level.

Power Ramping and Calibration 2

- The number of compensative addends depends by the features RF_GENERIC_INTERFACE and ANTENNA_DETECTION, if they are active:

PACT[16] = Default_Level_BAND[16]

+ eep_static.rf_adjcomp.pa_offset[x][x]

+ eep_static.rf_tx_comp.pa_ch_comp[x][RF_get_ch_comp_index]

+ eep_static.rf_comp.pa_temp_comp

+ gsm.pl_vcc_offset

+eep_static.rf_tx_comp.antenna_ch_comp[x][RF_get_ch_comp_index]

the [x][x] above indicates the band and the power level.

Default Power Ramp Table

- There is one different default table for every frequency BAND XX:
  - Default_Level_XX[1..16] are the up ramp values for power level XX,
  - Default_Level_XX[17..32] are the down ramp values for power level XX.
  - Default_Level_XX[16] is the max power level of the ramp up and corresponds to the default power level of Tx burst.

Power Level Calibration

- The applied offset values are calculated from measurements in production and saved in EEPROM. The offset values should be added to the last parameter in the ramp up, and there is a value for each power level:

Eep_static.rf_adjcomp.pa_offset[x][0..19]

The first parameter x indicates the selected band.

TX Channel Compensation 1

- The TX channel compensation can be made mainly to compensate for ripple in the transmit output path. The channel compensation is only necessary for maximum power level supported by the mobile, while these levels have the closest tolerances. RF driver supports a maximum number of ten sub-bands.

EGSM900	GSM1800	EEprom name
1 to 25	512 to 600	Eep_static.rf_comp.pa_ch_comp[x][0]
26 to 99	601 to 700	Eep_static.rf_comp.pa_ch_comp[x][1]
100 to 124	701 to 800	Eep_static.rf_comp.pa_ch_comp[x][2]
975 to 1023	801 to 885	Eep_static.rf_comp.pa_ch_comp[x][3]

TX Channel Compensation 2

- When the features RF_GENERIC_INTERFACE and ANTENNA_DETECTION are active, Eep_static.rf_comp.pa_ch_comp[x][x] is replaced by Eep_static.rf_tx_comp.pa_ch_comp[x][x]. Furthermore if MS uses the internal antenna, there is the other addend Eep_static.rf_tx_comp.antenna_ch_comp, which compensates the effect of board-by-board channel calibration (for External Antenna).
- The future RF_GENERIC_INTERFACE allows setting the correspondent compensation value for a maximum of ten intervals for each band supported.

TX Temperature Compensation

- The TX temperature compensation can be made in five temperature ranges to compensate for tolerances in the PAOUT1 DAC and Power Amplifier.

Temperature [°C]	EEprom name
-30 to –11	eep_static.rf_comp.pa_temp_comp[x][0]
-10 to +9	eep_static.rf_comp.pa_temp_comp[x][1]
+10 to +29	eep_static.rf_comp.pa_temp_comp[x][2]
+30 to +49	eep_static.rf_comp.pa_temp_comp[x][3]
+50 to +69	eep_static.rf_comp.pa_temp_comp[x][4]

NEONSEVEN

TX Supply voltage compensation

- The TX supply voltage compensation has to lower the output power when the supply voltage (CHR_RF_MEAN_VCC measured inside tx burst) is below a threshold value. The compensation is only active at max power level. The delta to PACT[16] should be calculated as:

$$offset\_step * (threshold - CHR\_RF\_MEAN\_VCC)$$

eep_static.rf_comp.pa_vcc_comp[x].threshold	33
eep_static.rf_comp.pa_vcc_comp[x].offset_step	10

- The threshold value has to be Vcc*10 i.e. 3.3V is stored as 33. There should be a set of parameters for each band supported by the MS. By setting the offset step is possible to define the corrective delta value to be added to last power up value for each 100 mV variation in supply voltage.

Timing Adjustment 1

- The starting time of the power ramp up and down of the Tx burst could be adjusted for different frequency band and power level value setting the correspondent values in eep:

  eep_static.rf_adjcomp.pa_timing_offset[x][0..19].rampup;

  eep_static.rf_adjcomp.pa_timing_offset[x][0..19].rampdown;

- ATTENTION: applied time adjustment to start the ramp up and down MUST be inside the allowed range highlighted in the next slide: PA dependent

NEONSEVEN

Timing Adjustment 2

PA	PA timing offset ramp up Allowed range	PA timing offset ramp down Allowed Range
Infineon PMB6293	[-14; +142]	[-50;+7]
Agilent AGPM7863	[-4; +46]	[-16; +16]

Multi slot intermediate ramp

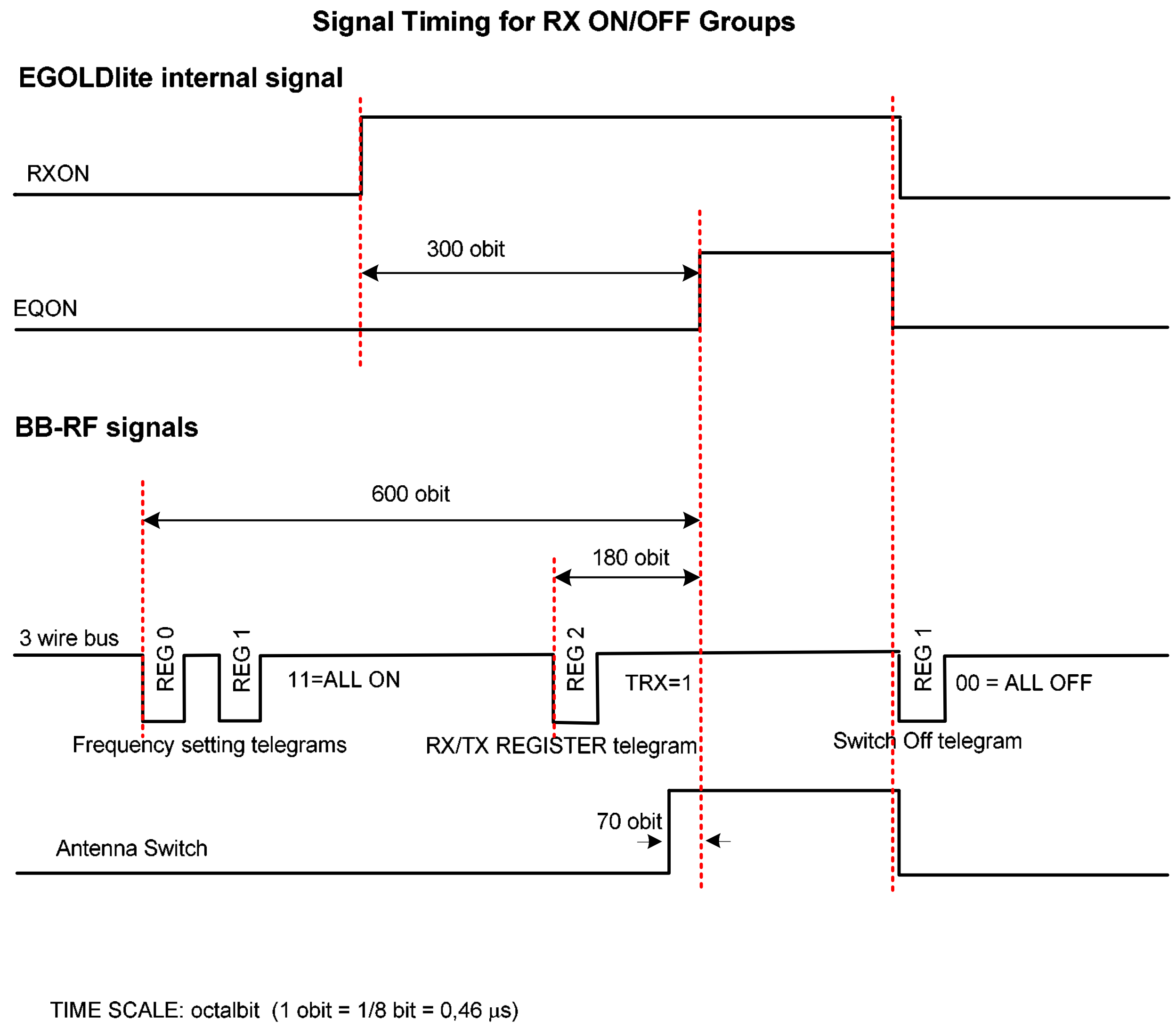
Intermediate ramp values between tx ts with power level 13 and 8 respectively (EGSM 900).

Down Ramp TS1	Hold value 340	320	250	200	180	150	50	50	50	50	50	50	50	50	50	50	50
Up Ramp TS 2	Hold value 750	50	50	50	50	50	50	50	50	50	150	180	280	400	500	650	750
Inter. Ramp	-	340	340	340	340	340	340	340	400	500	650	750	750	750	750	750	750

Intermediate ramp values between tx ts with power level 8 and 13 respectively (EGSM 900).

Down Ramp TS1	Hold value 750	660	500	320	200	170	50	50	50	50	50	50	50	50	50	50	50
Up Ramp TS 2	Hold value 340	50	50	50	50	50	50	50	50	50	140	150	150	220	300	320	340
Inter. Ramp	-	750	750	750	750	750	660	500	340	340	340	340	340	340	340	340	340

Signal Timing for RX Window



RX/TX Register (REG2) configuration for Rx window

- The RX/TX Register is used to control the internal RX path of SMARTi SD that it could be divided in the following main parts:
  - **RF front-end:** GSM850/900/1800/1900 **LNAs**
  - **Demodulator and Baseband Stage:**
    - **PGC** programmable gain correction stage - 6dB to +7dB in 1dB steps
    - **RSGS** additional **6dB** gain step to minimize the baseband ADC noise contribution
    - **OGS** overall gain step **6 dB**

Rx Gain Bit Setting

RX Gain level [dB]	RXCORR value = 0dB - PGC	RXGAIN LNA	OGS	RSGS
23	0110	0	0	0
57	0110	1	0	0
63	0110	1	0	1

RX gain vs. channel calibration

- **The EGSM900 RX path might be calibrated in six sub-bands for GSM900 and eight sub-bands for GSM1800 and to compensate for tolerances in the receive filters. The RX gain vs. channel compensation might be done in the production tester.**

RX channel EGSM900 X = 1	RX channel GSM1800 X = 2	EEprom name
0 to 25	512 to 550	eep_static.rf_adjcomp.rxlev_ch_comp[x][0]
26 to 50	551 to 600	eep_static.rf_adjcomp.rxlev_ch_comp[x][1]
51 to 75	601 to 650	eep_static.rf_adjcomp.rxlev_ch_comp[x][2]
76 to 100	651 to 700	eep_static.rf_adjcomp.rxlev_ch_comp[x][3]
101 to 124	701 to 750	eep_static.rf_adjcomp.rxlev_ch_comp[x][4]
975 to 1023	751 to 800	eep_static.rf_adjcomp.rxlev_ch_comp[x][5]
	801 to 850	eep_static.rf_adjcomp.rxlev_ch_comp[x][6]
	851 to 885	eep_static.rf_adjcomp.rxlev_ch_comp[x][7]

RX level linearity calibration

- Rx Gain linearity must be calibrated to compensate for tolerances on the biggest gain steps. The mobile is tested at least at two different input levels per band:
  - one using low Rx Gain (LNA off) setting
  - the second when LNA is switched on (e.g. at RF input levels of -48dBm and -75dBm respectively).

- The EEprom parameter name is:

  eep_static.rf_adjcomp.rxlev_gain_comp[x][0..69]

  where the first parameter x indicates the selected band.

Rx temperature compensation

- RX Temperature compensation is adjusted in five temperature ranges to compensate for temperature dependencies in the receive filters and gain stages. The temperature compensation is to be fixed on all units and need no production measurement. The exact delta values must be determined on the last pre series before FTA.

Temperature [°C]	EEprom name
-30 to –11	eep_static.rf_comp.rxlev_temp_comp[0..3][0]
-10 to +9	eep_static.rf_comp.rxlev_temp_comp[0..3][1]
+10 to +29	eep_static.rf_comp.rxlev_temp_comp[0..3][2]
+30 to +49	eep_static.rf_comp.rxlev_temp_comp[0..3][3]
+50 to +69	eep_static.rf_comp.rxlev_temp_comp[0..3][4]

Temperature Sensor

- The temperature sensor is a NTC thermistor that is connected to M7 measurement input of E-GOLDlite. It will be useful to perform temperature measurement used for temperature compensation of the RF.
- Actually this external temperature sensor isn't used and only on-chip temperature measurement is performed. We assume that the temperature of E-GOLDlite and transceiver is the same.
- The temperature sensor for measurement of the on chip temperature (TIC) is placed in the mixed signal section of the chip in the neighborhood of the controller block. The temperature characteristic of a well-defined semiconductor junction at a defined current level is used for determining the on chip temperature.

Reference Oscillator

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Nominal Frequency	F0		26		MHz
Startup time to reach 90% output voltage	T_{st}			5	msec
Power Supply Voltage	V_{cc}	2.4	2.5	2.6	V
Control voltage V_{con} = 1.5+/-1.0V	dF/V	+/- 9		+/-16	ppm/V
DAC resolution		-	11	-	bit
AFC sensitivity (1 DAC step)			15		Hz/bit @900 MHz
Frequency Stability vs. Temp (-20 to +75°C)	df/F	-2.5	-	+2.5	ppm
Frequency Aging Rate (Ta =25±2 °C)	dfag	-1	-	+1	ppm
Aging 10 years		-5	-	+5	ppm

AFC: XOTUNE and XOCAL programming