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Track: Signal Chain

Title: Spec distribution of TI IF solution base on 3GPP

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Content

1. Introduction

This paper presents TI IF solution for transceiver and indicates how the 3GPP RF specs such as ACLR, SFDR, receive sensitivity and so on distribute to TI ADC, DAC and IQ modulator specs. It analyzes the specs distribution for TX, RX and feedback signal chain of transceiver base on UMTS system. Furthermore it also shows TI IF solution can satisfy the MC-GSM system requirement by appropriate channel design and DPD solution.

2. TI IF solution for base station transceiver

TI high speed signal chain solution for base station transceiver is as following:

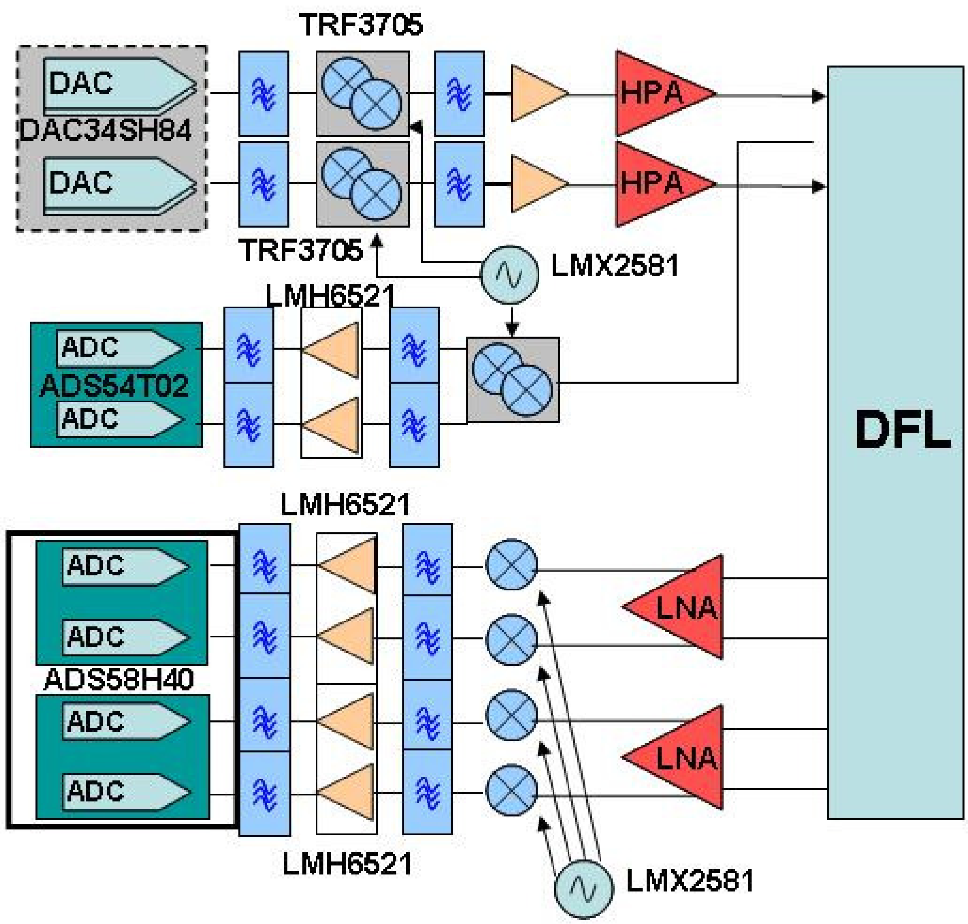

Figure 1 TI HSP solution for transceiver

This article focus on the IF solution analysis, the key devices are DAC34SH84, TRF3705, ADS54T02 and ADS58H40. They are license free.

DAC34SH84 is high performance, low power consumption, quad-channel, 16bit, 1.5 GSPS, digital to analog converter, supports 600MHz bandwidth.

TRF3705 is high linearity, high performance, 300MHz to 4GHz, IQ modulator. It moves baseband or IF to RF.

ADS54T02 is dual-channel, 12bit, 750 MSPS, analog to digital converter supports ultra wideband feedback application.

ADS58H40 is quad-channel, 14bit, 250MSPS, analog to digital converter, has 3 modes which supports both RX and FB applications.

3. RF Specs distribution

The WCDMA is the most popular 3G wireless communication system and the first class MC-GSM has the strictest system performance requirement. If the system can satisfy MC-GSM, it also satisfies other wireless communication system with margins. Therefore, this article focuses on WCDMA and MC-GSM analysis.

3GPP sets the RF specs requirement for base station. These RF specs distributes to each devices on the signal chain of transceiver. In order to analysis them, there are two stages NF and OIP3 equations need to be known at first:

$$NF_{system} = NF_1 + \frac{NF_2 - 1}{G_1} \quad (1)$$

$$OIP3_{system} = \frac{1}{\frac{1}{OIP3_2} + \frac{1}{OIP3_1 * G_2}} \quad (2)$$

The system NF and OIP3 can be calculated by iterated above equations.

3.1 TX analysis

TI IF solution for TX channel is DAC34SH84 and TRF3705.

The 5 order base band low pass filter which located between DAC34SH84 and TRF3705 normally has a gain of -0.2dB.

The output signal amplitude of DAC34SH84 is normally 1Vpp. That equal to $10 * \lg[(\frac{V_{pp}}{2\sqrt{2}})^2 * 1000 / R] = 4dBm$.

TRF3705 high gain mode has a voltage gain of 2.9dB at UMTS frequency band. The full scale single tone output of this system is $4 - 0.2 + 2.9 = 6.7dBm$.

WCDMA four carriers signal theoretically has a PAR of $10.3+6=16.3dB$ before peak clipping, after peak clipping it is less than 8dB. In order to get better linearity performance, more DPD and temperature compensation margins, normally needs more back off, so the output of this system should be about -17dBFS (-10dBm). Please note, this output power is decided by the noise floor and linearity balance, in addition the gain of power amplifier and RF VGA also need to be taken into account. For MC-GSM system due to the high intermodulation products, more back off is needed.

The noise floor of both DAC34SH84 and TRF3705 are better than -160dBm with this output signal power, therefore the NF of DAC34SH84 and TRF3705 are better than $-160+174(KTB)=14dB$.

The OIP3 of DAC34SH84 is calculated as $OIP3 = P_{out} + \frac{IMD3}{2} = 4-12(dBFS)+78/2 = 31dBm$.

In summary, the TX system features can be presented in the following table:

							Pin
TX							-12.7
Device	Gain	NF	IP3	S Gain	S NF	S IP3	Pout
DAC34SH84	0	14	31	0	14	31	-12.7
LPF	-0.2	0.2	1000	-0.2	14.01	30.8	-12.9
TRF3705	2.9	14	30	2.7	17.03	28.46	-10

Table 1 TX system RF specs calculation

Higher DAC sample frequency results in lower DAC quantization noise (requires good clock phase noise performance). HD2, HD3 spurs are problems for low IF application, but High IF decreases DAC SFDR and IMD3 performance.

In order to get good noise floor and SFDR performance, DAC34SH84 is recommended to work with 1474.56MHz sample frequency and 184.32MHz intermediate frequency.

This system has a noise floor of -155dBm/Hz or -160dBm/Hz with -12dBFS or -17dBFS output signal respectively and its IMD3 more than 78dBc with -10dBm output signal. The first class MC-GSM system requires an intermodulation performance of 70dBc and a noise floor of 145dBm/Hz (For 40W RRU, Noise floor=

$$\max spur - p_{out} - 10*\lg BW - 10(margin) = -36-46-10*\lg 200000 - 10 = -145dBm/Hz$$

).

Therefore, this system satisfies the SNR and intermodulation requirements of all the wireless communication systems for base station with enough margins.

ACLR analysis

The ACLR requirement of 3GPP is relaxed with current DPD solution. Regarding the TX channel design of transceiver, for wideband system such as WCDMA due to the ACLR performance more relies on the system noise floor, so it needs keep more margins for DPD application. In addition, for the narrowband multi-carriers system such as MC-GSM the IMD3 is the key factor for equivalent ACLR performance, thus keeps less margin is enough.

The single carrier WCDMA ACLR calculation of this system is as follow:

ACLR analysis (theoretically)	LOG/Freq	Instruction(theoretical)
KTB	-174	Thermal noise
FS (M)	1474.56	DAC Sample frequency
BW	3840000	WCDMA Bandwidth
IF (M)	184.32	DAC output intermediate frequency
CLK Noise	-135	Phase noise at far area
CLK to DAC Noise	-84.51849	CLK Noise - 20*lg(FS/IF)+channel gain+10*lg(3840000)
Channel NF	17	From table 1
Channel gain	2.7	From table 1
Channel OIP3	28.5	From table 1
Signal power P	-10	From table 1
LO Noise	-160	LO noise floor at far area
Pm	-13	P-3
Cn	3	IM3 correction factor 1C=3 2C=9 4C=12
LO Noise in BW	-94.15669	LO noise+10*lgBW
System KTB Noise	-88.45669	-174+10*lgBW+Gain+Channel NF
System IMD3	83	IMD3=2*(OIP3 - Pm)
IM3	-90	IM3=P - IMD3 + Cn
Total channel noise	-81.98	Total Noise=CLK TO DAC Noise+LO Noise in BW+System KTB Noise+IM3
Worst channel ACLR	71.98	P - total channel noise

Table 2 Theoretical system ACLR calculation for single carrier WCDMA

Calculation steps:

(1) DAC clock phase noise impact on channel output = Clock far area phase noise – 20*lg(FS/IF) + channel gain + 10*lgBW

$$= -135 - 20 * \lg \frac{1474.56}{184.32} + 2.7 + 10 * \lg 3840000 = -84.5 dBm .$$

(2) LO Noise floor impact on channel output = LO far area noise floor + 10*lgBW $= -160 + 10 * \lg 3840000 = -94.2 dBm$.

(3) System thermal noise floor = KTB + 10*lgBW + channel gain + channel NF

$$= -174 + 10 * \lg 3840000 + 2.7 + 17 = -88.5 dBm$$

(4) Equivalent intermodulation power Pm = P – 3 $= -10 - 3 = -13 dBm$.

(5) The system IMD3 at channel output = 2*(OIP3 - Pm) $= 2*(28.5+13) = 83dBc$

(6) The biggest IM3 at channel output = P – IMD3 + Cn (IM3 overlap correction factor) $= -10-83+3 = -90dBm$

(7) The total noise at channel output= (1) + (2) + (3) + (6)

$$= (-84.5dBm) + (-94.2)dBm + (-88.5)dBm + (-90)dBm = -82(dBm).$$

(8) The worst system ACLR = signal power – total noise $= 10-(-82) = 72dBc$.

The ACLR is about 6 dB lower for 4 carriers WCDMA signal (ACLR=66dBc, signal power for each carrier is -16dBm, the ACLR performance is limited by high noise floor). The 3GPP only requires an ACLR of 50dBc. There are more than 15dB margins.

In addition, please note this calculation result is limited by the clock and LO noise, and the -160dBm/Hz output noise density in the chip datasheet has already contained the DAC clock phase noise and LO noise floor, so these two items can be removed in the calculation with good performance DAC clock and LO. The above analysis is to show how the DAC clock and LO noise degrade system performance.

Therefore, the actually system NF is 14.2, and step (1)&(2) should not be calculated. The revised ACLR calculation is as follow:

ACLR analysis (actually)	LOG/Freq	Instruction(actually)
KTB	-174	Thermal noise
FS (M)	1474.56	DAC Sample frequency
BW	3840000	WCDMA Bandwidth
IF (M)	184.32	DAC output intermediate frequency
CLK Noise	-1000	Removed
CLK to DAC Noise	-949.5185	Removed
Channel NF	14.2	14+0.2
Channel gain	2.7	From table 1
Channel OIP3	28.5	From table 1
Signal power P	-10	From table 1
LO Noise	-1000	Removed
Pm	-13	P-3
Cn	3	IM3 correction factor 1C=3 2C=9 4C=12
LO Noise in BW	-934.1567	Removed
System KTB Noise	-91.25669	-174+10*lgBW+Gain+Channel NF
System IMD3	83	IMD3=2*(OIP3 - Pm)
IM3	-90	IM3=P - IMD3 + Cn
Total channel noise	-87.57	Total Noise =System KTB Noise+IM3
Worst channel ACLR	77.57	P - total channel noise

Table 3 Actual system ACLR calculation for single carrier WCDMA

The actually worst single carrier WCDMA ACLR is 77.5dBc. The system test result is almost the same as the calculation.

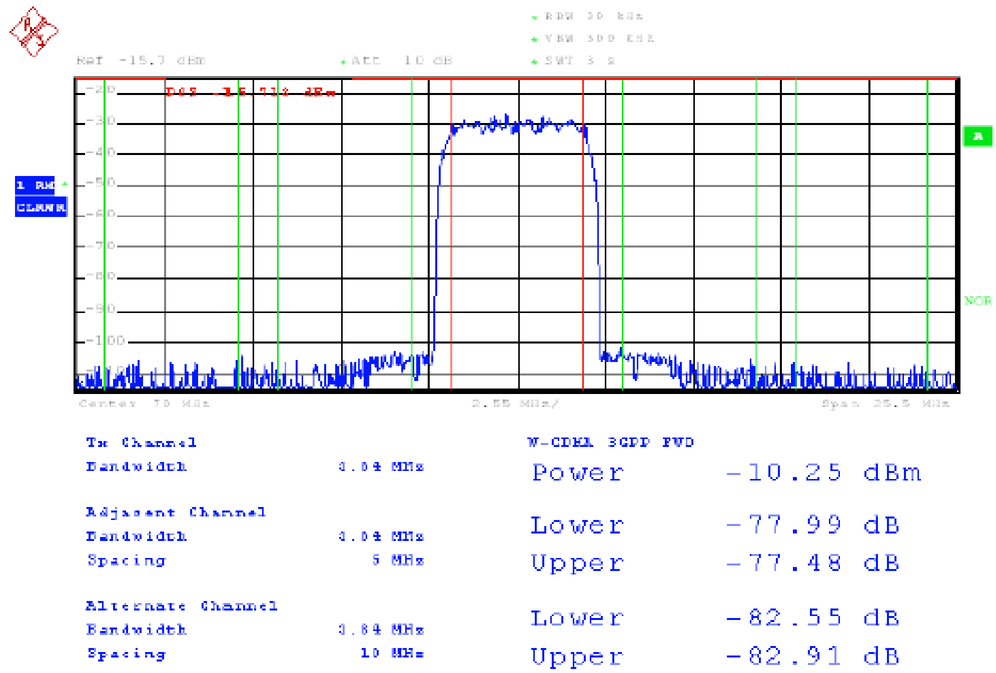

Figure 2 TM1 single carrier WCDMA ACLR test result

For multi-carriers GSM system, in order to get better performance another 3 dB back off is needed (Pout=-13dBm=-20dBFS). In this way the equivalent ACLR of 4 carriers GSM can be calculated as follow:

ACLR analysis MC-GSM	LOG/Freq	Instruction(4 carriers)
KTB	-174	Thermal noise
FS (M)	1474.56	DAC Sample frequency
BW	200000	GSM Bandwidth
IF (M)	184.32	DAC output intermediate frequency
CLK Noise	-1000	Removed
CLK to DAC Noise	-962.351	Removed
Channel NF	14.2	14+0.2
Channel gain	2.7	From table 1
Channel OIP3	28.5	From table 1
Signal power P	-13	Total signal power
Carrier number	4	
LO Noise	-1000	Removed
Pm	-16	P-3
P carrier	-19.0206	Power for each carrier
Cn	12	IM3 correction factor 1C=3 2C=9 4C=12
LO Noise in BW	-946.99	Removed
System KTB Noise	-104.09	-174+10*lgBW+Gain+Channel NF

System IMD3	89	IMD3=2*(OIP3 - Pm)
IM3	-96.0206	IM3=Pcarrier - IMD3 + Cn
Total channel noise	-95.39	Total Noise =System KTB Noise+IM3
Worst channel ACLR	76.37	Pcarrier - total channel noise

Table 4 System equivalent ACLR calculation for 4 carriers GSM

The intermodulation requirement of first class MC-carrier GSM system is 70dBc or -36dBm. The equivalent ACLR is 76.4dBc and the IM3 at power amplifier output is IM3+Gain= $-96+46-(-13)=-37dBm$ which are both satisfied the protocol requirement with enough margins.

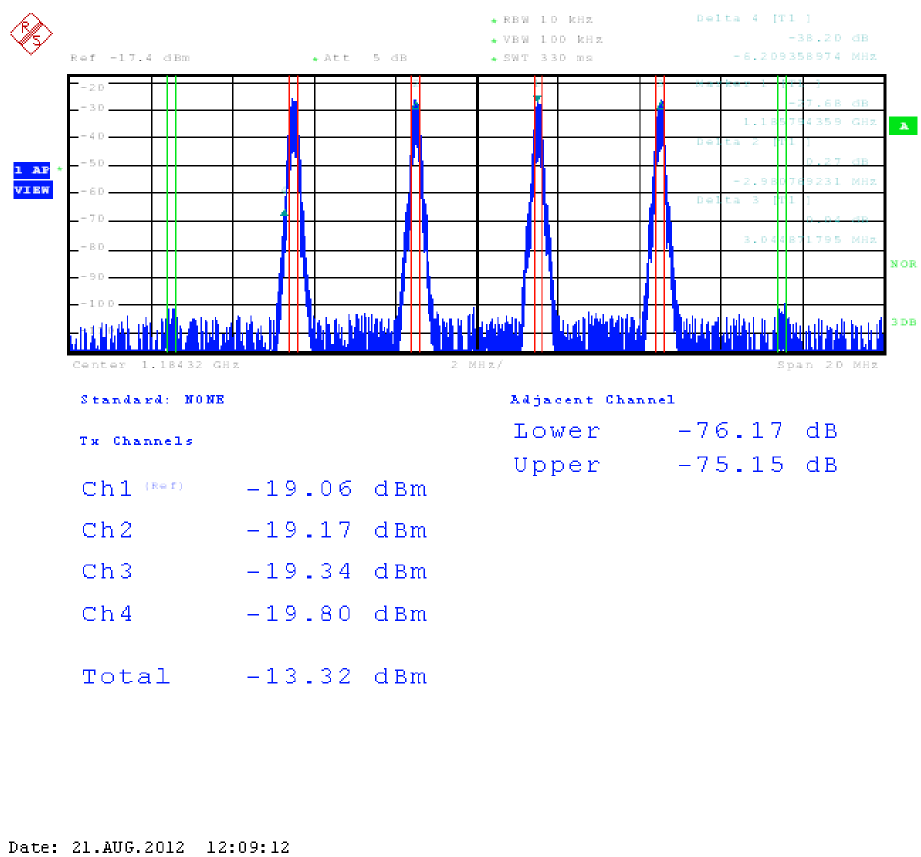

Figure 3 Four carriers GSM intermodulation test result

The test result is about 1dB worse than the calculation result; this is because of the noise floor of the spectral analyzer.

SFDR analysis

Normally the ACLR requirement is not the limitation for TX channel, there is a lot of margin for DPD application, the most limited spec is SFDR, especially for multi-carriers GSM system.

3GPP TS 25.104 sets the spurious emission requirement for UMTS base station:

Band	Maximum Level	Measurement Bandwidth	Note
9 kHz ↔ 150 kHz	-36 dBm	1 kHz	Note 1
150 kHz ↔ 30 MHz	-36 dBm	10 kHz	Note 1
30 MHz ↔ 1 GHz	-36 dBm	100 kHz	Note 1
1 GHz ↔ F_{low} - 10 MHz	-30 dBm	1 MHz	Note 1
F_{low} - 10 MHz ↔ F_{high} + 10 MHz	-15 dBm	1 MHz	Note 2
F_{high} + 10 MHz ↔ 12.75 GHz	-30 dBm	1 MHz	Note 3
12.75 GHz - 5th harmonic of the upper frequency edge of the DL operating band in GHz	-30 dBm	1 MHz	Note 3, Note 4

Table 5 BS Mandatory spurious emissions limits (quote from 3GPP TS 25.104)

Due to DFL(duplex filter) provides suppression of out band spurs, the most strictly point is -30dBm@1MHz BW (red in the table 4) for UMTS system, and for first class MC-GSM system the requirement is -36dBm@100kHz BW which is stricter than UMTS system.

Take 40W RRU as example (46dBm), the calculation is as follow:

SFDR analysis WCDMA	LOG/Freq	Instruction
Signal power at PA output	46	40W
RRU SFDR requirement	-30	From 3GPP
SFDR for single tone	76	P-SFDR requirement
BW gain for WCDMA	-5.843312	10*lg(1M/3.84M)
DAC+IQM SFDR	70.15669	76 + BW gain

Table 6 DAC SFDR requirement calculation for WCDMA

SFDR analysis MC-GSM	LOG/Freq	Instruction
Signal power at PA output	46	40W
RRU SFDR requirement	-36	From 3GPP
SFDR for single tone	82	P-SFDR requirement
BW gain for MC-GSM	-3	10*lg(100k/200k)
DAC+IQM SFDR	79	82 + BW gain

Table 7 DAC SFDR requirement calculation for MC-GSM

Calculation steps (table 6):

(1) The SFDR requirement for single tone = Pout – SFDR requirement $= 46 + 30 = 76dBc$

(2) The bandwidth gain between spur measure BW and signal BW = 10*lg(measure BW/ signal BW) = $10 * \lg(1M / 3.84M) = -5.8dB$.

(3) The SFDR spec for DAC+IQM = (3) + (4) $= 76 - 5.8 = 70.2dBc$.

Please note the spur power measure BW is different to signal BW, so the SFDR spec requirement normally is lower than single tone test.

For MC-GSM system the SFDR spec should be better than 79dBc as table 7 calculation.

The below figure shows the single tone SFDR test result of DAC34SH84 + TRF3705 system:

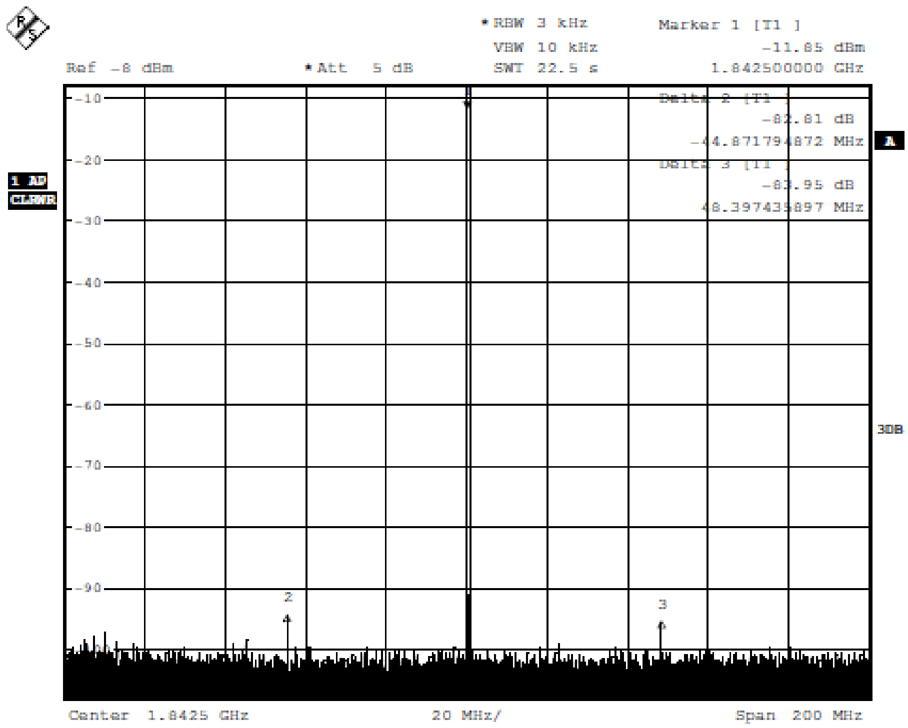

Figure 4 Single tone SFDR test

This system can support a single tone SFDR performance better than 82dBc, it satisfy first class MC-GSM system application.

3.2 FB analysis

TI FB ADC is ADS54T02. The main function of feedback channel is to capture the coupling signal from power amplifier for DPD application. DPD algorithm normally needs to capture 5 or 7 order intermodulation products, thus for multi-carriers and wideband LTE system this DPD bandwidth is very wide.

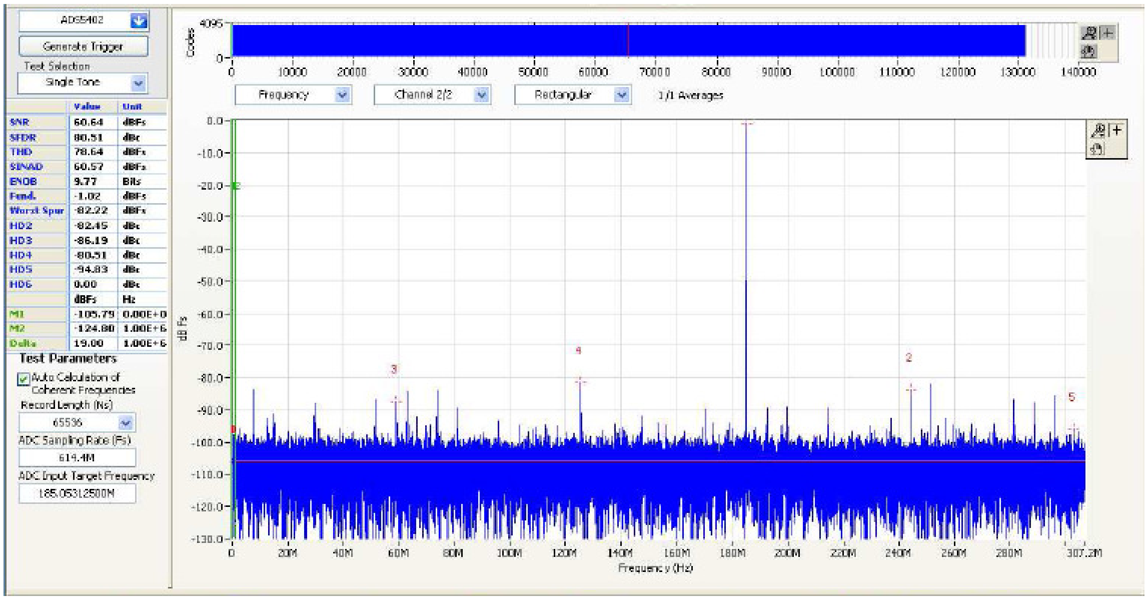

Figure 5 ADS54T02 SFDR test

The SFDR performance of ADS54T02 is 80dBc, and its IMD3 performance is better than 84dBc with -7dBFS input signal. Its performance satisfies all the requirement of DPD application.

In order to analyze the DPD performance requirement, it is necessary to involve in the FB channel specs.

There are some real assumptions for FB channel (channel parameters provided by base station equipment productor):

(1) The input coupling signal is +6dBm.

(2) Channel gain is -6dB, NF is 18dB and OIP3 is 40dBm except FB ADC.

(3) The impedance of FB ADC input driver circuit is 50 Ω.

Therefore, the full scale FB ADC input power (single tone) can be calculated as: $10*\lg[(\frac{V_{pp}}{2\sqrt{2}})^2*1000/R]=10dBm$ which also means the ADC input signal of this system is -10dBFS ($6-6=0dBm$).

The ADC equivalent NF and IP3 specs also need to be calculated at first.

FB ADC NF&IP3 analysis	LOG/Freq	Instruction
SNR BW	375000000	Nyquist bandwith
SNR FS	60.5	From test result
FS power (50Ω input)	10	2Vpp input signal with 50Ω
ADC noise density	-136.2403	SNRFS - FS - 10*lgBW
KTB	-174	Thermal noise
ADC noise figure	37.759687	Noise density - KTB
ADC IMD3	84	From test result
ADC input power with IMD3	3	-7dBFS
ADC IP3	45	IP3=P+0.5*IMD3

Table 8 ADS54T02 equivalent NF and IP3 calculation

Calculation steps:

(1) ADC noise density = SNRFS – FS power – 10*lgBW

$$=60.5-10-10*\lg 375000000=-136.2 dBm/Hz$$

(2) ADC equivalent NF = ADC noise density – KTB $=-136.2-(-174)=37.6dB$.

(3) ADC IP3 = P + IMD3/2 $=(10-7)+84/2=45dBm$.

In summary, the FB system is present as follow:

							Pin
CP WCDMA							6
Device	Gain	NF	IP3	S Gain	S NF	S IP3	Pout
CP channel	-6	18	40	-6	18	40	0
ADS54T02	0	37.8	45	-6	43.77	38.81	0

Table 9 WCDMA FB system calculation

For MC-GSM system, in order to get better performance, another 3 dB back off is needed, the CP channel specs also changes with the channel gain decreasing.

							Pin
CP MC-GSM							6
Device	Gain	NF	IP3	S Gain	S NF	S IP3	Pout
CP channel	-9	21	38	-9	21	38	-3
ADS54T02	0	37.8	45	-9	46.77	37.21	-3

Table 10 MC-GSM FB system calculation

The ACLR performance of this system is critical; at certain extent it indicates the signal ACLR which can be achieved at the out put of power amplifier.

FB ACLR analysis

FB ACLR analysis WCDMA	LOG/Freq	Instruction
System NF	43.8	From table 9
Channel gain	-6	From table 9
System OIP3	38.8	From table 9
Signal power	0	From table 9
KTB	-174	Thermal noise
BW	3840000	WCDMA Bandwidth
Pm	-3	P-3
Cn	3	IM3 correction factor 1C=3 2C=9 4C=12

System KTB Noise	-70.35669	KTB+10*lgBW+gain+NF
System IMD3	83.6	IMD3=2*(OIP3 - Pm)
IM3	-80.6	IM3=P - IMD3 + Cn
Total Noise	-69.96	IM3+system KTB noise
FB ADC ACLR	69.96	P - total noise

Table 11 FB ADC input signal ACLR for single carrier WCDMA

FB ACLR analysis MC-GSM	LOG/Freq	Instruction (4 carries)
Carriers number	4	
System NF	46.8	From table 10
Channel gain	-9	From table 10
System OIP3	37.2	From table 10
Signal power P	-3	Total signal power
KTB	-174	Thermal noise
BW	200000	GSM Bandwidth
P carrier	-9.0206	Power for each carrier
Pm	-6	P-3
Cn	12	IM3 correction factor 1C=3 2C=9 4C=12
System KTB Noise	-83.1897	KTB+10*lgBW+gain+NF
System IMD3	86.4	IMD3=2*(OIP3 - Pm)
IM3	-83.4206	IM3=Pcarrier - IMD3 + Cn
Total Noise	-80.29	IM3+system KTB noise
FB ADC ACLR	71.27	Pcarrier - total noise

Table 12 FB ADC input signal ACLR for 4 carriers GSM

Calculation steps (table 11):

(1) The signal BW noise floor in the FB ADC = KTB + 10*lgBW + gain + NF

$$= -174 + 10 * \lg 3840000 - 6 + 43.8 = -70.4 dBm.$$

(2) Equivalent intermodulation power Pm = P – 3= $0 - 3 = -3dBm$.

(3) System IMD3 = 2*(OIP3 – Pm) $= 2*(38.8+3) = 83.6dBc$.

(4) The power of IM3 = P – IMD3+Cn $= 0 - 83.6 + 3 = -80.6dBm$.

(5) The total noise in FB ADC = Noise floor + IM3

$$= (-70.4dBm) + (-80.6dBm) = -70dBm.$$

(6) The signal ACLR in FB ADC = Pin – Total noise $= 0 + 70 = 70dBc$

The theoretical calculation result indicates that if DPD algorithm does its best, and the power amplifier doesn't degrade the system linearity performance, the single carrier WCDMA ACLR at power amplifier output can be better than 70dBc, because the ACLR performance is limited by the noise floor, and theoretically the DPD more relies on the IMD3 performance.

Please note, the linearity performance of power amplifier and the ability of DPD algorithm are also the key factors to system ACLR spec.

3.3 RX analysis

TI RX ADC is ADS58H40. It provides very good SNR, SFDR and IMD3 performances for RX system. Regarding RX system design, the receive sensitivity spec for small signal and the blocking spec for large signal are the key factors. Due to the high SNR performance of modern high speed ADC, the blocking requirement is more critical than RX sensitivity requirement.

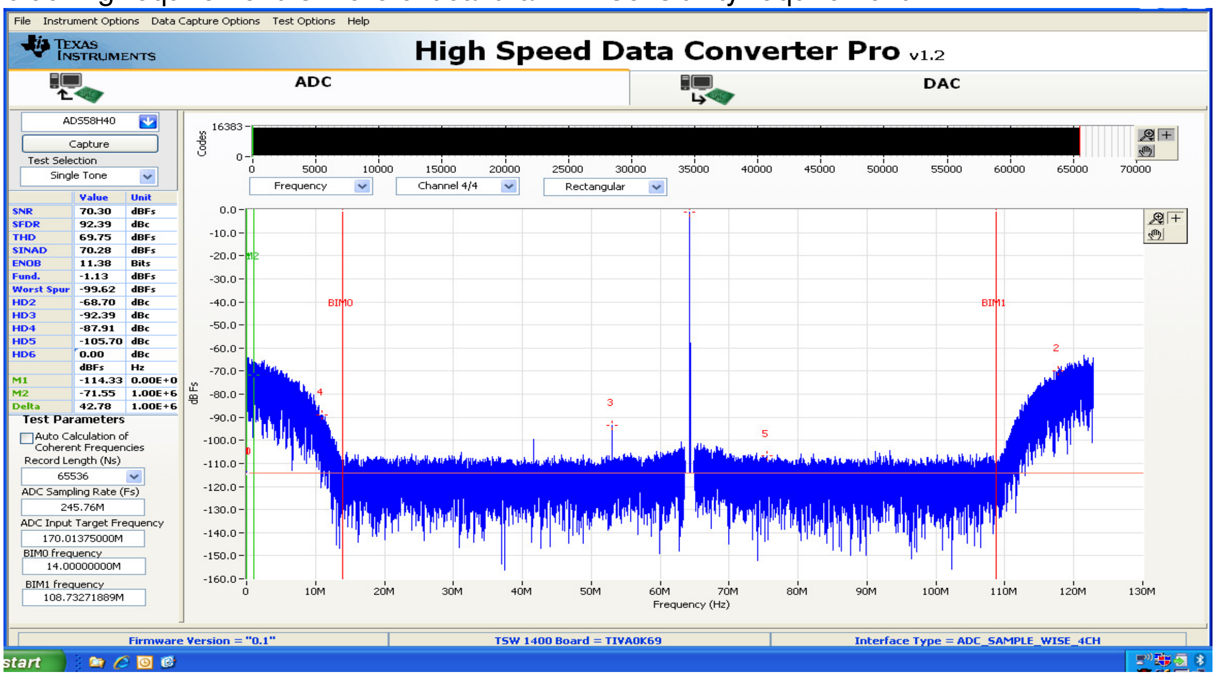

Figure 6 ADS58H40 SFDR test

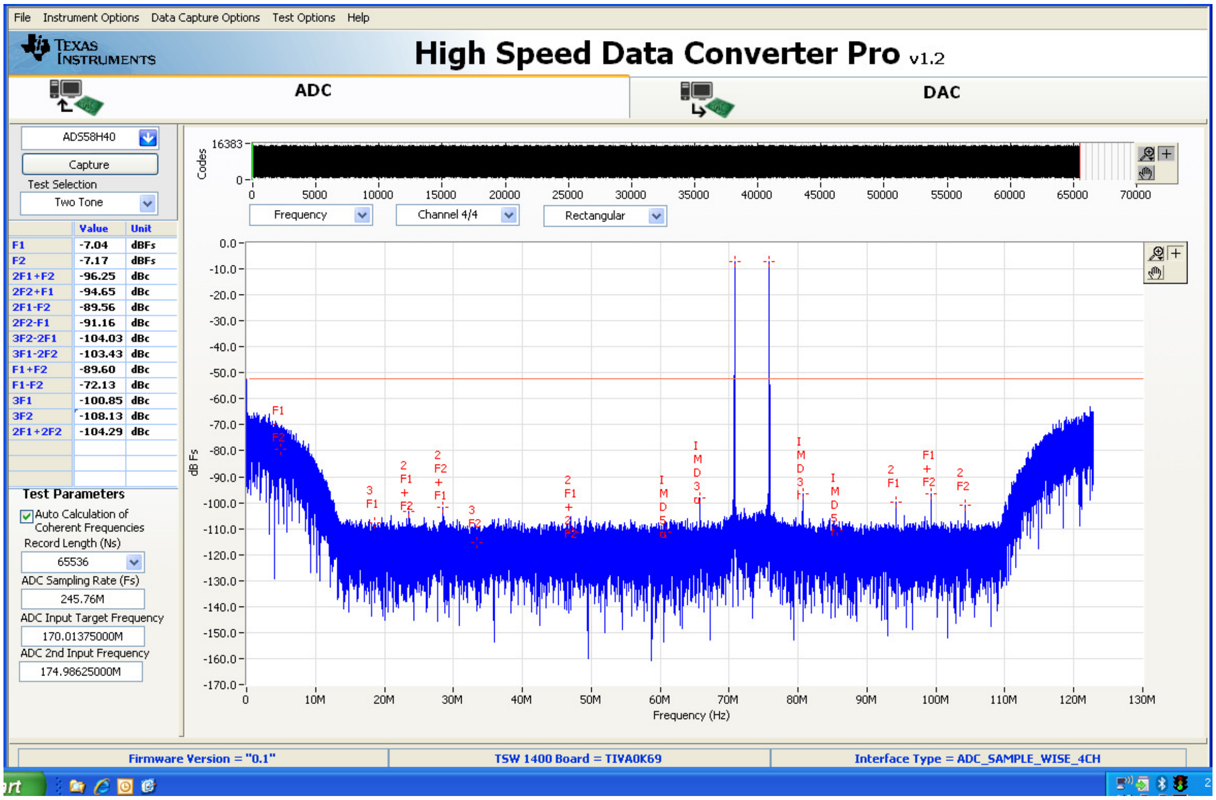

Figure 7 ADS58H40 IMD test

Both the SFDR and IMD3 performances of ADS58H40 are 90dBc. There are enough margins for RX system design.

The same as FB system of transceiver, it is necessary to involve in RX channel spec to evaluate ADS58H40.

There are some real assumptions for RX channel (channel parameters provided by base station equipment productor):

(1) For small signal the channel gain is 50dB, channel NF is 2.2dB, OIP3 is 42dBm.

(2) For big signal the channel gain is 40dB, channel NF is 3dB, OIP3 is 39dBm.

(3) For large signal the channel gain is 25dB, channel NF is 4.5dB, OIP3 is 32dBm.

(4) The impedance of RX ADC input driver circuit is 100Ω.

Therefore, the full scale RX ADC input power (single tone) can be calculated as: $10*\lg[(\frac{V_{pp}}{2\sqrt{2}})^2*1000/R]=7dBm$.

Again, the ADC equivalent NF and IP3 specs calculated in the below table:

RX ADC NF&IP3 analysis	LOG/Freq	Instruction
SNR BW	90000000	SNRBoost BW

SNR	70.5	From test result
FS power (100Ω input)	7	2Vpp input signal with 100Ω
ADC Noise	-143.0424	SNRFS - FS - 10*lgBW
KTB	-174	Thermal noise
ADC Noise figure	30.95757	Noise density - KTB
ADC IMD3	90	From test result
ADC input power with IMD3 test	0	-7dBFS
ADC IP3	45	IP3=P+0.5*IMD3

Table 13 ADS58H40 equivalent NF and IP3 calculation

The calculation step is the same as FB ADC, so the RX channel specs are summarized as follow:

							Pin
RX Sensitivity							-125
Device	Gain	NF	IP3	S Gain	S NF	S IP3	Pout
RX channel	50	2.2	42	50	2.2	42	-75
ADS58H40	0	31	45	50	2.233	40.24	-75

Table 14 RX system calculation for sensitivity

There are enough margins for RX sensitivity, so just a quick calculation:

(1) WCDMA RX sensitivity $= KTB + 10*\lg BW + NF + C/N - ProcessGain$

$= -174 + 10*\lg 3840000 + 2.2 + 6 - 10*\lg(3.84M/12.2k) = -125dBm$.

(2) MC-GSM RX sensitivity $= KTB + 10*\lg BW + NF + C/N$

$= -174 + 10*\lg 200000 + 2.2 + 7 = -112dBm$.

The 3GPP only requires a RX sensitivity of -121dBm for WCDMA and -102dBm for GSM respectively.

Blocking analysis

The blocking signal can't exceed the full scale of RX ADC (+7dBm), and there also need to keep margins, so the gain of channel needs to be reduced. As a result, the NF and OIP3 performances are also degraded.

							Pin
RX Block W							-40
Device	Gain	NF	IP3	S Gain	S NF	S IP3	Pout
RX channel	40	3	39	40	3	39	0
ADS58H40	0	31	45	40	3.266	38.03	0

Table 15 RX system calculation for WCDMA Blocking

							Pin
RX Block MG							-16
Device	Gain	NF	IP3	S Gain	S NF	S IP3	Pout
RX channel	20	4.5	32	20	4.5	32	4
ADS58H40	0	31	45	20	11.87	31.79	4

Table 16 RX system calculation for MC-GSM Blocking

The DFL and other filters on the RX channel remove the out band blocking signal, only in band blocking signal needs to be analyze for RX ADC.

The SFDR requirement of ADC can be gotten from blocking analysis.

Blocking analysis WCDMA	LOG/Freq	Instruction
Wanted Signal	-115	3GPP RX sensitivity+6
System NF	3.2	From table 15
KTB	-174	Thermal noise
BW	3840000	WCDMA Bandwidth
C/N	6	Demodulation threshold
Process Gain	25	10*lg(3.84M/12.2k)
Acceptable total noise	-96	P- C/N + PGain
KTB in band	-104.9567	KTB+10lgBW+NF
Acceptable noise except KTB	-96.59	Total noise - KTB in band
Block (Assuming 50%)	-99.59	Intermodulation 50%
3GPP block signal	-40	3GPP
SFDR	59.59	Block - acceptable noise

Table 17 RX ADC SFDR requirement calculation for WCDMA

Blocking analysis MC-GSM	LOG/Freq	Instruction
Wanted Signal	-90	3GPP RX sensitivity+12
System NF	11.87	From table 16
KTB	-174	Thermal noise
BW	200000	GSM Bandwidth
C/N	7	Demodulation threshold
Acceptable total noise	-97	P - C/N
KTB in band	-109.1197	KTB+10lgBW+NF
Acceptable noise except KTB	-97.28	Total noise - KTB in band
Block(Assuming 50%)	-100.28	Intermodulation 50%
3GPP block signal	-16	3GPP
SFDR	84.28	Block - acceptable noise

Table 18 RX ADC SFDR requirement calculation for MC-GSM

Calculation steps (table 18):

(1) The acceptable total noise for -94dBm wanted signal = P – C/N $= -90 - 7 = -97 dBm$.

(2) GSM BW thermal noise = KTB + 10*lgBW +NF

$= -174 + 10 * \lg 200000 + 11.9 = -109.1 dBm$.

(3) Acceptable noise except thermal noise = (1) – (2)

$= (-97 dBm) - (-109.1 dBm) = -97.3 dBm$.

(4) Assume Blocking and intermodulation effect occupy 50% noise respectively, the acceptable blocking signal power

$= (3) - 3 = -97.3 - 3 = -100.3 dBm$.

(5) The SFDR requirement of RX ADC = 3GPP blocking signal – (4) $= -16 + 100.3 = 84.3 dBc$.

Therefore first class MC-GSM system requires RX ADC with a SFDR performance better than 84.3dBc. ADS58H40 satisfy it with 6dB margins.

4. Conclusion

This article presents a way to analyze and calculate the system ACLR performance and SFDR requirement. Through these analyses, TI IF solution can support the first class MC-GSM system with performance margins based on the 3GPP requirement, and it is also work perfectly with WCDMA system.

5. Appendix

System specs calculation form

ADC&DAC spec calculation.xls

6. Reference

- DAC34SH84 datasheet, 2012 June, Texas Instruments Inc.
- TRF3705 datasheet, 2011 Oct, Texas Instruments Inc.
- ADS54T02 datasheet, 2012 July, Texas Instruments Inc.
- ADS58H40 datasheet, 2012 July, Texas Instruments Inc.
- 3GPP TS 25.104, 2012 March, 3GPP Org.
- 3GPP TS 45.005, 2011 Sep, 3GPP Org.