AN10544

TDA6650/51(A)TT C1 and C3 - known limitations

Rev. 01 — 24 November 2006

Application note

founded by Philips

Revision history

Rev	Date	Description
01	20061124	First release

Contact information

For additional information, please visit: **http://www.nxp.com**

For sales office addresses, please send an email to: **salesaddresses@nxp.com**

1. Introduction

The TDA6650/51(A)TT C1 and C3 have some limitations when used with very specific fractional ratios.

AN10544 reviews the main TV standards and summarizes the way the TDA6650/51(A)TT C1 and C3 must be programmed.

Reviewed standards are:

- DVB-T
- ISDB-T
- NTSC
- ATSC
- HRC (analog cable)
- IRC (analog cable)

2. DVB-T standard

European DVB-T standard is defined by the NorDig II specification.

2.1 Channels definition

According to the specification, the channel centre frequency (f_c) is defined as:

$$f_c = 474\,MHz + (N - 21) \times 8\,MHz \tag{1}$$

Where,

   N = 21 to 69.

DVB-T standard uses a 36.125 MHz IF frequency.

Table 1.   European DVB-T channels

Band	f_c (MHz)	f_{LO} (MHz)
High	474	510.125
	482	518.125
	490	526.125
	498	534.125
	506	542.125
	514	550.125
	522	558.125
	530	566.125
	538	574.125
	546	582.125
	554	590.125
	562	598.125
	570	606.125

Table 1. **European DVB-T channels** *…continued*

Band	f_c (MHz)	f_{LO} (MHz)
High	578	614.125
	586	622.125
	594	630.125
	602	638.125
	610	646.125
	618	654.125
	626	662.125
	634	670.125
	642	678.125
	650	686.125
	658	694.125
	666	702.125
	674	710.125
	682	718.125
	690	726.125
	698	734.125
	706	742.125
	714	750.125
	722	758.125
	730	766.125
	738	774.125
	746	782.125
	754	790.125
	762	798.125
	770	806.125
	778	814.125
	786	822.125
	794	830.125
	802	838.125
	810	846.125
	818	854.125
	826	862.125
	834	870.125
	842	878.125
	850	886.125
	858	894.125

2.2 TDA6650/51TT C1 or C3 configuration

The TDA6650/51 fractional settings can be calculated with formula:

$$f_{LO} = \left(I + \frac{k}{q}\right) \times f_{comp} \qquad (2)$$

Where,

f_{LO} = local oscillator frequency

I = main divider ratio

$\frac{k}{q}$ = fractional ratio

f_{comp} = comparison frequency

For DVB-T reception a 166.67 kHz frequency step is chosen:

f_{comp} = 4 MHz

q = 24

All channels use the fractional ratio $\left(\frac{13}{24}\right)$.

This results in:

$$f_{LO} = \left(I + \frac{13}{14}\right) \times 4\,MHz \qquad (3)$$

In DVB-T the nominal configuration does not present any limitation.

The configuration $\left(\frac{12}{24}\right)$ can bring a degradation of the LO spectrum. This configuration, one step below the nominal configuration, must not be programmed.

3. ISDB-T standard

ISDB-T standard uses a 57 MHz IF frequency.

3.1 Channels definition

Table 2. **Japanese ISDB-T channels**

Band	f_{pc} (MHz)	f_{LO} (MHz)
Low (6 MHz)	93.143	150.143
	99.143	156.143
	105.143	162.143
	111.143	168.143
	117.143	174.143
	123.143	180.143
	129.143	186.143
	135.143	192.143
	141.143	198.143
	147.143	204.143
	153.143	210.143
	159.143	216.143
	165.143	222.143
	171.143	228.143
	177.143	234.143
	183.143	240.143
	189.143	246.143
	195.143	252.143
	201.143	258.143
	207.143	264.143
	213.143	270.143
	219.143	276.143
Mid (6 MHz)	225.143	282.143
	231.143	288.143
	237.143	294.143
	243.143	300.143
	249.143	306.143
	255.143	312.143
	261.143	318.143
	267.143	324.143
	273.143	330.143
	279.143	336.143
	285.143	342.143
	291.143	348.143
	297.143	354.143

Table 2. **Japanese ISDB-T channels** *…continued*

Band	f_{pc} (MHz)	f_{LO} (MHz)
Mid (6 MHz)	303.143	360.143
	309.143	366.143
	315.143	372.143
	321.143	378.143
	327.143	384.143
	333.143	390.143
	339.143	396.143
	345.143	402.143
	351.143	408.143
	357.143	414.143
	363.143	420.143
	369.143	426.143
	375.143	432.143
	381.143	438.143
	387.143	444.143
	393.143	450.143
	399.143	456.143
	405.143	462.143
	411.143	468.143
	417.143	474.143
	423.143	480.143
	429.143	486.143
	435.143	492.143
	441.143	498.143
	447.143	504.143
	453.143	510.143
	459.143	516.143
	465.143	522.143
High (6 MHz)	473.143	530.143
	479.143	536.143
	485.143	542.143
	491.143	548.143
	497.143	554.143
	503.143	560.143
	509.143	566.143
	515.143	572.143
	521.143	578.143
	527.143	584.143
	533.143	590.143
	539.143	596.143
	545.143	602.143

Table 2. **Japanese ISDB-T channels** *…continued*

Band	f_{pc} (MHz)	f_{LO} (MHz)
High (6 MHz)	551.143	608.143
	557.143	614.143
	563.143	620.143
	569.143	626.143
	575.143	632.143
	581.143	638.143
	587.143	644.143
	593.143	650.143
	599.143	656.143
	605.143	662.143
	611.143	668.143
	617.143	674.143
	623.143	680.143
	629.143	686.143
	635.143	692.143
	641.143	698.143
	647.143	704.143
	653.143	710.143
	659.143	716.143
	665.143	722.143
	671.143	728.143
	677.143	734.143
	683.143	740.143
	689.143	746.143
	695.143	752.143
	701.143	758.143
	707.143	764.143
	713.143	770.143
	719.143	776.143
	725.143	782.143
	731.143	788.143
	737.143	794.143
	743.143	800.143
	749.143	806.143
	755.143	812.143
	761.143	818.143
	767.143	824.143

3.2 TDA6650/51ATT C1 or C3 configuration

The TDA6650/51 fractional settings can be calculated with formula:

$$f_{LO} = \left(I + \frac{k}{q} \right) \times f_{comp} \tag{4}$$

Where,

f_{LO} = local oscillator frequency

I = main divider ratio

$\frac{k}{q}$ = fractional ratio

f_{comp} = comparison frequency

For ISDB-T reception a 142.86 kHz frequency step is chosen:

f_{comp} = 4 MHz
q = 28

All channels use the fractional ratios $\left(\frac{1}{28} \right)$ or $\left(\frac{15}{28} \right)$.

This results in:

$$f_{LO} = \left(I + \frac{1}{28} \right) \times 4\ MHz \tag{5}$$

or

$$f_{LO} = \left(I + \frac{15}{28} \right) \times 4\ MHz \tag{6}$$

In ISDB-T the nominal configuration does not present any limitation.

The configuration $\left(\frac{14}{28} \right)$ can bring a degradation of the LO spectrum. This configuration, one step below some nominal configurations, must not be programmed.

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4. NTSC standard

4.1 Channels definition

US NTSC standard uses a 45.75 MHz IF frequency (f_{IF}). Channels are defined with respect to the picture carrier frequency (f_{pc}), see Table 3.

Table 3. **US NTSC channels**

Band	f_{pc} (MHz)	f_{LO} (MHz)
Low	55.25	101
	61.25	107
	67.25	113
	77.25	123
	83.25	129
Mid	175.25	221
	181.25	227
	187.25	233
	193.25	239
	199.25	245
	205.25	251
	211.25	257
High	471.25	517
	477.25	523
	483.25	529
	489.25	535
	495.25	541
	501.25	547
	507.25	553
	513.25	559
	519.25	565
	525.25	571
	531.25	577
	537.25	583
	543.25	589
	549.25	595
	555.25	601
	561.25	607
	567.25	613
	573.25	619
	579.25	625
	585.25	631
	591.25	637
	597.25	643
	603.25	649

Table 3. **US NTSC channels** …*continued*

Band	f_{pc} (MHz)	f_{LO} (MHz)
High	609.25	655
	615.25	661
	621.25	667
	627.25	673
	633.25	679
	639.25	685
	645.25	691
	651.25	697
	657.25	703
	663.25	709
	669.25	715
	675.25	721
	681.25	727
	687.25	733
	693.25	739
	699.25	745
	705.25	751
	711.25	757
	717.25	763
	723.25	796
	729.25	775
	735.25	781
	741.25	787
	747.25	793
	753.25	799
	759.25	805
	765.25	811
	771.25	817
	777.25	823
	783.25	829
	789.25	835
	795.25	841
	801.25	847
	807.25	853
	813.25	859
	819.25	865
	825.25	871
	831.25	877
	837.25	883
	843.25	889
	849.25	895

Table 3. **US NTSC channels** ...*continued*

Band	f_{pc} (MHz)	f_{LO} (MHz)
High	855.25	901
	861.25	907
	867.25	913
	873.25	919
	879.25	925
	885.25	931

4.2 TDA6650/51TT configuration

In US NTSC standard, the TDA6650/51TT must be programmed using the 50 kHz frequency step.

The frequency synthesis does not use the fractional-N algorithm. LO frequency is a multiple of the comparison frequency:

$$f_{LO} = \left(I + \frac{k}{q} \right) \times f_{comp} \tag{7}$$

Where,

f_{LO} = local oscillator frequency

I = main divider ratio

$\dfrac{k}{q}$ = fractional ratio

f_{comp} = comparison frequency

For NTSC reception a 50 kHz frequency step is chosen:

f_{comp} = 1 MHz

$q = 20$

All LO frequencies described in Table 3 can be written with **k = 0**:

$$f_{LO} = I \times f_{comp} \tag{8}$$

Where,

I = integer

5. ATSC standard

5.1 Channels definition

US ATSC standard uses a 44 MHz IF frequency. Channels are defined with the centre frequency (f_c) of the used bandwidth, see Table 4.

Table 4.   US ATSC channels

Band	f_c (MHz)	f_{LO} (MHz)
Low	57	101
	63	107
	69	113
	75	119
	81	125
	87	131
	93	137
	99	143
	105	149
	111	155
	117	161
	123	167
	129	173
	135	179
	141	185
	147	191
	153	197
	159	203
	165	209
	171	215
Mid	177	221
	183	227
	189	233
	195	239
	201	245
	207	251
	213	257
	219	263
	225	269
	231	275
	237	281
	243	287
	249	293
	255	299
	261	305

Table 4. **US ATSC channels** ...*continued*

Band	f_c (MHz)	f_{LO} (MHz)
Mid	267	311
	273	317
	279	323
	285	329
	291	335
	297	341
	303	347
	309	353
	315	359
	321	365
	327	371
	333	377
	339	383
	345	389
	351	395
	357	401
	363	407
	369	413
	375	419
	381	425
	387	431
	393	437
	399	443
	405	449
	411	445
	417	461
	423	467
	429	473
	435	479
	441	485
	447	491
	453	497
	459	503
	465	509
High	471	515
	477	521
	483	527
	489	533
	495	539
	501	545
	507	551

Table 4.   **US ATSC channels** …*continued*

Band	f_c (MHz)	f_{LO} (MHz)
High	513	557
	519	563
	525	569
	531	575
	537	581
	543	587
	549	593
	555	599
	561	605
	567	611
	573	617
	579	623
	585	629
	591	635
	597	641
	603	647
	609	653
	615	659
	621	665
	627	671
	633	677
	639	683
	645	689
	651	695
	657	701
	663	707
	669	713
	675	719
	681	725
	687	731
	693	737
	699	743
	705	749
	711	755
	717	761
	723	767
	729	773
	735	779
	741	785
	747	791
	753	797

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Table 4. **US ATSC channels** *…continued*

Band	f_c (MHz)	f_{LO} (MHz)
High	759	803
	765	809
	771	815
	777	821
	783	827
	789	833
	795	839
	801	845
	807	851
	813	857
	819	863
	825	869
	831	875
	837	881
	843	887
	849	893
	855	899
	861	905

5.2 TDA6650/51TT configuration

In US ATSC standard, the TDA6650/51TT must be programmed using the 50 kHz frequency step.

The frequency synthesis does not use the fractional algorithm. LO frequency is a multiple of the comparison frequency (**k = 0**).

6. HRC standard (analog cable)

6.1 Channels definition

US HRC cable standard uses a nominal IF frequency (f_{IF}) of 45.75 MHz. **With the TDA6650/51TT it is mandatory to shift f_{IF}: 45.75 MHz + 62.5 kHz = 45.8125 MHz.**

The channels must be tuned according to Table 5.

Table 5.   HRC analog cable channels (with TDA6650/51TT)

Band	f_{pc} (MHz)	f_{LO} (MHz)
Low	54	99.8125
	60	105.8125
	66	111.8125
	72	117.8125
	78	123.8125
	84	129.8125
	90	135.8125
	96	141.8125
	102	147.8125
	108	153.8125
	114	159.8125
	120	165.8125
	126	171.8125
	132	177.8125
	138	183.8125
	144	189.8125
	150	195.8125
	156	201.8125
	162	207.8125
	168	213.8125
Mid	174	219.8125
	180	225.8125
	186	231.8125
	192	237.8125
	198	243.8125
	204	249.8125
	210	255.8125
	216	261.8125
	222	267.8125
	228	273.8125
	234	279.8125
	240	285.8125
	246	291.8125

Table 5. **HRC analog cable channels (with TDA6650/51TT)** *…continued*

Band	f_{pc} (MHz)	f_{LO} (MHz)
Mid	252	297.8125
	258	303.8125
	264	309.8125
	270	315.8125
	276	321.8125
	282	327.8125
	288	333.8125
	294	339.8125
	300	345.8125
	306	351.8125
	312	357.8125
	318	363.8125
	324	369.8125
	330	375.8125
	336	381.8125
	342	387.8125
	348	393.8125
	354	399.8125
	360	405.8125
	366	411.8125
	372	417.8125
	378	423.8125
	384	429.8125
	390	435.8125
	396	441.8125
	402	447.8125
	408	453.8125
	414	459.8125
	420	465.8125
	426	471.8125
	432	477.8125
	438	483.8125
	444	489.8125
	450	495.8125
	456	501.8125
	462	507.8125
High	468	513.8125
	474	519.8125
	480	525.8125
	486	531.8125
	492	537.8125

Table 5. **HRC analog cable channels (with TDA6650/51TT)** *...continued*

Band	f$_{pc}$ (MHz)	f$_{LO}$ (MHz)
High	498	543.8125
	504	549.8125
	510	555.8125
	516	561.8125
	522	567.8125
	528	573.8125
	534	579.8125
	540	585.8125
	546	591.8125
	552	597.8125
	558	603.8125
	564	609.8125
	570	615.8125
	576	621.8125
	582	627.8125
	588	633.8125
	594	639.8125
	600	645.8125
	606	651.8125
	612	657.8125
	618	663.8125
	624	669.8125
	630	675.8125
	636	681.8125
	642	687.8125
	648	693.8125
	654	699.8125
	660	705.8125
	666	711.8125
	672	717.8125
	678	723.8125
	684	729.8125
	690	735.8125
	696	741.8125
	702	747.8125
	708	753.8125
	714	759.8125
	720	765.8125
	726	771.8125
	732	777.8125
	738	783.8125

Table 5.   **HRC analog cable channels (with TDA6650/51TT)** *…continued*

Band	f_pc (MHz)	f_LO (MHz)
High	744	789.8125
	750	795.8125
	756	801.8125
	762	807.8125
	768	813.8125
	774	819.8125
	780	825.8125
	786	831.8125
	792	837.8125
	798	843.8125

6.2 TDA6650/51TT configuration

In US analog cable HRC standard, the TDA6650/51TT must be programmed using the 62.5 kHz frequency step.

The LO frequency can be written as follows:

$$f_{LO} = \left(I + \frac{k}{q} \right) \times f_{comp} \tag{9}$$

Where,

f_{LO} = local oscillator frequency

I = main divider ratio

$\dfrac{k}{q}$ = fractional ratio

f_{comp} = comparison frequency

For HRC reception a 62.5 kHz frequency step is chosen:

f_{comp} = 2 MHz

q = 32

All f_{LO} described in Table 5 can be written with k = 29

This results in:

$$f_{LO} = \left(I + \frac{29}{32} \right) \times 2\ MHz \tag{10}$$

Where,

I = integer

7. IRC standard (analog cable)

7.1 Channels definition

US IRC (analog cable) standard uses a 45.75 MHz IF frequency (f_{IF}). The channels are defined in Table 6.

Table 6. IRC (analog cable) channels

Band	f_{pc} (MHz)	f_{LO} (MHz)
Low	55.25	101
	61.25	107
	67.25	113
	73.25	119
	79.25	125
	85.25	131
	91.25	137
	97.25	143
	103.25	149
	109.25	155
	115.25	161
	121.25	167
	127.25	173
	133.25	179
	139.25	185
	145.25	191
	151.25	197
	157.25	203
	163.25	209
	169.25	215
Mid	175.25	221
	181.25	227
	187.25	233
	193.25	239
	199.25	245
	205.25	251
	211.25	257
	217.25	263
	223.25	269
	229.25	275
	235.25	281
	241.25	287
	247.25	293
	253.25	299
	259.25	305

Table 6. **IRC (analog cable) channels** ...continued

Band	f_{pc} (MHz)	f_{LO} (MHz)
Mid	265.25	311
	271.25	317
	277.25	323
	283.25	329
	289.25	335
	295.25	341
	301.25	347
	307.25	353
	313.25	359
	319.25	365
	325.25	371
	331.25	377
	337.25	383
	343.25	389
	349.25	395
	355.25	401
	361.25	407
	367.25	413
	373.25	419
	379.25	425
	385.25	431
	391.25	437
	397.25	443
	403.25	449
	409.25	455
	415.25	461
	421.25	467
	427.25	473
	433.25	479
	439.25	485
	445.25	491
	451.25	497
	457.25	503
	463.25	509
High	469.25	515
	475.25	521
	481.25	527
	487.25	533
	493.25	539
	499.25	545
	505.25	551

Table 6. **IRC (analog cable) channels** *…continued*

Band	f_{pc} (MHz)	f_{LO} (MHz)
High	511.25	557
	517.25	563
	523.25	569
	529.25	575
	535.25	581
	541.25	587
	547.25	593
	553.25	599
	559.25	605
	565.25	611
	571.25	617
	577.25	623
	583.25	629
	589.25	635
	595.25	641
	601.25	647
	607.25	653
	613.25	659
	619.25	665
	625.25	671
	631.25	677
	637.25	683
	643.25	689
	649.25	695
	655.25	701
	661.25	707
	667.25	713
	673.25	719
	679.25	725
	685.25	731
	691.25	737
	697.25	743
	703.25	749
	709.25	755
	715.25	761
	721.25	767
	727.25	773
	733.25	779
	739.25	785
	745.25	791
	751.25	797

Table 6. **IRC (analog cable) channels** *…continued*

Band	f_{pc} (MHz)	f_{LO} (MHz)
High	757.25	803
	763.25	809
	769.25	815
	775.25	821
	781.25	827
	787.25	833
	793.25	839
	799.25	845

7.2 TDA6650/51TT configuration

In US IRC (analog cable) standard, the TDA6650/51TT must be programmed using the 50 kHz frequency step.

The frequency synthesis does not use the fractional algorithm. LO frequency is a multiple of the comparison frequency (**k = 0**).

8. Conclusions

For nominal operation, the TDA6650/51(A)TT C1 and C3 have to follow the recommendations mentioned below:

- DVB-T:
  - In the nominal configuration the IC is fully functional.
  - If f_{LO} is programmed one frequency step below the nominal configuration, the spectrum might be degraded. This configuration must not be used.

- ISDB-T:
  - In the nominal configuration the IC is fully functional.
  - If f_{LO} is programmed one frequency step below the nominal configuration, the spectrum might be degraded. This configuration must not be used.

- NTSC:
  - In the nominal configuration (frequency step is 62.5 kHz) the spectrum might be degraded. A software work-around must be applied.
  - The frequency step parameter must be changed to 50 kHz.

- ATSC:
  - In the nominal configuration (frequency step is 62.5 kHz) the spectrum might be degraded. A software work-around must be applied.
  - The frequency step parameter must be changed to 50 kHz.

- HRC (analog cable):
  - In the nominal configuration the spectrum might be degraded. A software work-around must be applied.
  - The f_{IF} must be shifted by one step (f_{IF} = 45.8125 MHz).

- IRC (analog cable):
  - In the nominal configuration (frequency step is 62.5 kHz) the spectrum might be degraded. A software work-around must be applied.
  - The frequency step parameter must be changed to 50 kHz.

9. Abbreviations

Table 7.   Abbreviations

Acronym	Description
ATSC	Advanced Television Systems Committee
DVB-T	Digital Video Broadcasting - Terrestrial
HRC	Harmonically Related Carriers
IF	Intermediate Frequency
IRC	Incrementally Related Carriers
ISDB-T	Integrated Services Digital Broadcasting - Terrestrial
LO	Local Oscillator
NTSC	National Television Systems Committee

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10. Legal information

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