RECOMMENDATION ITU-R BT.801-1*

Test signals for digitally encoded colour television signals conforming with Recommendations ITU-R BT.601 (Part A) and ITU-R BT.656

(1992-1995)

The ITU Radiocommunication Assembly,

considering

a) that digital television systems operate in very different ways from analogue systems with the consequence that a quite different set of picture impairments may be introduced;

b) that impairments may occur both from the conversions to and from the digital domain (which include filtering, sampling and quantization), and by degradations of the digital signal itself (such as individual digit errors, timing jitter or loss of frame synchronization);

c) that for measurements of such impairments it is necessary to provide the test signals,

recommends

1 that for measurements of quantization errors and timing errors between analogue and digital active lines in conversion process from and to the digital signals conforming with Recommendation ITU-R BT.601 (Part A), using 8-bit quantization, and for verifying the conformity of the multiplex format with Recommendation ITU-R BT.656, and checking for the correct operation of the associated interfaces, test signals used should be selected from the list given in Table 1, rows No. 1 to 15;

2 that for the verification of cable equalizers and phase-locked loop (PLL) circuits the test signal of Table 1, row 16 should be used.

The test signals are listed in Table 1 and its brief description and precise sample values are annexed in Annexes 1 and 2, respectively.

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* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2003 in acordance with Resolution ITU-R 44.

TABLE 1

List of test signals

No.	Title
1	Grey
2	Alternating white/black at 0.1 Hz
3	End-of-line pulses
4	Black/white ramp
5	Yellow/grey ramp
6	Grey/blue ramp
7	Cyan/grey ramp
8	Grey/red ramp
9	C_B, Y, C_R, Y ramp
10	White, end-of-line porches
11	Blue, end-of-line porches
12	Red, end-of-line porches
13	Yellow, end-of-line porches
14	Cyan, end-of-line porches
15	Digital colour-bar
16	Check field signal

Annex 1

Brief description of test signals

The formulae corresponding to the test signals are defined in § 1, and the waveforms are illustrated in § 2.

1 Formulae (see Note 1)

In cases where sample values are derived by computation, an addition of 0.5 is included in the formula to ensure that the appropriate level is obtained by rounding the result.

NOTE 1 – Y, C_R, C_B sample numbering is in accordance with Recommendation ITU-R BT.656.

These digital waveforms are made up of pulses in uniform ranges, ramps between two uniform ranges, and transitions between two uniform ranges, shaped by a filter whose impulse response $R(t)$ is defined as a function of time t as follows:

– for $-3T < t < 3T$, $\quad R(t) = 0.42 + 0.50\cos(\pi t/3T) + 0.08\cos(2\pi t/3T)$

– otherwise $R(t) = 0$

($R(t)$: Blackman window).

The value of T is 74 ns for digital waveforms $A1$, $A2$, $A3$ and $A4$ and 148 ns for $A5$ and $A6$.

1.1 Test signal No. 1: grey

The active video lines of this signal are defined by:

$$Y(i) = A1(i), \qquad C_R = C_B = 128.$$

This signal is critical for transmission via a parallel interface, since each of the 8 interface data binary signals then contains a succession of bits 0, 1, 0, 1, 0, 1 ... and attains maximum power concentration at high frequencies (multiples of 13.5 MHz) which often prove difficult to preserve in practical transmission links.

1.2 Test signal No. 2: alternating white/black at 0.1 Hz

This signal produces alternately:

– for 5 s, pictures containing "white" digital active video lines defined by:

$$Y(i) = A2(i), \qquad C_R = C_B = 128;$$

– for 5 s, pictures containing "black" digital active video lines defined by:

$$Y = 16, \qquad C_R = C_B = 128.$$

This signal produces a variation of the black level in the corresponding analogue video signals, owing to the suppression of continuous components and very low frequencies by the analogue transmission links. It provides a means of checking the compensation for this variation, as well as black stability and accuracy in digital coding.

1.3 Test signal No. 3: end-of-line pulses

The signal's digital active video lines are defined by:

$$Y(i) = A3(i), \qquad C_R = C_B = 128.$$

This four-pulse signal can be used to check the position of the digital active line in relation to the analogue reference, as well as the activity of samples situated at the end of the digital active line. The outside edges of the two internal pulses coincide with the ends of the line, in the 625/50 system.

1.4 Test signal No. 4: black/white ramp

The digital active video lines of this signal are defined by:

$$Y(i) = \text{int}\,(A4(i)), \qquad C_R = C_B = 128.$$

This signal may be used to test the existence and position of quantization levels 1 to 254 of the luminance signal.

1.5 Test signal No. 5: yellow/grey ramp

The digital active lines of this signal are defined by:

$$C_B(i) = \text{int}\,(A5(i))$$

$$C_R(i) = \text{int}\,(128.5 - (0.114 / 0.701)\,(A5(i) - 128))$$

$$Y(i) = \text{int}\,(126 - (169 / 224)\,(A5(i) - 128)).$$

This signal can be used to test the existence and position of quantization levels 1 to 128 of the colour difference signal C_B.

1.6 Test signal No. 6: grey/blue ramp

The digital active video lines of this signal are defined by the same formulae as in § 1.5, replacing $A5$ by $A6$.

This signal can be used to test the existence and position of quantization levels 128 to 254 of the colour difference signal C_B.

1.7 Test signal No. 7: cyan/grey ramp

The digital active video lines of this signal are defined by:

$$C_B(i) = \text{int}\,(128.5 - (0.299 / 0.886)\,(A5(i) - 128))$$

$$C_R(i) = \text{int}\,(A5(i))$$

$$Y(i) = \text{int}\,(126 - (88 / 224)\,(A5(i) - 128)).$$

This signal may be used to test the existence and position of quantization levels 1 to 128 of the colour difference signal C_R.

1.8 Test signal No. 8: grey/red ramp

The digital active video lines of this signal are defined by the same formulae as in § 1.7, replacing $A5$ by $A6$.

This signal may be used to test the existence and position of quantization levels 128 to 254 of the colour difference signal C_R.

1.9 Test signal No. 9: C_B, Y, C_R, Y ramp

The active video lines of this signal are defined by $A7(i)$ in Table 2 for 1 440 samples of the digital active line multiplex.

This signal is useful for testing the conformity of the digital video signal format at the output of the digital processing equipment carrying out demultiplexing and remultiplexing operations on the components of the digital video signal.

NOTE 1 – This signal produces spurious colours in the R, G, B field.

1.10 Test signal No. 10: white, end-of-line porches

The active video lines of this signal are defined by:

$$Y(i) = A8(i), \qquad C_B = C_R = 128.$$

This signal has no shaping of the transitions on Y at the ends of the digital active line and is useful for observing the analogue shaping of the line blankings by the 4:2:2 decoders.

Two integral transitions of the Blackman pulse with a rise time of 300 ns are placed 3 µs from the leading and trailing edges of analogue line blankings for 625-line systems, permitting comparative observation of the transitions and verification of the conformity of the digital-analogue time correspondence on Y.

1.11 Test signal No. 11: blue, end-of-line porches

The active video lines of this signal are defined by:

$$Y = 41, \qquad C_B(i) = A9(i), \qquad C_R = 110.$$

This signal can be used to make the observations described in § 1.10 for high transitions on C_B.

1.12 Test signal No. 12: red, end-of-line porches

The active video lines of this signal are defined by:

$$Y = 81, \qquad C_B = 90, \qquad C_R = A9(i).$$

This signal can be used to make the observations described in § 1.10 for high transitions on C_R.

1.13 Test signal No. 13: yellow, end-of-line porches

The active video lines of this signal are defined by:

$$Y = 210, \qquad C_B(i) = A10(i), \qquad C_R = 146.$$

This signal can be used to make the observations described in § 1.10 for low transitions on C_B.

1.14 Test signal No. 14: cyan, end-of-line porches

The active video lines of this signal are defined by:

$$Y = 170, \qquad C_B = 166, \qquad C_R(i) = A10(i).$$

This signal can be used to make the observations described in § 1.10 for low transitions on C_R.

1.15 Digital colour bar signals

The frequent use of colour bar signals in analogue television suggests the need to define such encoded signals for digital, in order to monitor levels and phasing between components after 4:2:2 decoding.

Tables 3a) and 3b) give a description of 100/0/100/0 and 100/0/75/0 colour bars calculated by means of mathematical equations with the following characteristics:

– shaping of transitions by integral of the Blackman impulse;

– rise time 10% to 90% for $Y = 150$ ns;

– rise time 10% to 90% for C_B and $C_R = 300$ ns.

1.16 Check field test signal

The following description specifies digital test sequences suitable for evaluating the low-frequency response of equipment handling serial digital video signals. Although a range of sequences will produce the desired low-frequency effects, two specific sequences are defined to test cable equalization and phase-locked loop (PLL) circuits.

1.16.1 Equalizer testing

Equalizer testing is accomplished by producing a serial digital sequence with maximum DC content. Applying the sequence C0.0h, 66.0h continuously during the active line portion of at least one-half of a field and forcing the last sample in the first active line of the first field to the value 20.0h accomplishes the desired result. If other data is added to the test signal, an odd number of 1s should be provided in a majority of frames to ensure that both polarities of the test sequence are produced.

1.16.2 Phased-locked loop testing

Phased-locked loop testing is accomplished by producing a serial digital sequence with maximum low-frequency content and minimum number of zero crossings. Applying the sequence 80.0h, 44.0h continuously during the active line portion of at least one-half of a field accomplishes the desired result.

Figure 1 gives a brief description of "check field signal".

FIGURE 1

Brief description of "check field test signal"

Vertical blanking interval
First half of active field C0.0h, 66.0h (Note 1) as described by: $Y = A12$ and $C_B/C_R = A14$ For cable equalization testing
Second half active field (Notes 2 and 3) 80.0h, 44.0h as described by: $Y = A13$ and $C_B/C_R = A15$ For phase locked loop testing

<---------- Horizontal active line (only) ---------->

Note 1 – The last sample in the first active line of the first field is 20.0h, or $Y = A11$.

Note 2 – The first half active field is defined as line 20 to $(X - 1)$ where $140 \leq X \leq 148$ and 283 to $(X - 1)$ where $400 \leq X \leq 408$ for 525 system and X is integer.

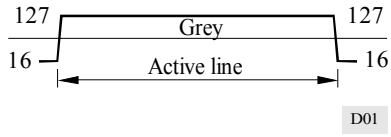
Note 3 – The first half active field is defined as line 23 to $(X - 1)$ where $160 \leq X \leq 168$ and 336 to $(X - 1)$ where $470 \leq X \leq 478$ for 625 system and X is integer.

$A11$, $A12$, $A13$, $A14$ and $A15$ in Table 2 describe the exact numerical definitions of "check field signals".

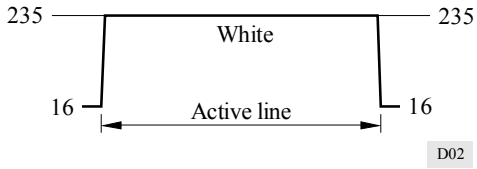
2 Waveforms of test signals

Figures as follows indicate sample levels.

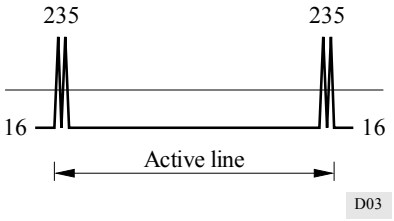
2.1 Grey: *A*1



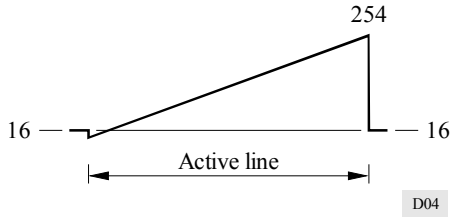
2.2 White: *A*2



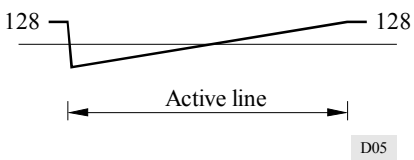
2.3 End-of-line pulses: *A*3



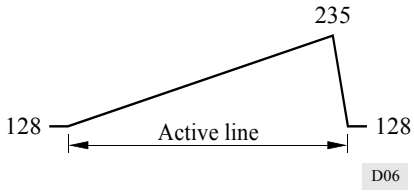
2.4 Black/white ramp: *A*4



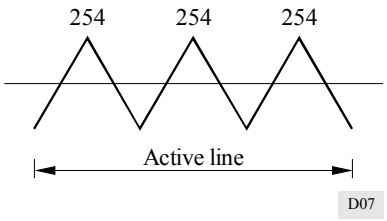
2.5 Yellow/grey and cyan/grey ramp: *A*5



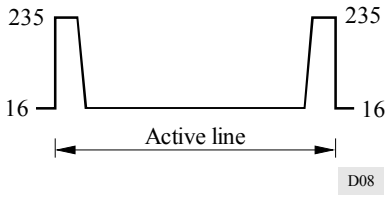
2.6 Grey/blue and grey/red ramp: *A*6



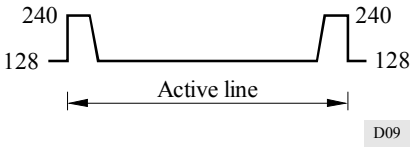
2.7 C_B, Y, C_R, Y ramp: *A*7



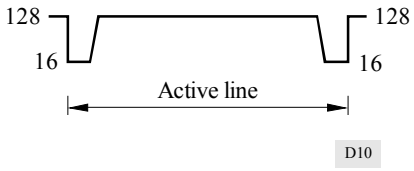
2.8 White, end-of-line porches: *A*8



2.9 Blue and red, end-of-line porches: *A*9



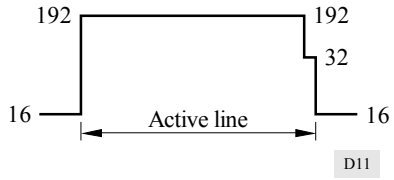
2.10 Yellow and cyan, end-of-line porches: *A*10



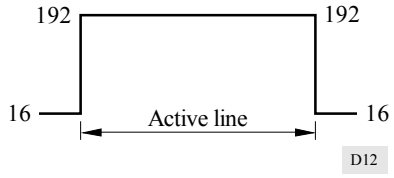
2.11 Check field test signals

2.11.1 *Y* for the first active line of the first field: *A*11

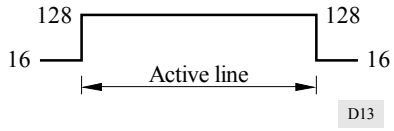
This waveform is used as the line 20 for 525 system and the line 23 for 625 system.



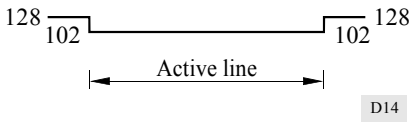
2.11.2 *Y* for equalizer testing: *A*12



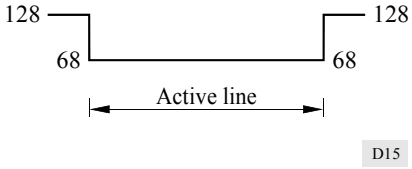
2.11.3 *Y* for phase locked loop testing: *A*13



2.11.4 *C* for equalizer testing: *A*14



2.11.5 *C* for phase locked loop testing: *A*15



Annex 2

Sample values corresponding to test signal

TABLE 2

Table of values used for defining digital test signals

A1: Grey

i	0 to 19	20	21	22	23	24	25 to 693	694	695	696	697	698	699 to 719
*A*1(*i*)	16	18	33	72	110	125	127	125	110	72	33	18	16

A2: White

i	0 to 19	20	21	22	23	24	25 to 693	694	695	696	697	698	699 to 719
*A*2(*i*)	16	19	50	126	201	232	235	232	201	126	50	19	16

A3: End-of-line pulses

i	0	1	2	3	4	5	6 to 9	10	11	12	13	14	15	16 to 705	706	707
*A*3(*i*)	16	44	154	235	154	44	16	17	64	185	229	121	31	16	17	64

i	708	709	710	711	712	713	714	715	716	717	718	719
*A*3(*i*)	185	229	121	31	16	16	44	154	235	154	44	16

A4: Black/white ramp

i	0 to 20	21	22	23	24 to 59	60 to 87	88 to 99	100 to 535	536 to 549	550 to 585
*A*4(*i*)	16	14	9	3	1	((*i* – 56) / 2)	16	((*i* – 66) / 2)	235	((*i* – 78) / 2)

i	586 to 599	600	601	602	603	604	605 to 719
*A*4(*i*)	254	250	217	135	53	20	16

i: sample number and takes on values from 0 to 719.

TABLE 2 (*continued*)

A5: Yellow/grey and cyan/grey ramp

i	0 to 19	20	21	22	23	24	25	26	27	28	29 to 39	40 to 95
$A5(i)$	128	126	120	108	89	65	40	21	9	3	1	$((i - 32) / 4)$

i	96 to 119	120 to 563	564 to 719
$A5(i)$	16	$((i - 52) / 4)$	128

A6: Grey/blue and grey/red ramp

i	0 to 19	20 to 563	564 to 579	580 to 631	632 to 659	660	661	662	663	664
$A6(i)$	128	$((i + 396) / 4)$	240	$((i + 384) / 4)$	254	252	246	234	215	191

i	665	666	667	668	669 to 719
$A6(i)$	167	148	136	130	128

A7: C_B, Y, C_R, Y ramp

i	0 to 253	254 to 507	508 to 761	762 to 1 015	1 016 to 1 269	1 270 to 1 439
$A7(i)$	$i + 1$	$508 - i$	$i - 507$	$1\,016 - i$	$i - 1\,015$	$1\,524 - i$

A8: White, end-of-line porches

i	0 to 46	47	48	49	50	51	52	53	54	55 to 667
$A8(i)$	235	232	218	187	139	86	46	24	17	16

i	668	669	670	671	672	673	674	675	676 to 719
$A8(i)$	19	33	64	112	165	205	227	234	235

TABLE 2 (*end*)

A9: Blue and red, end-of-line porches

i	0 to 23	24	25	26	27 to 333	334	335	336	337	338 to 359
*A*9(*i*)	240	232	191	143	128	130	152	204	236	240

A10: Yellow and cyan, end-of-line porches

i	0 to 23	24	25	26	27 to 333	334	335	336	337	338 to 359
*A*10(*i*)	16	24	65	113	128	126	104	52	20	16

A11: Y for the first active line of the first field

i	0 to 718	719
*A*11(*i*)	192(C0.0h)	32(20.0h)

A12: Y for equalizer testing

i	0 to 719
*A*12(*i*)	192(C0.0h)

A13: Y for phase locked loop testing

i	0 to 719
*A*13(*i*)	128(80.0h)

A14: C for equalizer testing

i	0 to 359
*A*14(*i*)	102(66.0h)

A15: C for phase locked loop testing

i	0 to 359
*A*15(*i*)	68(44.0h)

TABLE 3

Description of encoded colour-bar signals according to the 4:2:2 level of Recommendation ITU-R BT.601

a) *Designation: 100/0/100/0 colour bars*

Definition of Y for digital active line with rise time = 150 ns

i	0 to 13	14	15	16	17	18	19 to 99	100	101	102	103	104	105 to 185
$Y(i)$	16	16	39	126	212	235	235	235	232	223	213	210	210

i	186	187	188	189	190	191 to 271	272	273	274	275	276	277 to 357	358
$Y(i)$	210	206	190	174	170	170	169	167	157	147	145	145	144

i	359	360	361	362	363 to 443	444	445	446	447	448	449 to 529	530	531
$Y(i)$	141	126	110	107	106	106	104	94	84	82	81	81	77

i	532	533	534	535 to 615	616	617	618	619	620	621 to 719
$Y(i)$	61	45	41	41	41	38	28	19	16	16

Definition of C_R for digital active line with rise time = 300 ns

i	0 to 5	6	7	8	9	10	11 to 48	49	50	51	52	53	54 to 91
$C_R(i)$	128	128	128	128	128	128	128	128	130	137	144	146	146

i	92	93	94	95	96	97 to 134	135	136	137	138	139	140 to 177	178
$C_R(i)$	146	133	81	29	16	16	16	18	25	32	34	34	35

i	179	180	181	182	183 to 220	221	222	223	224	225	226 to 263	264	265	266
$C_R(i)$	54	128	202	221	222	222	224	231	238	240	240	240	227	175

i	267	268	269 to 306	307	308	309	310	311	312 to 359
$C_R(i)$	123	110	110	110	112	119	126	128	128

i: sample number and takes on values from 0 to 719.

TABLE 3 (*continued*)

Definition of C_B for digital active line with rise time = 300 ns

i	0 to 5	6	7	8	9	10	11 to 48	49	50	51	52	53	54 to 91	92
$C_B(i)$	128	128	128	128	128	128	128	128	116	72	28	16	16	16

i	93	94	95	96	97 to 134	135	136	137	138	139	140 to 177	178	179	180
$C_B(i)$	31	91	150	166	166	166	154	110	65	54	54	54	69	128

i	181	182	183 to 220	221	222	223	224	225	226 to 263	264	265	266	267
$C_B(i)$	187	202	202	202	191	146	102	90	90	90	106	165	225

i	268	269 to 306	307	308	309	310	311	312 to 359
$C_B(i)$	240	240	240	228	184	140	128	128

b) *Designation: 100/0/75/0 colour bars*

Definition of Y for digital active line with rise time = 150 ns

i	0 to 13	14	15	16	17	18	19 to 99	100	101	102	103	104	105 to 185
$Y(i)$	16	16	39	126	212	235	235	235	227	198	169	162	162

i	186	187	188	189	190	191 to 271	272	273	274	275	276	277 to 357	358
$Y(i)$	161	158	146	134	131	131	131	129	122	114	112	112	112

i	359	360	361	362	363 to 443	444	445	446	447	448	449 to 529	530
$Y(i)$	109	98	87	84	84	84	82	74	67	65	65	65

i	531	532	533	534	535 to 615	616	617	618	619	620	621 to 719
$Y(i)$	62	50	38	35	35	35	33	25	18	16	16

TABLE 3 (*end*)

Definition of C_R for digital active line with rise time = 300 ns

i	0 to 5	6	7	8	9	10	11 to 48	49	50	51	52	53	54 to 91
$C_R(i)$	128	128	128	128	128	128	128	128	129	135	140	142	142

i	92	93	94	95	96	97 to 134	135	136	137	138	139	140 to 177	178
$C_R(i)$	141	132	93	54	44	44	44	45	51	56	58	58	58

i	179	180	181	182	183 to 220	221	222	223	224	225	226 to 263	264	265	266
$C_R(i)$	72	128	184	198	198	198	200	205	211	212	212	212	202	163

i	267	268	269 to 306	307	308	309	310	311	312 to 359
$C_R(i)$	124	115	114	114	116	121	127	128	128

Definition of C_B for digital active line with rise time = 300 ns

i	0 to 5	6	7	8	9	10	11 to 48	49	50	51	52	53	54 to 91
$C_B(i)$	128	128	128	128	128	128	128	128	119	86	53	44	44

i	92	93	94	95	96	97 to 134	135	136	137	138	139	140 to 177	178
$C_B(i)$	44	56	100	145	156	156	156	148	114	81	73	72	73

i	179	180	181	182	183 to 220	221	222	223	224	225	226 to 263	264	265
$C_B(i)$	84	128	172	183	184	183	175	142	108	100	100	100	111

i	266	267	268	269 to 306	307	308	309	310	311	312 to 359
$C_B(i)$	156	200	212	212	212	203	170	137	128	128