EE470
Analog Communication Systems

NTSC Television Broadcasting
Monochrome TV transmitter

Interlaced scanning raster with two fields.

Two interlaced fields make up a frame.

Lines are blanked during the horizontal retrace.
Video waveform for one full horizontal line.

(Carrier Amplitude %)

- **Sync**: 100
- **Black**: 75
- **White**: 12.5

- **Horizontal sync pulse**: 5 μs
- **Back porch**: 10 μs

- **Active line time**: 53.5 μs
- **Horizontal retrace (blanking interval)**: 10 μs

$t, \mu s$
Repeated Image with Unbroken Path
Video Spectrum for a Still Image

For NTSC $f_h = 15.75$ kHz and $f_v \approx 60$ Hz
Video Spectrum for a Still Image

The required baseband bandwidth is

\[ B = 0.35 \left( \frac{H}{V} \right) \frac{N - N_{vr}}{T_{line} - T_{hr}} \]

\( \left( \frac{H}{V} \right) \) is the aspect ratio

\( N \) is the total number of raster lines

\( N_{vr} \) is the number of lines lost during vertical retrace

\( T_{line} \) is the duration of one line

\( T_{hr} \) is the horizontal retrace time

For an NTSC signal the required bandwidth is 4.2 MHz
## TV Standards Comparison

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<th>NTSC</th>
<th>CCIR</th>
<th>HDTV/USA</th>
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<td>Aspect ratio, horizontal/vertical</td>
<td>4/3</td>
<td>4/3</td>
<td>16/9</td>
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<tr>
<td>Total of lines per frame</td>
<td>525</td>
<td>625</td>
<td>1125</td>
</tr>
<tr>
<td>Field frequency, Hz</td>
<td>60</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Line frequency, kHz</td>
<td>15.75</td>
<td>15.625</td>
<td>33.75</td>
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<tr>
<td>Line time, μs</td>
<td>63.5</td>
<td>64</td>
<td>29.63</td>
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<tr>
<td>Video bandwidth, MHz</td>
<td>4.2</td>
<td>5.0</td>
<td>24.9</td>
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<tr>
<td>Optimal viewing distance</td>
<td>7H</td>
<td>7H</td>
<td>3H</td>
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<td>Sound</td>
<td>Mono/Stereo</td>
<td>Mono/Stereo</td>
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<tr>
<td></td>
<td>output</td>
<td>output</td>
<td></td>
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<tr>
<td>Horizontal retrace time, μs</td>
<td>10</td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td>Vertical retrace, lines/field</td>
<td>21</td>
<td></td>
<td>45</td>
</tr>
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</table>
a) Transmitted TV Spectrum

b) VSB Shaping at Receiver
Monochrome TV transmitter
Monochrome TV receiver
The color TV signal was designed to be compatible with monochrome television receivers.

The luminance signal is:

\[ x_Y(t) = 0.30 x_R(t) + 0.59 x_G(t) + 0.11 x_B(t) \]

The chrominance signals are:

\[ x_I(t) = 0.60 x_R(t) - 0.28 x_G(t) - 0.32 x_B(t) \]
\[ x_Q(t) = 0.21 x_R(t) - 0.52 x_G(t) + 0.31 x_B(t) \]
Color Television

The chrominance signals are broadcast using quadrature-carrier multiplexing with a carrier frequency that is halfway between the 227th and 228th harmonic of $f_h$:

$$f_{cc} = \frac{455}{2} f_h = 3.58 \text{ MHz}$$
a) Chrominance spectral lines

b) Line to line phase reversal

Chrominance lines (dashed) are interleaved between luminance lines.

Line-to-line phase reversal of chrominance variations on luminance. (There is also field-to-field reversal.)
Color subcarrier modulation system
Color demodulation system

Diagram:

- LPF 4.2 MHz
- BPF 2.1-4.1 MHz
- PLL 3.6 MHz
- Gate
- LPF 0.5 MHz
- LPF 1.5 MHz
- Matrix

Signals:

- $x_p(t)$
- Horiz sync
- Color level
- Tint
- $x_R$
- $x_G$
- $x_B$