TDA 5660 P
Modulator for TV, Video and Sound Signals

The monolithically integrated circuit TDA 5660 P is especially suitable as modulator for the 48 to 860 MHz frequency range and is applied e.g. in video recorders, cable converters, TV converter installations, demodulators, video generators, video security systems, amateur TV applications, as well as personal computers.

- Synchronizing level-clamping circuit
- Peak white value gain control
- Continuous adjustment of modulation index for positive and negative modulation
- Dynamic residual carrier setting
- FM sound modulator
- AM sound modulator
- Picture carrier to sound carrier adjustment
- Symmetrical mixer output
- Symmetrical oscillator with own RF ground
- Low radiation
- Superior frequency stability of main oscillator
- Superior frequency stability of sound oscillator
- Internal reference voltage

Circuit description
Via pin 1, the sound signal is capacitively coupled to the AF input for the FM modulation of the oscillator. An external circuitry sets the preemphasis. This signal is forwarded to a mixer which is influenced by the AM modulation input of pin 16. The picture to sound carrier ratio can be changed by connecting an external voltage to pin 16, which deviates from the internal reference voltage. In case, the sound carrier should not be FM but AM modulated, pin 1 should be connected to pin 2, while the AF signal is capacitively coupled to pin 16. Through an additional external dc voltage at pin 16, the set AM modulation index can be changed by overriding the internally adjusted control voltage for a fixed AM modulation index. At the output of the above described mixer the FM and/or AM modulated sound signal is added to the video signal and mixed with the oscillator signal in the RF mixer. A parallel resonant circuit is connected to the sound carrier oscillator at pin 17, 18. The unloaded Q of the resonant circuit must be $Q = 25$ and the parallel resistor $R_T = 6.8 \, k\Omega$ to ensure a picture to sound carrier ratio of 12.5 dB. At the same time, the capacitative and/or inductive reactance for the resonance frequency should have a value of $X_C \approx X_L \approx 800 \, \Omega$.

The video signal with the negative synchronous level is capacitively connected to pin 10. The internal clamping circuit is referenced to the synchronizing level. Should the video signal change by 6 dB, this change will be compensated by the resonant circuit which is set to the peak white value. At pin 11, the current pulses of the peak white detector are filtered through the capacitor which also determines the control time constant. When pin 12 is connected to ground, the RF carrier switches from negative to positive video modulation.
With the variable resistor of \( R = \infty \) \( \ldots \) \( 0 \, \Omega \) at pin 12, the modulation depth, beginning with \( R = \infty \) and a negative modulation of \( m_{0/N} = 80\% \), can be increased to \( m_{D/N} = 100\% \) and continued with a positive modulation of \( m_{D/P} = 100\% \) down to \( m_{D/P} = 88\% \) with \( R = 0 \, \Omega \). The internal reference voltage has to be capacitively blocked at pin 2.

The amplifier of the RF oscillator is available at pins 3-7. The oscillator operates as a symmetrical ECO circuit. The capacitive reactance for the resonance frequency should be \( X_C \approx 70 \, \Omega \) between pins 3, 4 and 6, 7 and \( X_C \approx 26 \, \Omega \) between pins 4, 6. In order to set the required residual carrier suppression, pin 9 is used to compensate for any dynamic asymmetry of the RF mixer during high frequencies of \( > 300 \, \text{MHz} \). The oscillator chip ground, pin 5, should be connected to ground at the oscillator resonant circuit shielding. Via pin 3 and 7 an external oscillator signal can be injected inductively or capacitively. The peripheral layout of the PCB board should be provided with a minimum shielding attenuation of approx. \( 80 \, \text{dB} \) between the oscillator pins 3-7 and the modulator outputs 13-15.

For optimum residual carrier suppression, the symmetric mixer outputs at pins 13, 15 should be connected to a matched balanced-to-unbalanced broadband transformer with excellent phase precision at 0 and 180 degrees, e.g., a Guanella transformer. The transmission loss should be less than 3 dB. In addition, an LC low pass filter combination is required at the output. The cut-off frequency of the low pass filter combination must exceed the maximum operating frequency.

If the application circuit according to figure 1, 2 is used, a multiplication factor \( V_{\text{RF}} / V_{\text{RF}} \) (application) = \( V_{\text{RF}} / V_{\text{RF}} \) (data sheet) 3.9 must be used to convert a 300 \, \Omega \) symmetrical impedance to an asymmetrical impedance of 75 \, \Omega \) for the stated RF output voltage \( V_a \) of the type specification in order to ensure a transmission attenuation of 0 dB for the balanced-to-unbalanced mixer.
### Maximum ratings

<table>
<thead>
<tr>
<th></th>
<th>min</th>
<th>max</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>$V_S$</td>
<td>−0.3</td>
<td>14.5 V</td>
</tr>
<tr>
<td>Current from pin 2</td>
<td>$-I_2$</td>
<td>0</td>
<td>2 mA</td>
</tr>
<tr>
<td>Voltage at pin 1</td>
<td>$V_1$</td>
<td>$V_2 -2$</td>
<td>$V_2 +2$ V</td>
</tr>
<tr>
<td>Voltage at pin 9</td>
<td>$V_9$</td>
<td>−4</td>
<td>1 V</td>
</tr>
<tr>
<td>Voltage at pin 10</td>
<td>$V_{10 \text{pp}}$</td>
<td>1.5</td>
<td>V</td>
</tr>
<tr>
<td>Capacitance at pin 2</td>
<td>$C_2$</td>
<td>0</td>
<td>100 nF</td>
</tr>
<tr>
<td>Capacitance at pin 11</td>
<td>$C_{11}$</td>
<td>0</td>
<td>15 μF</td>
</tr>
<tr>
<td>Voltage at pin 12</td>
<td>$V_{12}$</td>
<td>−0.3</td>
<td>1.4 V</td>
</tr>
<tr>
<td>Voltage at pin 13</td>
<td>$V_{13}$</td>
<td>$V_2$</td>
<td>$V_S$ V</td>
</tr>
<tr>
<td>Voltage at pin 15</td>
<td>$V_{15}$</td>
<td>$V_2$</td>
<td>$V_S$ V</td>
</tr>
<tr>
<td>Voltage at pin 16</td>
<td>$V_{16}$</td>
<td>$V_2 -1.5$</td>
<td>$V_2 +1.5$ V</td>
</tr>
<tr>
<td>Junction temperature</td>
<td>$T_J$</td>
<td></td>
<td>150 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{\text{st}}$</td>
<td>−40</td>
<td>125 °C</td>
</tr>
<tr>
<td>Thermal resistance (system-air)</td>
<td>$R_{\text{th SA}}$</td>
<td></td>
<td>80 K/W</td>
</tr>
</tbody>
</table>

*Only the external circuitry shown in application circuits 1 and 2 may be connected to pins 3, 4, 6, 7, 17 and 18.*

### Operating range

<table>
<thead>
<tr>
<th></th>
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<th>max</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>$V_S$</td>
<td>9.5</td>
<td>13.5 V</td>
</tr>
<tr>
<td>Video input frequency</td>
<td>$f_{\text{VIDEO}}$</td>
<td>0</td>
<td>5 MHz</td>
</tr>
<tr>
<td>Sound input frequency</td>
<td>$f_{\text{AF}}$</td>
<td>0</td>
<td>20 kHz</td>
</tr>
<tr>
<td>Output frequency</td>
<td>$f_q$</td>
<td>48</td>
<td>860 MHz</td>
</tr>
<tr>
<td>Ambience temperature</td>
<td>$T_A$</td>
<td>0</td>
<td>70 °C</td>
</tr>
<tr>
<td>Sound oscillator</td>
<td>$f_{\text{OSC}}$</td>
<td>4</td>
<td>7 MHz</td>
</tr>
<tr>
<td>Voltage at pin 13, 15</td>
<td>$V_{13,15}$</td>
<td>$V_2$</td>
<td>$V_S$ V</td>
</tr>
</tbody>
</table>

*depending on the oscillator circuitry at pins 3-7*
### Characteristics

$V_s = 11 \text{ V}; \ T_A = 25 \text{ } ^\circ\text{C}$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test conditions</th>
<th>Figure</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current consumption $I_s$</td>
<td>$I_s = 0 \text{ mA}$</td>
<td>1; 2</td>
<td>22</td>
<td>30</td>
<td>40</td>
<td>mA</td>
</tr>
<tr>
<td>Reference voltage $V_2$</td>
<td>$0 \leq I_2 \leq 1 \text{ mA}$</td>
<td>1; 2</td>
<td>7</td>
<td>7.5</td>
<td>8</td>
<td>V</td>
</tr>
<tr>
<td>Oscillator frequency range $f_{osc}$</td>
<td>External circuitry adjusted to frequency TC value of capacitor in osc. circuit is 0; drift is referenced only to self-heating of the component $t = 0.5-10 \text{ s}$; $T_A = \text{ const.}$</td>
<td>1; 2</td>
<td>48</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>Turn-on start-up drift $\Delta f_{osc}$</td>
<td>Ch 30</td>
<td>1; 2</td>
<td>0</td>
<td>-50</td>
<td>-500</td>
<td>kHz</td>
</tr>
<tr>
<td></td>
<td>Ch 40</td>
<td>1; 2</td>
<td>0</td>
<td>-200</td>
<td>-500</td>
<td>kHz</td>
</tr>
<tr>
<td>Frequency drift as function of $V_s$</td>
<td>$V_s = 9.5-13.5 \text{ V}$</td>
<td>1; 2</td>
<td>0</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>Video input current at pin 10 $-I_{10}$</td>
<td>C$_{10}$ $\leq 1 \mu$ &amp;</td>
<td>5</td>
<td>0</td>
<td>150</td>
<td>150</td>
<td>kHz</td>
</tr>
<tr>
<td>Video input voltage at pin 10 $V_{10pp}$</td>
<td>$C_{10} \leq 1 \mu$ &amp;</td>
<td>0</td>
<td></td>
<td></td>
<td>10</td>
<td>$\mu$A</td>
</tr>
<tr>
<td>Modulation depth $m_{D/N}$</td>
<td>at coupling capac.</td>
<td>21; 22</td>
<td>0.7</td>
<td>1.4</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{VIDEO,pp} = 1 \text{ V}; f_{VIDEO} = 200 \text{ kHz}$ sine signal</td>
<td>$C \leq 1 \mu$ &amp;</td>
<td>0</td>
<td></td>
<td></td>
<td>10</td>
<td>$\mu$A</td>
</tr>
<tr>
<td>Output impedance $Z_{13}; Z_{15}$</td>
<td>$I_{leak} \leq \pm 0.3 \mu$ &amp;</td>
<td>24</td>
<td>10</td>
<td></td>
<td></td>
<td>k$\Omega$</td>
</tr>
<tr>
<td>RF output voltage $V_{q, rms}$</td>
<td>static</td>
<td>1b</td>
<td>2.5</td>
<td>3.5</td>
<td>5.5</td>
<td>mV</td>
</tr>
<tr>
<td>Modulation signal in neg. modulation pin 12 open</td>
<td>Ch 40</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output capacitance $C_{13} = C_{15}$</td>
<td>25</td>
<td>0.5</td>
<td>1</td>
<td>2.0</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>S parameter at pins 3, 4 and 6, 7</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF output phase $\alpha_{13, 15}$</td>
<td>140</td>
<td>180</td>
<td>220</td>
<td></td>
<td></td>
<td>degrees</td>
</tr>
<tr>
<td>RF output voltage change; adjustment range $\Delta V_q$</td>
<td>$f = 543.25-623.25 \text{ kHz}$; $\Delta f = 80 \text{ MHz}$</td>
<td>Ch 30-Ch 40</td>
<td>0</td>
<td>0</td>
<td>1.5</td>
<td>dB</td>
</tr>
<tr>
<td>RF output voltage change $\Delta V_q$</td>
<td>$f = 100-300 \text{ MHz}$</td>
<td>1</td>
<td>0</td>
<td>1.5</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>RF output voltage change $\Delta V_q$</td>
<td>$f = 48-100 \text{ MHz}$</td>
<td>6</td>
<td>0</td>
<td>1.5</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Oscillator interference FM caused by AM modulation and coupling of the modulator output with the oscillator resonant circuit; $V_{VIDEO,pp} = 1 \text{ V}; f_{VIDEO} = 10 \text{ kHz}$ sine signal</td>
<td>Ch 30</td>
<td>1; 9</td>
<td>0</td>
<td>5</td>
<td>15</td>
<td>kHz</td>
</tr>
<tr>
<td></td>
<td>Ch 40</td>
<td>1; 9</td>
<td>0</td>
<td>7</td>
<td>21</td>
<td>kHz</td>
</tr>
</tbody>
</table>
### Characteristics

\( V_S = 11 \, \text{V}; \, T_A = 25 ^\circ \text{C} \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test conditions</th>
<th>Figure</th>
<th>min</th>
<th>typ</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermodulation ratio</td>
<td>( a_{MR} )</td>
<td>( f_p + 1.07 , \text{MHz} )</td>
<td>1; 7; 15</td>
<td>54</td>
<td>75</td>
</tr>
<tr>
<td>Harmonic wave ratio</td>
<td>( a_H )</td>
<td>( f_p + 8.8 , \text{MHz} ) without video signal 19, 20, 21 unmodulated video and sound carrier, measured with the spectrum analyzer as difference between video carrier signal level and sideband signal level without video and sound modulation.</td>
<td>1; 7; 15</td>
<td>35</td>
<td>dB</td>
</tr>
<tr>
<td>Harmonic wave ratio</td>
<td>( a_H )</td>
<td>( f_p + 2f_S )</td>
<td>1; 7</td>
<td>35</td>
<td>48</td>
</tr>
<tr>
<td>Harmonic wave ratio</td>
<td>( a_H )</td>
<td>( f_p + 3f_S )</td>
<td>1; 7</td>
<td>42</td>
<td>48</td>
</tr>
<tr>
<td>Harmonic wave ratio</td>
<td>( V_q ) with spectrum analyzer; loaded Q factor ( Q_L ) of the sound oscillator resonant circuit adjusted by ( R_S ) to provide the required picture to sound carrier ratio of 12.5 dB; ( R_S = 6.8 , \text{k}\Omega; , Q_U = 25 ) of the sound oscillator circuit.</td>
<td>1; 7</td>
<td>10</td>
<td>12.5</td>
<td>15</td>
</tr>
<tr>
<td>Sound carrier ratio</td>
<td>( a_{p/s} )</td>
<td>( f_p + 4.4 , \text{MHz} ) (dependent on video signal)</td>
<td>1; 7; 17</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td>Color picture to sound carrier ratio</td>
<td>( a_p )</td>
<td>( f_p + 4.4 , \text{MHz} ) (dependent on video signal)</td>
<td>1</td>
<td>17</td>
<td>dB</td>
</tr>
<tr>
<td>All remaining harmonic waves</td>
<td>( a )</td>
<td>Multiple of fundamental wave of picture carrier, without video signal, measured with spectrum analyzer; ( f_{p/s} = 523.25-623.25 , \text{MHz} )</td>
<td>1; 13</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>Amplitude response of the video signal</td>
<td>( a_V )</td>
<td>( V_{VIDEO_{pp}} = 1 , \text{V} ) with additional modulation ( f = 15 , \text{kHz-5 MHz sine signal between black and white} )</td>
<td>1; 13</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>Residual carrier suppression</td>
<td>( a_R )</td>
<td>With adjustment at pin 9 Ch 30...Ch 40 ( V_S ) adjusted to ( \Delta V_{13/15} ) minimum</td>
<td>1; 12</td>
<td>32</td>
<td>mV</td>
</tr>
<tr>
<td>Static mixer balance characteristic</td>
<td>( \Delta V_{13/15} )</td>
<td>( V_S ) adjusted to ( \Delta V_{13/15} ) minimum</td>
<td>21; 23</td>
<td>-100</td>
<td>+100</td>
</tr>
<tr>
<td>Dynamic mixer balance characteristics</td>
<td>( V_{13 , \text{rms}} )</td>
<td>( V_S ) adjusted to ( V_{13 , \text{rms}} ) minimum</td>
<td>21; 23</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Stability of set modulation depth</td>
<td>( \Delta m_D )</td>
<td>Video input voltage changes with sine signals ( f = 0.2 , \text{MHz}; , \Delta V_{VIDEO_{pp}} = 1 , \text{V} \pm 3 , \text{dB}; , \text{Ch 30...Ch 40}; , V_S = 12 , \text{V}; , T_A = \text{const.} )</td>
<td>1; 13</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Stability of set modulation depth</td>
<td>( \Delta m_D )</td>
<td>1</td>
<td>1</td>
<td>±2.5</td>
<td>%</td>
</tr>
<tr>
<td>Stability of set modulation depth</td>
<td>( \Delta m_D )</td>
<td>6</td>
<td>1</td>
<td>±2.5</td>
<td>%</td>
</tr>
<tr>
<td>Stability of set modulation depth</td>
<td>( \Delta m_D )</td>
<td>6</td>
<td>2</td>
<td>±4</td>
<td>%</td>
</tr>
<tr>
<td>Stability of set modulation depth</td>
<td>( \Delta m_D )</td>
<td>1</td>
<td>1</td>
<td>±2.5</td>
<td>%</td>
</tr>
</tbody>
</table>
**Characteristics**  
 \( V_S = 11 \text{ V}; T_A = 25 ^\circ \text{C} \)

<table>
<thead>
<tr>
<th>Stability of set modulation depth</th>
<th>( \Delta m_D )</th>
<th>( V_S = 9.5-13; 5 \text{ V}; T_A = \text{ const.} )</th>
<th>1</th>
<th>1</th>
<th>( \pm 2.5 )</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interference product ratio sound in video; sound carrier FM mod.</td>
<td>( a_{S/P} )</td>
<td>Ch 30...Ch 40</td>
<td>1;11</td>
<td>48</td>
<td>60</td>
<td>dB</td>
</tr>
<tr>
<td>Signal-to-noise ratio in video; sound carrier unmodulated interference product ratio sound in video sound carrier AM mod.</td>
<td>( a_{N/P} )</td>
<td>Ch 30...Ch 40</td>
<td>1;11</td>
<td>48</td>
<td>74</td>
<td>dB</td>
</tr>
<tr>
<td>Unweighted FM noise level ratio video in sound; FuBK test picture as video signal</td>
<td>( a_{P/S} )</td>
<td>Ch 39</td>
<td>1a; 8</td>
<td>48</td>
<td>54</td>
<td>dB</td>
</tr>
<tr>
<td>Unweighted FM noise level ratio video in sound</td>
<td>( a_{P/S} )</td>
<td>Ch 39; test picture VU G-Y; U/V</td>
<td>2; 8</td>
<td>48</td>
<td>56</td>
<td>dB</td>
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<tr>
<td>Signal-to-noise ratio of sound oscillator</td>
<td>( a_{S/N} )</td>
<td>Ch 39; color bar</td>
<td>2; 8</td>
<td>46</td>
<td>52</td>
<td>dB</td>
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<tr>
<td></td>
<td></td>
<td>Ch 39; uniform red level</td>
<td>2; 8</td>
<td>48</td>
<td>58</td>
<td>dB</td>
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<tr>
<td></td>
<td></td>
<td>Ch 39; uniform white level</td>
<td>2; 8</td>
<td>45</td>
<td>51</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ch 39; test pattern</td>
<td>2; 8</td>
<td>48</td>
<td>55</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ch 39; white bar</td>
<td>2; 8</td>
<td>46</td>
<td>52</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ch 39; bar</td>
<td>2; 8</td>
<td>45</td>
<td>50.8</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ch 39; 20T/2T</td>
<td>2; 8</td>
<td>43</td>
<td>49</td>
<td>dB</td>
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<tr>
<td></td>
<td></td>
<td>Ch 39; 30% white level</td>
<td>2; 8</td>
<td>48</td>
<td>58</td>
<td>dB</td>
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<td></td>
<td>Ch 39; 250 kHz</td>
<td>2; 8</td>
<td>46</td>
<td>52</td>
<td>dB</td>
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<tr>
<td></td>
<td></td>
<td>Ch 39; multiburst</td>
<td>2; 8</td>
<td>46</td>
<td>53</td>
<td>dB</td>
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<tr>
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<td>Ch 39; ramp</td>
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<td>50</td>
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<td>Differential gain</td>
<td>( G_{\text{diff}} )</td>
<td>measured with measurement demodulator, video test signals and vector scope</td>
<td>1</td>
<td>10</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Differential phase</td>
<td>( \varphi_{\text{diff}} )</td>
<td>C at pin 11 = 10 ( \mu \text{F}; I_{\text{peak}} \leq 2 \mu \text{A} )</td>
<td>1</td>
<td>6</td>
<td>50</td>
<td>( \mu \text{s} )</td>
</tr>
</tbody>
</table>
Characteristics

$V_S = 11\, V; \ T_A = 25\, ^\circ C$

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<tr>
<th>Test conditions</th>
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<th>typ</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting time for video signal change from \ 0 \ V_{pp} \ to \ 1.4 \ V_{pp}</td>
<td>$t$</td>
<td>Video blanking signal content is uniform white level</td>
<td>1</td>
<td>120</td>
</tr>
<tr>
<td>Setting time for video blanking signal from 100% white level to 42% grey level with subsequent rise in grey level to 71% of video blanking signal (due to decontrol process)</td>
<td>$t$</td>
<td></td>
<td>1</td>
<td>2.25</td>
</tr>
<tr>
<td>Sound oscillator frequency range</td>
<td>$f_{S/OSC}$</td>
<td>Unloaded Q factor of resonant circuit $Q_U = 25$; resonance frequency $5.66, MHz$</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Turn-on start-up drift</td>
<td>$\Delta f_{S/OSC}$</td>
<td>Capacitor TC value in sound oscillator circuit is $0$, drift is based only on component heating. $T_A = \text{const.}$; $f_{S/OSC} = 5.5, MHz$</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Sound oscillator frequency operating voltage</td>
<td>$\Delta f_{S/OSC}$</td>
<td></td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>FM mod. harmonic distortion</td>
<td>$THD_{FM}$</td>
<td></td>
<td>19; 19a</td>
<td>0.6</td>
</tr>
<tr>
<td>Audio preamplifier input impedance (dyn.); FM operation</td>
<td>$Z_1$</td>
<td>$V_{1 \text{ rms}} = 150, mV$</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>FM sound modulator, static modulation characteristic</td>
<td>$\Delta f_{S/OSC} V_{1/2} = V_1 - V_2 = \pm 1, V$; $f_{S/OSC} = 5.5, MHz$; $Q_U = 25$</td>
<td>1; 14</td>
<td>$\pm 210$</td>
<td>$\pm 270$</td>
</tr>
<tr>
<td>FM sound modulation characteristic (dynamic)</td>
<td>$\Delta f_M/\Delta V_1$</td>
<td></td>
<td>1a; 10a</td>
<td>0.3</td>
</tr>
<tr>
<td>AM sound modulation factor</td>
<td>$m$</td>
<td>$V_{AF} = 0.3, V$</td>
<td>2; 3; 4a, b</td>
<td>30</td>
</tr>
<tr>
<td>AM sound modulation harmonic distortion</td>
<td>$THD_{AM}$</td>
<td>$m = 86%$; $V_{AF} = 0.64, V$; $f_{AF} = 1, kHz$</td>
<td>\</td>
<td>0.7</td>
</tr>
<tr>
<td>AM audio preamplifier input impedance</td>
<td>$Z_{16}$</td>
<td></td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>AM sound modulator input voltage</td>
<td>$V_{AF}$</td>
<td>$m = 90%$; $f_{AF} = 1, kHz$</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Pin</td>
<td>Function</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>----------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>AF input for FM modulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Internal reference voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Symmetrical oscillator input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Symmetrical oscillator output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Oscillator ground</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Symmetrical oscillator output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Symmetrical oscillator input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Supply voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Dynamic residual carrier adjustment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Video input with clamping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Connection for smoothing capacitor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>for video control loop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Switch for positive and negative modulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>as well as residual carrier control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Symmetrical RF output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Remaining ground of component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Symmetrical RF output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Picture to sound carrier ratio (adjustment and AM sound input)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Sound oscillator symmetrical input for tank circuit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Sound oscillator symmetrical input for tank circuit</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Test and measurement circuit 1 for FM sound carrier and negative video modulation

5.5 MHz Sound Oscillator Tank Circuit

TDA 5660 P

Dynamic Residual Carrier Adjustment (if Required)

Figure 1
Test and measurement circuit 1 for FM sound carrier and negative video modulation

Figure 1a
Test and measurement circuit 1 for FM sound carrier and negative video modulation

Figure 1b

7-102
Test and measurement circuit 2 for FM sound carrier and negative video modulation.

Figure 2
AM sound modulation measurement

Broadband Amplifier 30 dB; e.g. OM 361 Fa. Philips

RF Input

Modulation Measurement Device
e.g. FAM by R&S

Filter: 30 Hz-20 kHz
Detector: (P+P)/2 Type of
Modulation: AM

Test Circuit 2

Pin 9
V₀ = -3.4 V

AM AF Input

Sound Generator
f_AF = 1 kHz

V_AFrms

Measurement of AF Input Level

Figure 3
AM sound carrier modulation index versus AF input voltage at pin 16

Figure 4a

AM sound carrier modulation index versus dc voltage offset at pin 16
$V_{AF_{rms}} = 0.6 \text{ V}; \Delta V_{16/2} (\text{V}) = V_2 - V_{16}$

Figure 4b
Measurement circuits

Figure 5

Adjusted to Calibration Frequency
12 623.25 MHz
13 300 MHz
14 100 MHz

Refer to Characteristics Specifications

TDA 5660 P

Remaining External Circuitry as Fig. 1

Figure 6
Frequency spectrum above the video carrier, measured at clamp $V_a$ with a spectrum analyzer

![Diagram of frequency spectrum](image)

**Figure 7**

- **BT** = Video Carrier
- **FT** = Frequency Carrier
- **TT** = Sound Carrier
Description of the measurement configuration to measure the noise voltage, video in sound

with 50 µs Deemphasis

Audio Input

Ch39

Measurement
Demodulator

e.g. AFM2 by R&S

Audio Output

Modulation
Measurement Device
e.g. FAM by R&S

Filter: 30 Hz–20 kHz
Detector: RMS \sqrt{2}

Broadband Amplifier
20 dB e.g. OM 361
Fa. Philips

\[ V_{q} \]

Test Board According to Test Circuit 1a
at Pin 1

Adjustment Voltage, Oscillator Adjusted to Ch39

FM sound input:
270 mV\text{rms}

Video input
1 \text{V}_{\text{pp}}

FuBK or Other Test Pictures

Video Generator
e.g. VG 1000 Fa.
Grundig

S.G.

Sound Generator at modulation frequency \( f_{AF} = 400 \text{ Hz} \)

Figure 8

Calibration: A signal of \( V_{AF\text{ rms}} = 270 \text{ mV} \) and \( f = 0.4 \text{ kHz} \), corresponding to a nominal deviation of 30 kHz, is connected to the sound input, and the demodulated AF reference level at the audio measurement device is defined as 0 dB. No video signal is pending.

Measurement: 1) The AF signal is switched off and the FuBK video signal is connected to the video input with \( V_{\text{VIDEO}_{\text{pp}}} = 1 \text{ V} \). The audio level in relation to the reference calibration level is measured as ratio \( a_{p/p_{\text{rms}}} = 20 \log \left(V_{\text{FuBK}}/V_{\text{nominal}}\right) \).
2) AF and video signal are switched off. The noise ratio in relation to the AF reference calibration level is measured as signal-to-noise ratio \( a_{S/N} \).
Description of the measurement configuration to measure the oscillator interference FM

Figure 9
Description of the measurement configuration to measure the total harmonic distortion during FM operation of the sound carrier.

Test circuit 1 or 2 for AM

- Pin 9 is set at max. 5.5 MHz signal at output by connecting \( V_9 = -3.9 \) V
- \( V_{AF,ms} = 1 \) V
- \( V_0 = 0 \) V connected; Oscillation is ended

Harmonic Distortion Analyser
- e.g. BKF-10 from R&K
- \( f = 0.05-12 \) kHz

Broadband Amplifier 30 dB; e.g. OM 361 from Philips

Modulation Measurement Device e.g. FAM from R&S

Filter: 30 Hz-20 kHz
Detector: \( (P+P)/2 \) or PEAK CCIR with 50 \( \mu \)s Preemphasis

Figure 10
Description of the measurement configuration to measure the total harmonic distortion during FM operation of the sound carrier

Pin 9 is Set at max. 5.5 MHz Signal at Output by Connecting $V_0 = -3.9$ V

$V_0 = 0$ V Connected, Oscillation is Ended

AF Generator with $THD \leq 0.05\%$
e.g. CR-116

Sound Input FM $V_{AF,ms} = \text{var.}$

Output

Test Circuit 1a

Broadband Amplifier 30 dB; e.g. OM 361 from Philips

Modulation Measurement Device e.g. FAM from R&S

FM Range Measurem.

Filter: 30 Hz-20 kHz

Detector: $(P+P)/2$

Figure 10a
Description of the measurement configuration to measure the sound and/or noise in video during FM and/or AM sound carrier modulation

![Diagram of measurement configuration]

- **Modulation Measurement Device**
  - e.g. FAM from R&S

- **Broadband Amplifier**
  - 30 dB e.g. OM 361 from Philips

- **Sound Generator**
  - $V_{AF, r.m.s.} = 1$ V
  - $f_{AF} = 1$ kHz

- **FM Sound Input**

- **Test Circuit 1**

- **Video Signal**
  - $V_{VID, r.m.s.} = 1$ V
  - $f_{VID} = 100$ kHz

- **Sine Signal**

**Figure 11**

**Calibration:** AF signals are switched off; video signal is pending at the video input; device to measure modulation set at AM is adjusted to video carrier; filter: 300 Hz...200 kHz; detector $(P+P)/2$; resulting modulation index is defined as $m_v = 0$ dB.

**Measurement:**
1) Measurement of interference product ratio sound in video during FM modulation of the sound carrier: AF signal is connected to FM sound input; video signal is switched off; device to measure modulation is set to AM; filter: 300 Hz...3 kHz; detector: $(P+P)/2$; a ratio of $a_{S/P} = 20 \log m_{vs/vm}$ is derived from the resulting modulation index $m_{vs/vm}$.

2) Measurement of interference product ratio sound in video during AM modulation of sound carrier: AF signal is connected to AM sound input; otherwise identical with measurement 1.

3) Measurement of signal-to-noise ratio in video without AM/FM modulation of sound carrier: AF signals are switched off; video signal is switched off; control voltage at pin 11 is clamped to value present during connected video signal; modulation device is set to AM; filter: 300 Hz...3 kHz; detector: RMS $\sqrt{2}$; readout in dB to reference level of calibration is $a_{S/P}$.  

7-112
Description of the measurement configuration to measure the residual carrier suppression

Video Measurement Demodulator
e.g. AMF 2 from R&S

Oscilloscope

Test Circuit 1

A Voltage of $V_{12} = 0.4$ V is connected to Pin 12 for setting overmodulation

Video Signal Generator
$V_{VID PP} = 1$ V
e.g. Tektronix 148

Superimposed 4.43 MHz Burst Signal

Remaining Amplitude $V_R$

$0\%$

$100\%$

$V_V$

$\alpha_V = 20 \log \frac{V_R}{V_V}$ (dB)

Adjust $C_p$ in Circuit 1 and Dynamic Residual Carrier Suppression to Suppression Maximum.

Figure 12
Description of the measurement configuration to measure the video amplitude response

![Diagram of the measurement configuration]

**Figure 13**

**Equation:**

\[ a_V = 20 \log \frac{V_{\text{min}}}{V_{\text{max}}} \text{ (dB)} \]

**Components:**

- **Test Circuit 1**
- **Video Input**
- **Video Signal Generator**
  - \( V_{\text{VID PP}} = 1 \text{ V} \)
  - e.g. PM5570 from Philips
- **Line Sync Signal**
- **Trigger Input**
- **Sine Generator**
  - 15 kHz-5 MHz Can Be Wobbled
  - e.g. TM503 from Tektronix
  - Triggered by Line Sync Signal
- **Measurement Demodulator**
  - e.g. AMF 2 from R&S
- **Oscilloscope**
- **Demodulated Video Signal**

**Notes:**

- White: 15 kHz
- Black: 5 MHz

**Value:**

- \( V_{\text{max}} \)
Static modulation characteristic of the FM sound modulator

\[ Q = 25 \]
\[ R_1 = 6.8 \, \text{k} \]
\[ f_{\text{osc}} = 5.5 \, \text{MHz at } \Delta V_{1/2} = 0 \, \text{V} \]
\[ V_1 = \text{Voltage at Pin 1} \]
\[ V_2 = \text{Voltage at Pin 2} \]

Figure 14

Description of the measurement configuration to measure the 1.07 MHz moires

Spectrum Analyser (e.g. 8566 A from HP)

Test Circuit 1

Video Input

Sound Generator (Sine Signal)

\[ f = 4.43 \, \text{MHz} \]

\[ V_{\text{VID} \, \text{PP}} = 250 \, \text{mV}: \] Frequency carrier level lies below the activation point of the video amplitude control and has been set to provide a ratio of 17 dB with respect to the video carrier.

Figure 15
Modulation index during negative video modulation and/or the voltage at pin 12 versus current at pin 12

Figure 16a

Modulation depth is calculated as \( m_0 = \frac{(2 \times m)}{(1 + m)} \) from the modulation index. Prerequisite is a sine-shaped modulation.

- \( m_N \) = modulation index for negative modulation
- \( m_P \) = modulation index for positive modulation

If a resistor is connected to ground at pin 12 to adjust modulation depth, the resistor is calculated as \( R_{12/m} = \frac{(V_{12/m})}{I_{12}} \).
Modulation index during positive video modulation and/or the voltage at pin 12 versus current at pin 12

![Graph]

**Figure 16**

Modulation depth is calculated as $m_d = (2 \times m)/(1 + m)$ from the modulation index. Prerequisite is a sine-shaped modulation.

$m_n = \text{modulation index for negative modulation}$

$m_p = \text{modulation index for positive modulation}$

If a resistor is connected to ground at pin 12 to adjust modulation depth, the resistor is calculated as $R_{12/M} = (V_{12/M}/I_{12})$. 
Picture to sound carrier ratio versus dc voltage offset at pin 16  
unloaded Q factor of resonant circuit $Q_u = 25, R_T = 6.8 \, k\Omega, f = 5.5 \, MHz$.
The picture to sound carrier ratio of $a_{p/s} = 13$ dB was set via the loaded Q factor $Q_L$ without external voltage at pin 16.

![Graph showing dB vs. voltage offset](image)

**Figure 17**

To adjust the picture to sound carrier ratio, a component was used with a resistance of typ. 11.5 kΩ at pins 17, 18.
The loaded Q factor of the resonant circuit was derived from the internal resistance $R_{17/18}$ connected in parallel with the external resistor $R_e$. 

7-118
Measurement of the sound oscillator FM deviation without preemphasis and deemphasis; 
$f_{AF} = 1$ kHz; modulation deviation, sensitivity $(\Delta f_{AF})/(\Delta V_{AF}) = 0.38$ kHz/mV; $V_{AF} = \text{var}$; 
detector $(P+P)/2$; AF filter 30 Hz to 20 kHz, measurement in accordance with CCIR 468-2 
DIN 45405; test circuit 1a.

Figure 18
Measurement of the sound oscillator FM deviation without preemphasis and deemphasis;
\( f_{AF} = 1 \text{ kHz} \); modulation deviation, sensitivity \( \frac{\Delta f_{AF}}{\Delta V_{AF}} = 0.38 \text{ kHz/mV} \); \( V_{AF} = \text{var} \);
detector \( \frac{(P+P)}{2} \); AF filter \( 30 \text{ Hz to } 20 \text{ kHz} \), measurement in accordance with CCIR 468-2
DIN 45405; test circuit 1 a

Figure 18 a
Sound oscillator harmonic distortion without preemphasis and deemphasis;
AF signal routed in at pin 1; AF amplitude = 150 mV\text{rms}; AF filter 30 Hz to 20 kHz;
detector \((P+P)/2\); measurement in accordance with CCIR 468-2 DIN 45405; test circuit 1a

![Graph showing THD vs. frequency](image)

Figure 18 b
Sound oscillator frequency without preemphasis and deemphasis;
AF signal routed in at pin 1; AF amplitude = 150 mV_{rms}; AF filter 30 Hz to 20 kHz;
detector (P-P)/2; measurement in accordance with CCIR 468-2 DIN 45405; test circuit 1a

Figure 18c
Sound oscillator frequency with pre-/deemphasis;
AF filter 30 Hz to 20 kHz; measurement in accordance with CCIR 468-2 DIN 45405;
test circuit 1; $V_{AF} = 1 V_{\text{rms}}$
Description of the measurement configuration to measure the video signal control characteristics and the dynamic signal suppression in video frequencies

Figure 19
Characteristic of the video signal control circuit

\[ V_{13 \text{ rms}} = f(V_{10 \text{ rms}}); \]
\[ V_{11} = f(V_{10 \text{ rms}}); \]
\[ f_{\text{mod}} = 100 \text{ kHz} \]
\[ V_9 = 3.9 \text{ V} \]

Figure 20

Static and dynamic mixer test with respect to balance characteristics based on a typical component

\[ V_{13/15} = f(V_9) \]
\[ V_{13 \text{ rms}} = f(V_9) \]
\[ f = 10 \text{ kHz} \]

Figure 21
Measurement of the static output impedance

\[ Z_{15} = \frac{\Delta V_{15}}{\Delta I_{15}} \]

\[ Z_{13} = \frac{\Delta V_{13}}{\Delta I_{13}} \]

Figure 22
Output circuit S parameter

Typ. output capacity is approx. 1 pF

Figure 23
Figure 24
Application circuit 1

5.5 MHz Sound Oscillator Circuit

L6...L9 Balun Transformer with Ferrite Core

TDA 5660 P

FM AF Input

Reference 7.5 V

220 kΩ

220 pF

10 nF

22 pF

47 kΩ

BB 505 B

10 nF

47 kΩ

25 kΩ

Dynamic Residual Carrier Adjustment (If Required) at Pin 2

Channel 30...40

V_{o/V} 10...28

TDA 5660 P
Application circuit 2

5.5 MHz Sound Oscillator Circuit

L₁...L₉ Balun Transformer with Ferrite Core

TDA 5660 P

Channel 3

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Application circuit 3

5.5 MHz Sound Oscillator Circuit

Signal Output

L6...L9 Balun Transformer with Ferrite Core

Video

10µF

0.5µF

TDA 5660 P

1 2 3 4 5 6 7 8 9

22 kΩ

220 pF

10 nF

Reference 7.5 V

FM AF Input

Symmetrical Oscillator Layout
Harmonic Crystal
Operated in Series Resonance
TV IF 38.9 MHz

IF Filter Neosid
1) 2 Turns
2) 12 Turns

V5 = 9.5-13.5 V
Application circuit 4

5.5 MHz Sound Oscillator Circuit

Signal Output

L6...L9 Balun Transformer with Ferrite Core

Video

TDA 5660 P

FM AF Input

V_o = 9.5V-13.5V

to Pin 2 Residual Carrier Adjustment if Required

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Application circuit 5

5.5 MHz Sound Oscillator Circuit

+V_s

L_6...L_9 Balun Transformer with Ferrite Core

Video

10 μF 0.5 μF

TDA 5660 P

1 2 3 4 5 6 7 8 9
22 kΩ 220 pF 10 nF

Quartz 27 pF

25 kΩ

V_s = 9.5 V-13.5 V

10 nF

33 kΩ

FM AF Input

Alternative 2:
Series Crystal Oscillator with Harmonic Crystal
Good Oscillating Characteristics
TV IF 38.9 MHz

Residual Carrier Adjustment If Required

to Pin 2