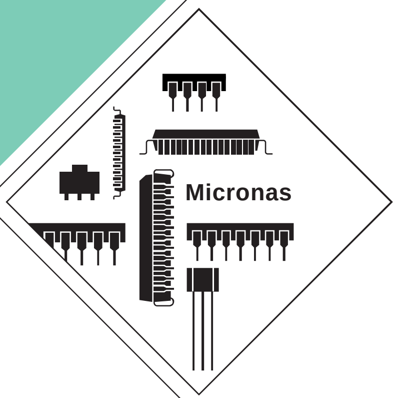
APPLICATION NOTE IC

DDP 3310B
Tube Measurement



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MICRONAS

Contents, continued

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1. SENSE Input Circuit with TDA 6111

The video output amplifier TDA 6111Q has an beam current measurement output (pin 5), which needs measurement output voltage of at least 1.4 V (max 14 V). But the SENSE input of DDP 3310B needs 0 V. To connect these two pins, a simple additional circuit with one transistor is necessary.

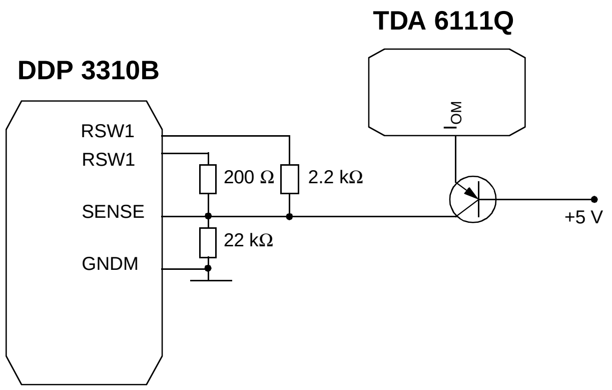

Fig. 1–1: SENSE input circuit with TDA 6111

2. BCL Adjustment

The Beam Current Limiter carries out gain controlling of RGB contrast (drive coefficients) and brightness in a recursive loop. It works on both the digital YUV input and the inserted analog RGB signals by using the SENSE for the beam current measurement. The BCL uses a filter to average the beam current during the active picture resulting in a 12-bit resolution with approximately 4 kHz bandwidth. During the active picture, the measurement range is selected with active range select 1&2 outputs (RSW1 and RSW2) connecting R2 in parallel to R3 and R1 (Fig. 2–1). These measurements are typically done at the summation point of the picture tube cathode currents.

To avoid jittering or oscillation, all parameters and components have to be adjusted carefully.

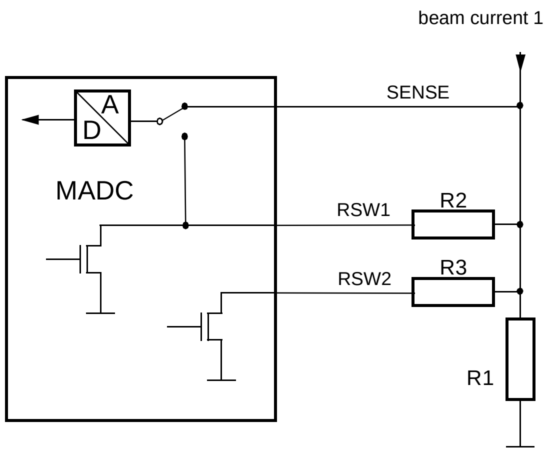

Fig. 2–1: MADC range switch

2.1. Explanation of the Parameters

BCL_THRES:
The control loop only works if the SENSE input signal rises above this threshold. The threshold range of 0...2047 corresponds to the MADC (Measuring A/D Converter) voltage range 0...1.6 V.

BCL_TC:
This parameter adjusts the speed of the control loop: The greater the value, the higher the controlling speed.

$$t_{BCL} = \frac{48}{2^{-9} \cdot BCLTC} \cdot \frac{1}{f_H}$$

BCL_GAIN:
The gain of the control loop should be adjusted as high as necessary, but as low as possible. With a very high gain, the loop can become unstable.

BCL_MIN_C:
If the beam current increases, the gain of the RGB signals will be decreased. This parameter limits the minimum RGB gain. If the minimum gain is reached and the beam current increases further, the brightness will be reduced.

BCL_MIN_B:
If the minimum brightness is reached, no more controlling of the beam current will be done. Therefore, this parameter should be adjusted to zero.

2.2. Adjustment Procedure

1. First of all the maximum average beam current I_{max} and the threshold beam current I_{thres} should be determined to the desired values. I_{max} is the average beam current with a white raster signal and maximum contrast and brightness user adjustments. If the beam current exceeds the value of I_{thres}, the BCL starts to reduce RGB gain.
   I_{thres} has to be smaller than I_{max}. The bigger the difference between I_{max} and I_{thres}, the smaller the adjustable loop gain.
   Example: I_{max} = 2.0 mA, I_{thres} = 1.8 mA
2. The load resistance between the SENSE input and the RSW1 output can now be calculated. The SENSE input voltage should be approximately 0.4 V (25 % of the MADC range) at I_{max}. In this case, the peak current can be four times higher before the MADC comes into limitation.
   Example:
   I_{max} = 2.0 mA, V_{madc}= 0.4 V --> R_{load}= 200Ω.

Note The measured voltage should not be low-pass filtered. There is a 4-kHz low-pass filter in the MADC circuit, and a second low-pass filter could make the loop unstable.

3. Adjustment of BCL_THRES:
   Set the Parameters BCL_GAIN to maximum, BCL_THRES, BCL_MIN_C and BCL_MIN_B to zero, BCL_TC to the middle of the range. The video signal should be white raster and the contrast and brightness adjustments at maximum. With a mA-meter you can measure the beam current and adjust it to I_{thres} (e.g. 1.8 mA) by increasing the parameter BCL_THRES.
   Alternatively, the voltage at the SENSE input can be measured with an oscilloscope. With the parameter BCL_THRES, the voltage will be adjusted to $V_{thres.}$
   Example: V_{thres} = 1.8 mA * 200 Ω = 0.36 V.
4. Adjustment of BCL_GAIN:
   With the parameter BCL_GAIN, the beam current has to be adjusted to I_{max} (e.g. 2.0 mA).
   Alternatively, the voltage at the SENSE input can be adjusted to V_{max}.
   Example: V_{max} = 2.0 mA * 200 Ω = 0.4 V.
5. Adjustment of BCL_TC:
   The speed of the BCL control loop should be as high as necessary but as low as possible. You can test it by switching over the video signal from white to black and vice-versa.
6. Adjustment of BCL_MIN_C:
   With typical video signals and different contrast and brightness adjustments, the parameter BCL_MIN_C has to be adjusted for a proper picture at the screen. Even with high contrast and brightness adjustments some picture contrast should remain. A typical value might be for example BCL_MIN_C = 150 (30%).

Be careful: If the value is to high, the BCL might not work at very high beam currents because the control stops if the brightness reaches the minimum.

3. Picture Tube G2, Cutoff and White-drive Adjustment

Cutoff and white-drive current measurement are carried out with 8-bit resolution during the vertical blanking interval. The current range for cutoff measurement is set by connecting the SENSE resistor R1 to the SENSE input. Due to the fact of a ratio of 1:10 between cutoff and white-drive current, the range select 2 output (RSW2) becomes active for the white-drive measurement and connects R3 in parallel to R1, thus determining the correct current range (Fig. 2–1). These measurements are typically done at the summation point of the picture tube cathode currents.

The picture tube measurement returns results on every field for:

– cutoff R

– cutoff G

– cutoff B

– white-drive R, or G, or B (sequentially)

Thus a cutoff control cycle for RGB requires one field only, while a complete white-drive control cycle requires three fields. During cutoff and white-drive measurement, the average beam current limiter function is switched off. The amplitude of the cutoff and white-drive measurement lines can be programmed separately with IBRM and WDRM. The start line for the tube measurement (cutoff red) can be programmed via I^2C-bus (TML).

The built-in control loop for cutoff and white-drive can operate in three different modes selected by CUT(WDR)_GAIN and CUT(WDR)_DIS.

– The user control mode is selected by setting CUT(WDR)_GAIN = 0. In this mode, the registers CUT(WDR)_R/G/B are used as direct control values for cutoff and drive using the whole 9-bit range. If the measurement lines are enabled (CUT(WDR)_DIS = 0) the user can read the measured cutoff and white-drive values in the CUTOFF(WDRIVE)_R/G/B registers. External software can now control the settings of the CUT(WDR)_R/G/B registers.

– The automatic mode is selected by setting CUT(WDR)_GAIN > 0 and CUT(WDR)_DIS = 0. In this mode, the registers CUT(WDR)_R/G/B are used as reference for the measured values (CUTOFF(WDRIVE)_R/G/B). Due to the 8-bit resolution of the ADC only 8 LSBs can be used as reference values. The calculated error is used with a small hysteresis (1,5%) to adjust cutoff and drive. The higher the loop gain (CUT(WDR)_GAIN) the smaller the time constant for the adjustment.

– If the automatic mode was once enabled (CUT(WDR)_GAIN > 0), the control loop can be stopped by setting CUT(WDR)_DIS = 1. In this mode, the calculated cutoff and drive values will no longer be modified and the measurement lines are suppressed. Changes of the reference values (CUT(WDR)_R/G/B) have no effect.

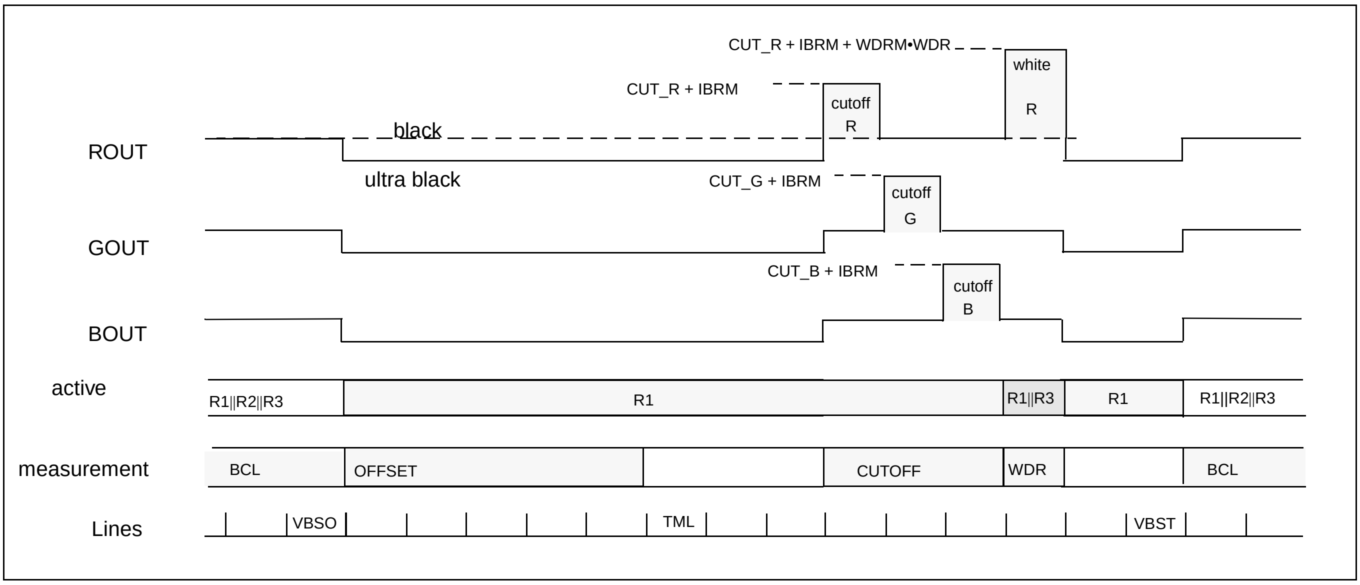

Fig. 3–1: MADC measurement timing

For a correct setup procedure of the cutoff and white-drive control loop, it is recommended to adjust the cutoff prior to the white-drive.

3.1. Explanation of the Parameters

TML:
start line for tube measurement.

MADCLAT:
Latch timing of MADC data in pixels before the begin of horizontal blanking (HBST).

IBRM:
Brightness for measurement (independent of the drive values). Can be set to measure at higher cutoff current.

BW_SEL:
78 or 156 kHz bandwidth for cutoff and white-drive measurement.

CUT(WDR)_DIS:
Enable / disable cutoff (white-drive) measurement lines.

CUT(WDR)_R, _G, _B:
Reference values for cutoff (white-drive) R/G/B.

CUTOFF(WDRIVE)_R, _G, _B:
Measured cutoff (white-drive) R/G/B values.

CUT(WDR)_GAIN:
Gain for cutoff (white-drive) control loop.

3.2. Adjustment Procedure for the Cutoff Control Loop

It is desirable to adjust the G2 voltage at a well defined cathode voltage at around 140 ... 170 V (depending on the picture tube). All following steps should be done with the BCL (beam current limitation) switched off (BCL_GAIN = 0).

1. Adjustment of the measurement resistor (R1 see Fig. 2–1) for the cutoff current:
   The resistance of R1 must be calculated according to the desired cutoff current and on the recommended condition, that the voltage at the SENSE input should be the half input range of the MADC.
   Example:
   I_{Cutoff} ~36 µA, V_{madc} = 0.8 V --> R_1 = 22kΩ.
2. Adjustment of the cathode voltage to the predefined value:
   Set CTM = 0 (no picture at RGB outputs), BRM~20 (digital brightness), INT_BRT = 0 (center brightness), G2-pot. to minimum, CUT_GAIN = 0, CUT_DIS = WDR_DIS = 1 (switch off measurement lines)
   Increment CUT_R/G/B at the same time starting with 0, until the desired voltage at one of the cathodes is reached. (measure voltage at one cathode with a oscilloscope).
3. Adjustment of the G2-pot.:
   Set ZOOM = 1 (no vertical deflection to display all lines at same position).
   Increase G2 voltage until a single line is slightly visible in the middle of the screen (in the color of the strongest cathode).
4. Adjustment of the amplitude for the cutoff measurement lines (IBRM):
   Due to the fact of a limited MADC range, it is desirable to adjust the measurement amplitude to the middle of the MADC range and keeping a lower and upper headroom.
   Increase IBRM starting with 0, until you measure for the middle value of the three cutoff measurement lines approximately 0,8 V at the SENSE input or reading approximately 128 in the corresponding CUTOFF_R, /G,/B register. At the same time the smallest value should be bigger than 0.2 V (32) and the biggest value should be smaller than 1.4 V (223), otherwise IBRM should be increased respectively decreased.
5. Activating the cutoff control loop:
   Set ZOOM~50, CUT_GAIN~60.
   CUT_R/G/B are now reference values for the control loop. Setting the three values to 128, the control loop regulates all cutoff currents to the same amplitude, and keeps the measurement amplitude around the middle of the MADC range. Now the “slight light” should appear as a dark gray. A further optimization can be achieved, by measuring the color temperature and adapting CUT_R/G/B accordingly.
6. Set ZOOM and CTM to the original values.

3.3. Adjustment Procedure for the White-drive Control Loop

All following steps should be done with the BCL (beam current limitation) switched off (BCL_GAIN = 0) and brightness set to the center brightness (INT_BRT=0).

1. Adjustment of the measurement resistor (R3 see Fig. 2–1) for the white-drive current:
   The resistance of R3||R1 must be calculated according to the desired white-drive current and V_{madc} = 0.8 V.
   Example:
   I_{Drive} ~360 µA, V_{madc} = 0.8 V --> R_3 = 2.2 kΩ.
2. Adjustment of the amplitude for the white-drive measurement lines (WDRM):
   Set WDR_R/G/B=480.
   Due to the fact of a limited MADC range, it is desirable to adjust the measurement amplitude to the middle of the MADC range and keeping a lower and upper headroom.
   Increase WDRM starting with 0, until you measure for the middle value of the three white-drive measurement lines approximately 0,8 V at the SENSE input or reading approximately 128 in the corresponding WDRIVE_R/G/B register. At the same time the smallest value should be bigger than 0.2 V (32) and the biggest value should be smaller than 1.4 V (223), otherwise WDRM should be increased respectively decreased.
3. Activating the white-drive control loop:
   Set WDR_GAIN~40.
   WDR_R/G/B are now reference values for the control loop. By setting the three values to 128, the control loop regulates all white-drives to the same amplitude, and keeps the measurement amplitude around the middle of the MADC range. A further optimization can be achieved, by measuring the color temperature and adapting WDR_R/G/B accordingly.

Note: If one of the red, green, or blue white-drive values calculated from the white-drive control loop exceeds it's maximal possible value (WDR_R/G/B>511), the white balance gets misadjusted. An automatic drive saturation avoidance prevents from this effect (WDR_SAT = 1). If one drive value exceeds the maximum allowed threshold (MAX_WDR), the amplitude of the white-drive measurement line will be increased and decreased if one of them goes below the fixed threshold 475.

4. Peak White Limiter for Digital Input Signals

It is possible to use the softlimiter in the digital luma path for a peak white beam current limiter functionality. Due to the fact, that the softlimiter block is calculated before the average beam current limiter (ABL) and the user brightness (INT_BRT) is added, it is necessary to adapt the softlimiter settings according to changing values of these two blocks. So this peak white limiter works independent off the cutoff settings. Since the ABL has a large time constant it's resulting correction factor for the RGB amplitude is changing very slowly (~ 1 field). Moreover the softlimiter settings will be latched only fieldwise. In this way, an external controller is able to recalculate the softlimiter settings using following formulas. In the F5 version of the DDP 3310B this is done in firmware.

The digital amplitude (without cutoff) at the RGB outputs computes as follows:

{MIN[YIN*2*CTM/32+BRM*2 , (LSLAL+256)*2]
+ 4/5*(INT_BRT+256)}*ABL*drive/511.

With the assumption that ABL and drive doesn't reduce the amplitude and YIN, LSLAL, and INT_BRT are at their maximum (255), the maximum output is 1433. Therefore the range for the maximum peak white parameter is:

YMAX = 0 ... 1433.

With this parameter and according to ABL and INT_BRT the absolute limit for the softlimiter is calculated as follows:

$$LSLAL = \frac{YMAX - (4/5 \cdot (IBR + 256))}{2 \cdot ABL} - 256$$

Using only the absolute limit causes a "hard clipping" of the video signals. To avoid this effect a soft limitation is possible by setting LSLSB not zero. The characteristic and the start point of the soft limitation can be configured with LSLB and TB_REL. The resulting tilt point B in the soft limiter is calculated as follows:

$$LSLTB = (LSLAL + 255) - (255 - LSLAL) \cdot \frac{TBREL}{511}$$

5. EHT Compensation

To compensate effects of electric high tension changes on the picture geometry due to beam current variations, the measured average beam current is taken to control the vertical and the East/West amplitude. The time constant of this control loop is free programmable and computes as follows:

$$t_{EHT} = \frac{18}{2^{-9} \cdot EHTVTC} \cdot \frac{1}{f_H}$$

A time constant of approximately 15 ms is recommended (EHTV_TC ~ 20). Due to the fact, that the ratio of the average beam current an the high tension is non-linear, especially for small beam currents, the calculation of the correction coefficients is approximated with two different slopes. If the measured beam current is below a programmable threshold EHTV_THRES, EHT_V/H are used, if it is beyond EHT_V2/H2 are used to calculate the vertical / horizontal amplitude correction.

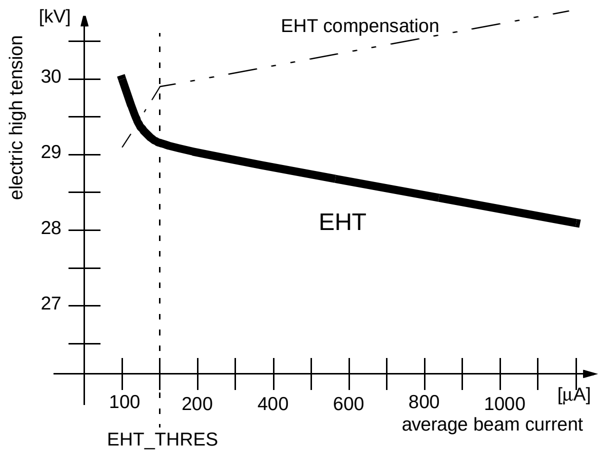

Fig. 5–1: EHT versus average beam current

6. Black Switch Off (BSO) Procedure

To discharge the CRT with the beam current, it is necessary to keep the vertical deflection in the overscan area to avoid any visible effects on the screen. To prevent the tube from permanent damages, the vertical sawtooth should get not to large to avoid any X-rays and the horizontal deflection must be running as long as there remains any high tension. The Black Switch Off procedure of the DDP 3310B-F5 provides following procedure:

1. the picture is immediately blanked
2. after picture is blanked vertical retrace is initiated and amplitude is set to 115%
3. when vertical retraced reached top of picture RGB outputs are set to maximal output current and horizontal blanking is disabled
4. initiates a soft stop of the horizontal drive pulse HOUT (ends with HOUT high after ~85ms)

This procedure is activated as a reaction of a malfunction detected at the HSAFETY Pin, if these registers are set as follows:

BSO_EN = 1; HPROT_DIS = 0; HPROT_SS = 1

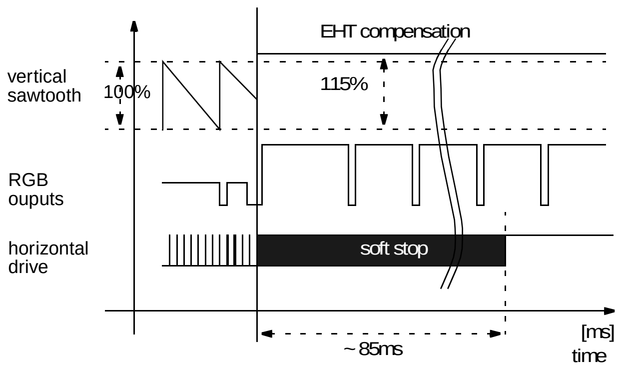

Fig. 6–1: Black Switch Off (BSO)

7. Application Note History

1. Application Note IC: “DDP 3310B Tube Measurement, Jan. 11, 2001, 6251-464-1AN. First release of the application note IC.

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