MT9V111 Developer Guide
1/4-Inch VGA CMOS Digital Image Sensor

About this Guide

The MT9V111 is a complete system-on-a-chip solution. It incorporates sophisticated, on-chip camera functions and is programmable through a simple two-wire serial interface. The developer guide is a quick reference for engineers who wish to develop applications for the MT9V111. The guide provides detailed information on working with chip registers. Also, please refer to Micron's developer software—DevWare, for a better understanding. The MT9V111 data sheet should be used along with this guide as a referenece for specific register and programing information.

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Features

This developer guide explores the auto exposure and auto white balance features of the MT9V111 image sensor.

Auto Exposure

Auto exposure (AE) works to keep the average image brightness constant. To see the role of auto exposure, disable AE by setting R6[14]=0 and pointing the camera around. IFP R46 specifies AE target brightness and the accuracy of tracking it.

The auto exposure logic adjusts integration time, analog and digital gains. If necessary, the frame rate can slow down in the dark. This feature can be enabled or disabled using IFP R55.

The speed of auto exposure can vary greatly with register settings (see IFP R47). AE should react fast in the preview mode of still capture applications. In video or web camera applications AE should be slower to avoid sudden changes in brightness

Automatic White Balance

The automatic white balance (AWB) adjusts image colors when illumination changes. Illuminations such as daylight and cloudy look bluish and cold, while incandescent illumination is reddish and warm. The human eye sees the scene about the same regardless of the illumination, but for the camera the illumination makes a difference. Blue-rich illumination can make a scene captured by the camera appears to have an intense blue tint. Similarly, red-rich illuminations can make a scene appear reddish.

AWB works to remove that kind of tint by making gray areas in the scene look gray in the image.

To see the role of AWB in the camera, try disabling the automatic adjustment and change illumination—turn on an incandescent lamp or move close to a window during daytime. To disable the automatic adjustment set IFP R6[1].

AWB consists of a proprietary measurement engine and color correction logic. The measurement engine processes image stream to detect the type of illumination. The output statistics are used to adjust digital gains of the red and blue channels, IFP R19-20, and adjust the color correction matrix, IFP R18.

Color correction matrices (CCM) can be loaded externally. These matrices must be calibrated for each kind of module. Also, if the automatic adjustment is disabled, one can exercise the white balance in manual mode by loading a fixed color correction matrix suitable for the current illumination. Digital color gains can also be set by writing to IFP R37 or reset to unity by writing R71[7]=1. To load a set of matrices, refer to IFP R2-4, 9-17, 21-30 and 94-96. After loading CCM put it into effect by setting IFP R6[11]=1, R6[15]=1, R6[15]=0 and R6[11]=0.

IFP R33 can skew the measured statistics to make the image look colder or warmer. This feature is useful to adjust the tint to customer preference and to compensate for display white point.

The speed of AWB adjustment can vary greatly depending on register settings (see IFP R37). The speed is adjusted separately for digital color gains and for color matrix update. Typically, AWB should work fast in preview mode in still capture applications. In video or web camera applications the AWB should be relatively slow to avoid sharp changes in color.

Image color saturation is controlled by IFP R37[13:11]. For example, R37[13:11]=000b specifies the nominal saturation and R37[13:11]=010b decreases it to 50%. To lower image noise, color saturation can be automatically decreased in low light conditions, see IFP R51,62.

The white balance can be configured to work in two modes:

- gray world (IFP R42=0,R31=63,R32=65280)
- real life (power-up default plus set IFP R42=128)

Typically, in the "gray world" mode AWB makes the picture gray. This is a standard mode for many cameras. This mode is recommended for use with DNP color bar and the skin tone (girl with rose) test charts.

The "real life" mode typically works better with real life scenes. For example, "gray world" AWB has difficulty with close-up photos of people's faces—the face will be gray. Here the AWB attempts to detect such situations and make colors look correct. However, color bar and skin tone charts may not look correct in this mode.

MT9V111 How To

Optimal Settings for the MT9V111

Please find the optimal settings in the latest MT9V111 image sensor data sheet. Also, start DevWare, click on "Presets" toolbar button and select defaults to load from the list of presets.

Interpreting the Design ID

The design ID can be read out in core R255.

Bits 15-12:   internal project ID number, 1st character

Bits 11-8:   internal project ID number, 2nd character

Bits 7-4:   analog core revision

Bit 3:   1=SOC, 0=standalone

Bits 2-0:   digital block revision

For example, the MT9V111 has the design ID 0x823A. "82" is the internal project ID number; the analog revision is "3". "A" means this is an SOC (bit 3 is set) and the digital block revision is 2.

To get advanced revision: Write page 0, register 0xF9 bit 4 =1, then read page 0, register 0xFD, bit [6-5].

Enable Raw Bypass Mode

The MT9V111 can output raw data (Bayer pattern) directly from the sensor. Two modes are available:

1. 10-bit bypass
2. 8+2 bypass

In 10-bit bypass the MT9V111 outputs 10-bit data just like it is the MT9V011. However, this mode is not available in the PLCC package as it requires additional pad bonding. To enable this mode set IFP R8[10]=1.

In the 8+2 mode you can get 10-bit raw data in PLCC. The 10 bits are output as 2 bytes—the first byte containing bits D[9:2]; the second byte is "0 0 0 0 0 0 D1 D0". To enable this mode set IFP R8[7] = 1.

Note: The defect values in the outgoing specification of the MT9V111 are different from that of the MT9V011.

Default Mode for the MT9V111

The default power-on mode is VGA YCbCr 15 frames per second (fps) using a 12 MHz input clock.

Speed up Auto Exposure

Use IFP R47 to speed up auto exposure, e.g. IFP R47 = 0x84. For the fastest auto exposure set IFP R47=128 and IFP R63=1.

Note: A fast AE may overshoot and oscillate on approach.

In dark conditions the frame rate can drop which naturally slows down auto exposure. To disable frame rate slowing down program IFP R55.

Speed up AWB

Use IFP R37[2:0] and R37[6:3] to speed up auto white balance.

Note: Faster adjustment may result in the white balance oscillating.
Example: IFP R37 = 17684.

When to Speed up AE and AWB

Generally, you need to speed up AE and AWB for digital still photography. The preview mode for digital stills should adjust very quickly. It may even be acceptable that AWB and AE oscillate slightly as they try to settle as fast as possible.

For video capture keep AWB and AE slower because it may be undesirable for image brightness and color to change because of slight scene changes, such as people walking by or the camera panning over a room.

IFP R42 = 0 configures the SOC to make picture gray at all times. If this is insufficient, try IFP R31=0 and R32=51200. Switch AWB to "gray world" mode, see "Automatic White Balance" on page 4.

How to Program the MT9V111 to Work off an Oscillator with a Given Frequency

The MT9V111 can work with master clock frequencies from 12 to 27 MHz:
- If TMCLK is close to 27 MHz, set core R7[4]=0.
- Use Micron software to calculate horizontal and vertical blanking for the sensor core to output desired fps—core R5 and R6.
- Set shutter width numbers in IFP R89-90.
- Set line length in IFP R57.
- Use the Micron Imaging software to calculate the SOC flicker avoidance parameters, IFP R92-93.

Contact your local Micron Imaging FAE to obtain a copy of this software.

When to Calibrate CCM and/or Lens Correction

The color correction matrix and lens correction must be calibrated for each combination of lens and infrared-cut filter. Each camera module manufacture needs its own set of optimized defaults.

How to Calibrate CCM

The following procedure is recommended: ask a Micron Imaging FAE to supply you with the setting for the module of interest and supply the FAE with several modules.

How to Calibrate Lens Correction

Image a uniformly illuminated surface. Adjust the lens shading correction registers IFP R128-149 to obtain a flat image. The color correction matrix must be disabled during capture.

In DevWare, click on "Controls" button, select the "Lens Shading" tab and check "Enable lens shading". Now you can adjust lens shading using the curve tool. To have DevWare calibrate lens shading for you automatically, point the camera at a uniformly illuminated surface and click "Detect Lens Shading" button. DevWare will adjust registers to get a flat image. Registers R128-149 will contain settings you are looking for.

How to Fire Flash

The MT9V111 supports both Xenon and LED light sources using a dedicated output pad. For Xenon flashes the pad generates a strobe to fire when the imager's shutter is fully open. For LED the pad can be asserted or de-asserted asynchronously. To turn LED off and on program R153[8]. To fire a Xenon flash, arm the strobe trigger by setting R153[13]=1. The strobe will appear when the shutter fully opens. Strobe length is set by R153[7:0]. Other available modes include continuous versus single firing and skipping a programmable number of frames after arming and before firing.

How to Enable Built-in Test Patterns

Set IFP R72[7]=1 and R72[2:0]=1..7 to enable test pattern at IFP input. R72 test patterns include color bars.

IFP R58 generates another set of test patterns at IFP output. Set IFP R58[5:3] to obtain ramps at output. You may want to selectively disable color or luma channels using IFP R8[4:2].

The sensor core has a register to test bayer bypass modes. This register is core R50. The test mode is enabled by core R7[6]=1.

How to Zoom and Pan Smoothly

Decimation control registers work to downsize output image to any size. The output image size is specified in IFP R167 and R170 for horizontal and vertical directions respectively. For example, to downsize the VGA output to QQVGA set R167=160 and R170=120. Whenever output image is downsized, the zoom feature becomes available. To zoom in, program R166 and R169 with the size of window to be decimated. For example, in QQVGA setting R166=320 and R169=240 results in 2x zoom. Here the output image of 160 x 120 is created from a pre-decimation window of 320 x 240 instead of the full VGA 640 x 480. Whenever the output image is zoomed, pan controls become available. To pan a zoomed image program R165 and R168 to offset the pre-decimation window in to the right and bottom respectively. When implementing a smooth zoom and pan, it is useful to synchronize the update of all decimation registers to avoid jerks in the output video. When writing a batch of decimation settings, set bit 15 of each datum to "1" to freeze the update. Set bit 15 of the last datum in the batch to "0" to enable normal operation. The entire batch of decimation settings will then be synchronously loaded on the next frame start.

How Fast does Two-Wire Serial Interface Run?

In the MT9V111 and the MT9V143 (SOC343), the SOC two-wire serial interface runs slower than in a standalone sensor. This is due to access to shared bus. A ballpark number for maximum speed is 500 KHz at 30 fps.

How to calculate Gamma Table

Use the following formula to calculate a YCbCr gamma table:

$$Yi = 224 \cdot (Xi/896)^{\gamma}$$

where X0..10 = {0, 16, 32, 64, 128, 256, 384, 512, 640, 768, 896}.

Here =0.45 typically. Calculated values are programmed in IFP R83-88.

For YUV output set IFP R52=0, R53=65280 and use the following formula:

$$Yi = 255 \cdot (Xi/896)^{\gamma}$$

where X0..10 = {0, 16, 32, 64, 128, 256, 384, 512, 640, 768, 896}.

Configuring a JPEG-friendly Output

By default the YCbCr output of MT9V143 and the MT9V111 are configured to comply with CCIR 601 and 656 standards. CCIR 601 limits Y to range from 16 to 235. However, JPEG accepts Y ranging from 0 to 255. Therefore, if the output is used for JPEG compression the SOC output should be reconfigured to use the full range of Y.

The SOC can be configured to output Y ranging from 0 to 255. First, program the appropriate clipping and offset by setting IFP R53=65280 and R52=0. Secondly, disable CCIR codes by setting R6[7]=0 (optional). Thirdly, reprogram the gamma table in R83-87 according to this formula:

$$Yi = 255 \cdot (Xi/896)^{\gamma}$$

where X0..10 = {0, 16, 32, 64, 128, 256, 384, 512, 640, 768, 896}.

For the MT9V111, set IFP_R60[9:0]=0 and use the formula above. For the MT9V143 stretching the range of Y may also require subtracting the IFP black offset. This can be done by manipulating the gamma table. Select a suitable offset from the Xi list, e.g. 16 for i = 1. Then use a modified formula for i = 2..10 as follows:

SOC343: $Yi = 255 \cdot ((Xi\ ?\ 16) / (896\ ?\ 16)) \wedge \gamma$

For convenience, please use the "gamma_calculator.xls" Excel spreadsheet to calculate register settings. This file is available from Micron Imaging FAEs. Below are several pre-calculated sets for the MT9V111, CCIR codes off IFP R6[7]=0 and black re-add zero IFP R60[9:0]=0.

Register Values for Gamma 0.6..1 and Output Luma Range of 0..2.55 for use with JPEG are shown below:

	0.6	0.7	0.8	1.0
R83	8983	6415	4618	2309
R84	20276	16680	13855	9234
R85	39288	36202	33118	27977
R86	53430	51628	50083	46738
R87	65512	65509	65505	65499
R88	0	0	0	0
R52	0	0	0	0
R53	65280	65280	65280	65280

How to Suppress Aliasing in Decimation

Aliasing in decimation modes can be suppressed by forcing the interpolation to do more averaging: R71dec = 127dec. Also, you may want to turn off aperture correction.

Note: These settings will result in a picture that is considerably less sharp.

How to Mirror the Image

To mirror the image vertically, set sensor R32[15]=1 and IFP R8[1]=1. To mirror the image horizontally, set sensor R32[14]=1, IFP R8[0]=1 and core R33=62465.

How to put Camera in Standby

The sequence is:

3. Drive STANDBY pin HIGH.
4. Set core R7[1]=0.
5. Stop master clock (optional, but recommended).
6. If peripheral logic has a finite input impedance, tri-state outputs.

Your standby current depends on the voltage of your interface logic. Standby power is smallest when logic connected to the camera uses 2.8V signaling. If your logic runs on a different power supply voltage, e.g. 3.3V, there will be pad leakage.

How to Load Defaults in DevWare

Click on the "Presets" button in the toolbar and choose defaults to load.

How to Configure the MT9V111 for Video Capture at Constant 15 fps Rate

Limit shutter width in IFP R55. For 15 fps, 12 MHz

R55=256   // constant 15 fps

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How does Noise vs. Frame Rate Trade-off Work

The MT9V111 can slow down its frame rate in the dark. Before it slows down the frame rate the MT9V111 will try to use higher analog gains. This keeps the camera running at full speed, but reduces the signal-to-noise ratio. IFP R64-69 specifies a threshold for the analog gain when the MT9V111 will start slowing down. This scheme is similar to choosing the ISO film speed setting on a digital still camera.

The MT9V111 can be configured to either:

1. keep noise low and start slowing fps at relatively high illumination, or
2. allow more noise in picture, but let the camera run at full speed up to a relatively low illumination.

How to Reduce Banding

Banding occurs if:

- there is resistance in the VAAPIX power supply (e.g. in a module assembly or power connector)
- there is no decoupling cap right next to VAAPIX

If you see banding, please check the module design and put a decoupling cap immediately next to VAAPIX and widen the VAAPIX trace. Banding can be greatly reduced by setting core R7[4]=0 when your master clock is <=13.5 MHz. Also, set core R47=63414 and IFP R57=290, using R5R6.exe.

How Soft Standby Compares to Hard Standby

Hard standby (driving STANDBY pin HIGH) powers down analog circuits and turns off clocks. Soft standby only powers down analog circuits—the digital block continues to run. Therefore, in soft standby externally stop the master clock to achieve same standby current as in hard standby.

Where to get Software to Calculate the MT9V111 Timing

This software is available from the Micron Imaging FAE.

Setting Exact Frame Rate

In the MT9V111 frame rate by default is set at not exactly 15 fps to allow for flicker detection. For reasons concerning a relation between fps and integration time, when the frame rate is set to exactly 15 fps, flicker detection does not work. Therefore, when having an exact frame rate is important, such as for capturing video clips, disable the flicker avoidance (freeze the current detected 50/60Hz frequency) and reprogram timing defaults.

Checking White and Black Levels Experimentally

The correctness of the white and black levels can be checked as follows.

1. Check if output range is 0..255
    a. In room-like conditions freeze auto exposure and white balance (IFP R6[14]=R6[1]=0).
    b. Turn on more light and check that histogram has 255 LSB codes.
    c. Turn off light and put camera in complete darkness; check that the majority of codes is 0 LSB.
2. Check if levels are not clipped.

    a. In (c) the histogram should look like a Gaussian distribution with its peak at 0 LSB. Not seeing the peak means the black level is clipped. To see the distribution better, you can let a bit of light into the camera and see the distribution move.

    b. Clipping of the white level can be deduced from register settings.

Gated Output Pixel Clock Mode

The MT9V111 has a special output mode when output pixel clock is gated by LINE_VALID. To enable this mode, set core R40[0]=1. This mode works for both 8-bit and 10-bit output. In 10-bit bypass mode (IFP R8[10]=1) you can capture raw, 10-bit sensor data and adjust output pixel clock phase using core R7[15,11:8].

Formulas used for Internal YCbCr Calculation

$Y = (0.299*R + 0.587*G + 0.114*B) + 16$

$Cr = (R-(Y-16))*0.713 + 128$

$Cb = (B-(Y-16))*0.564 + 128$

Creating Special Effects

The MT9V111 supports monochrome output. Set IFP R8[5]=1.

With some extra programming it is possible to produce sepia. Just before capturing a snapshot, reprogram the color correction matrix in IFP as follows:

1. Force AWB digital gains to 1: R72=128.
2. Load sepia CCM: R2=36; R3=10516; R4=2276; R9=9; R10=142; R11=17; R12=24; R13=134; R14=43; R15=10; R16=147; R17=17; R21=0; R22=0; R23=0; R24=0; R25=0; R26=0; R27=0; R28=0; R29=0; R30=0; R94=20560; R95=0; R96=0
3. Toggle R6[15] to new CCMs take effect: R6[15]=1; R6[15]=0

Note: Negative effect cannot be done in the MT9V111.

How to Suppress Row Noise in Dark

Under conditions with very low illumination the MT9V111 exhibits some row noise. In general, the noise is reduced:

1. By enabling saturation reduction in low light earlier.
   E.g. IFP R51=4462 will cut saturation and sharpness to 50% when the lens shading digital gain is >1.
2. By limiting maximum digital gain (the picture will look darker).
   For example, IFP R103=0x1910 enables lens correction ("second") digital gain to go up to 1.5x. By default this gain is allowed to go up to 4x.
3. By allowing fps to drop below 15 fps.
   E.g. IFP R55=768 (this is the default setting).
4. By increasing gamma.
   E.g. increase 0.45 to 0.6.
5. By programming a knee in gamma.
   E.g. gamma of 0.45 for CCIR YCbCr output and a knee can be
   IFP R83=11032; R84=23876; R85=39039; R86=49326; R87=57552; R88=0; R53=61456.

How to Choose IR-cut Filter

IR-cut filter spectral characteristics are very important, as shown below.

1. IR-cut transmission or infrared at ~1mkm can create blooming into dark pixels and blooming in active pixels in very bright conditions (90K Lx).
2. IR-cut cut-off can affect color quality, especially for red colors. We recommend calibrating color matrices for your IR-cut.

Micron Demo system uses this filter:

http://www.optics-online.com/IRC.asp?PN=IRC30-15x15

How to Run the SOC Slower than 5 fps

In low light conditions the MT9V111 can automatically increase integration time beyond one frame, thus decreasing output frame rate. The minimum supported frame rate is 5 fps. The minimum rate is 5 fps regardless of chosen maximum fps—15 fps or 30 fps. The following explains how the MT9V111 can be reconfigured to run below 5 fps.

Two solutions are available for reconfiguring the MT9V111 to run below 5 fps.
- Solution A is simple, but has a small trade-off.
- Solution B is more complicated and requires an external application processor help.

Before describing the solutions, here is an explanation of how the MT9V111 handles integration time. The MT9V111 calculates integration time and writes it into core R9. This number, expressed as lines of integration time, almost always equals to

$$\text{Core R9=IFP R89*k or}$$
$$\text{Core R9=IFP R90*k, where k=0,1,2…24.}$$

The SOC programs integration time as an integer multiple of the flicker period, $T_{FLICKER}$. The flicker period is the period of oscillation of indoor illumination, which is typically 2*60Hz in Europe and Japan and 2*50Hz in USA and Japan. IFP R89 specifies $T_{FLICKER}$ in lines of integration for 60Hz environment, while IFP R90 contains $T_{FLICKER}$ for 50Hz. The MT9V111 can automatically detect the flicker period in the scene and select IFP R89 or R90. In the MT9V111 manual one $T_{FLICKER}$ is also called "zone". Thus, the SOC integration time can be in "zones 0,1,2…24". The "24" is a hard limit in the SOC. This number limits the smallest fps: maximum integration time is 24*$T_{FLICKER}$, which works out to 5 fps in the 50Hz environment.

When illumination is too high and the SOC is operating in "zone 0" integration time must be reduced and is not an integer multiple of $T_{FLICKER}$ anymore. Since R9 is not an integer multiple of $T_{FLICKER}$, in indoor conditions in "zone 0" you will see rolling bands due to scene flicker aliasing with the camera frame rate.

Solution A

To allow fps to drop 2x more (to 2.5 fps) double the value in IFP R89 and IFP R90. To allow fps to drop 4x (to 1.25 fps) quadruple the value in IFP R89 and IFP R90, etc.

The drawback of this solution can be seen in indoor conditions. In indoor conditions having light sources with flicker, the MT9V111 will start showing rolling flicker bands at a certain level of illumination and above, for example 1000Lx. However, if R89 and R90 are doubled, flicker will start appearing at one-half the illumination, which would be 1000Lx*0.5=500Lx in our example.

Solution B

If an external application processor is available to monitor the SOC registers, that application processor can dynamically reconfigure the SOC to allow <5 fps frame rates without the flicker trade-off. The idea is to monitor the MT9V111 digital gains. In low light conditions when the digital gains increase to 2x or more, the application processor must quickly reprogram a number of the SOC registers. In particular, the processor must freeze the auto exposure, AWB and flicker avoidance, double IFP R89 and R90, double core R9 and halve IFP R98 containing the current digital gains. Then the processor unfreezes AE, AWB and flicker avoidance. The SOC then can decrease fps further. Please see sample code below. To avoid corrupt frames during programming the processor should discard several frames.

```
This routine automatically drops down framerate by increasing integration time
(in 2 times) in the dark.

bool  NMode = false;
WORDreg89 = GetIFPR006Register(89);// default values for reg89
WORDreg90 = GetIFPR006Register(90);// default values for reg90
WORD  reg6 = GetIFPR006Register(6);
WORD  IT;


void NightMode()
{// read current digital AE gains register
  WORD  reg98 = FMain->GetR006Register(98);
  WORD  DGain = reg98 >> 8;// calc. current digital AE gain

  if (NMode)
  {
    if (DGain==16)// turn off Night mode
    {
      IT = GetSensorRegister(9);// read current integration time
      SetIFPRegister(6, (reg6 & ~(1<<14))); // turn AE Off

// return minimal Integration time step to default     SetIFPRegister(89,
reg89);
      SetIFPRegister(90, reg90);

// double digital AE gain
      SetIFPRegister(98, DGain*256*2 + (reg98&255));
      SetSensorRegister(9,IT/2);// reduce IT

      SetIFPRegister(6, reg6); // turn AE On
      NMode = false;
    }
  }
  else
  {
    if (DGain>=32) // turn on Night mode
    {
      IT = GetSensorRegister(9);// read current integration time
      SetIFPRegister(6, (reg6 & ~(1<<14))); // turn AE Off

// double minimal Integration time step
```

```
        SetIFPRegister(89, reg89*2);
// to double maximal integration time
        SetIFPRegister(90, reg90*2);
        SetSensorRegister(9,IT*2);// double IT and
// reduce digital AE gain to compensate it
        SetIFPRegister(98, DGain*256/2 + (reg98&255));

        SetIFPRegister(6, reg6); // turn AE On
        NMode = true;
      }
    }
  }
```

LPF in the MT9V111

The MT9V111 contains an adaptive filter that suppresses noise in flat, texture-free image areas. IFP R71[7:1]=0 disables this filter.

Color Suppression in Saturated Areas

The MT9V111 decreases color saturation for overexposed pixels. Color suppression is activated when pixel values exceed a threshold. IFP R37[10:8] specifies this threshold.

Color Suppression in Low Light Conditions

The MT9V111 automatically decreases sharpness and color saturation in low light conditions. IFP R37[14]=1 enables automatic saturation reduction (default). IFP R5[3]=1 enables automatic decrease in sharpening (default).

IFP R51 and R62 specify threshold when saturation and sharpness are decreased. The reduction is performed in 2 steps: by decreasing values to 75% and 50%. The two thresholds can be specified with respect to current analog gain, ADC gain and either of the digital gains. IFP R51[7:0] and R62[9:8] specify the 75% setting threshold. IFP R51[15:8] and R62[11:10] specify the 50% setting threshold.

Size of Interpolation, Defect Correction and Sharpening Kernels

Interpolation, defect correction and sharpening kernels are up to 5 pixels on the side.

Defect Correction of the MT9V111

The MT9V111 has several defect correction techniques:
- 1D: Hot and dead pixels with known coordinates are corrected
- 2D: Hot and dead pixels are corrected on the fly
- 3D: Hot and dead pixel coordinates are determined on the fly, stored in a table and corrected

How to Switch Master Clock On-the-Fly

Some applications require special accommodations where master clock speed is halved during still capture. It can be done in this way:
1. Set the sensor up for 24 MHz.
   a. Program 1 zone to be 2xTint.
2. For still capture:
   a. Freeze AE/AWB/flicker (IFP R6,8).
   b. HALVE int. time core R9:=0.5*R9.
   c. Switch the clock to 12MHz; skip a bad frame.
   d. Capture a frame/save as snapshot.
   e. Switch the clock back to 24MHz.
   f. Restore core R9.
   g. Enable AE/AWB/flicker.
   h. Drop a bad frame.

How to Reduce EMI

EMI can be reduced by:
1. Limiting MCLK slew—put a resistor on the PCB in series with MCLK.
2. Limiting output pad slew—put resistors on the PCB in series.

3. Shielding the module.

How to Check AWB

1. Put a Macbeth chart in the scene, see the illustration below.
2. Capture the scene.
3. Send this image to the Micron Imaging FAE.
4. When using the Micron Demo, send both image (captureXXXX.bmp) and register dump (captureXXXX.txt)

How to Operate White Balance Manually

Input and output for color correction is R, G, B data.

|R| |c11 c12 c13| |r|
|G| = |c21 c22 c23| * |g|
|B| |c31 c32 c33| |b|

To change CCM in manual mode:

•   Set digital AWB gains to 1 (IFPReg72[7]=1 - set bit 7 of reg72). That will prevent CCM position to be changed.

- Change base CCM (IFPRegs 2-4, 9-17).
- Change ratios of imager analog gains for "Base" matrix (IFPReg94).
- Toggle bit 15 of IFPReg6 to set new values.

How to Achieve Red-Eye Reduction

Red-eye reduction can be achieved by adjusting flash.

1. Xenon—fire Xenon twice in a row, if possible.
   The eye will adapt after 1st flash.
2. LED—turn on LED for a longer time.
   The eye will have time to adapt when LED is on.

There is no hardware red-eye reduction otherwise in the MT9V111.

How to Increase Frame Start Blanking

Reconfigure image size to be 1 line larger (488+1=489) and use "windowing" at the SOC output to crop image back to VGA size.

Troubleshooting

Bad Colors

1. Make sure you load camera defaults. In DevWare, click "Defaults" button on the tool-bar. Alternatively, click "Presets" button and choose from a list of available preset defaults for various modes.
2. Check your IR-cut filter. A poor IR-cut filter can ruin colors, especially in incandescent illumination.
3. Check if IR leaks through module plastic.

Sunny Outdoors—Sky Not Blue

Set IFP R36=25600. This limits AWB range to make sky look blue. Besides, about white wall with green trees or hands on white paper, customers might set their own IFP R34 and R35 (ex 0x9080 or 0xFD40 other than default 0xD960) to fix AWB problems with trade-offs.

Black Offset too High

Black offset can be high due to optical reasons (caused by module packaging) or camera chip configuration. To distinguish between the two, turn off auto exposure R6[14]=0 and decrease integration time to a very small value, e.g. core R9=1. In addition, wrap the camera with black cloth so that no light can get in from anywhere. The image will go black. Now check RGB values or histogram. In DevWare the values of RGB are available in the Info panel; the Graphs button will bring up a histogram. If the black is still high, the camera chip needs configuration. Otherwise it is a module packaging problem.

- Chip configuration
a. Check that IFP R60[9:0]=0.
b. By default the camera output complies with CCIR 601 and limits output luma range to 16..240 LSB. If you expect the luma to have full range of 0..255LSB, reprogram the camera as described in "Configuring a JPEG-friendly Output" on page 9".

- Module packaging
a. Check lens flare. Lens flare can cause the black offset to be high.
b. Check camera module light leakage.

Low Contrast

Module/lens:
- Flare
- Light leakage

Sensor:
- In very bright conditions (Tint < 1row), active pixels overflow and bloom, causing color crosstalk.

Image Processor

- Compared to DSC cameras, there is no flare compensation or histogram stretching.
- Compared to DSC cameras, auto exposure is simplistic (center-weighted). These will be fixed in the MT9D111 (SOC2010). The MT9V111 is not sophisticated enough to handle these.
- Gamma setting <0.6.

See "Black Offset too High" on page 19" and ""Checking White and Black Levels Experimentally" on page 11.

Try increasing gamma to compensate for lens flare; use default 0.6 gamma.

Rolling Dark Bars

Rolling dark horizontal bands are typically caused by ambient flicker. You will typically see flicker under old fluorescent illumination.

If you see flicker, first check the speed of your oscillator. The MT9V111 by default is configured to run off 12 MHz oscillator (not 13.5 MHz like the MT9V143 or 27 MHz like the MT9V011). If your clock frequency must differ from 12 MHz, load the MT9V111 with proper settings for timing.

When the scene illumination is too bright flicker may be visible if illumination is old fluorescent or incandescent. This happens when the MT9V111 has to decrease the integration time below one $T_{FLICKER}$, which is 1/120 second in the US, 1/100 second in Europe and either in Japan. If the camera has an aperture, close it to reduce exposure. If the camera has a fixed aperture, set IFP R70 to a value higher than IFP R46[7:0] to delay the inevitable appearance of flicker in high light by overexposing the image.

I am trying to change sensor gains, but they don't change

By default, at the end of every frame the SOC writes gains (R43..R46), integration time (R9, R12) and ADC voltage reference (R41) settings to the sensor core. Therefore if you try changing sensor gains manually, your values will be overwritten.

To set gains manually, disable auto exposure (IFP R6[14]=0), AWB(IFP R6[1]=0) and flicker detection (IFP R8[11]=0).

I'm running at 27 MHz/30 fps and the image looks washed out. Why?

It is suggested that regardless of the master clock frequency, set core R7[4]=0; also set core R47=63408 for 30 fps operation.

White balance incorrect for a test color chart

The MT9V111 AWB by default is configured to work in the "real life" mode, which does not perform well on certain test charts. Change the AWB mode to "gray world". See "Automatic White Balance" on page 4 for details.

Image contouring when displayed on 16-bit monitor

To eliminate contouring during preview, set the following registers:

IFP R6[12]=0   // disable aperture correction noise suppression

IFP R5[3]=0   // disable sharpening reduction in dark

IFP R5[2:0]=7   // maximum sharpening (you can try setting
                        // it to a smaller value if picture is too sharp)

We recommend restoring register values before capture, but this is optional.

Sensor Behaves Oddly

Try a different die and check if all the samples behave the same. If only certain percentage of samples show the problem, contact your local Micron Imaging FAE or sales for RMA.

Faint Yellow-Green Bar

Check IR leaking through module walls. This can create a faint colored bar.

Draft 10/26/2005

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