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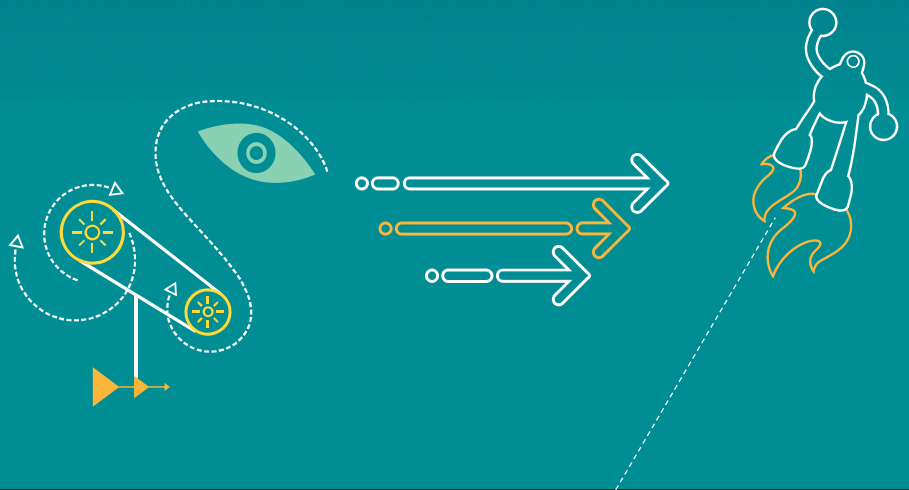
Qualcomm Technologies, Inc.



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Revision History

Revision	Date	Description
A	Dec. 2015	Initial release

Note: There is no Rev. I, O, Q, S, X, or Z per Mil. standards.

内容

- Camera
  - AF Tuning Document List
  - Basic AF tuning
  - Contrast AF Tuning
  - PDAF Tuning

Camera

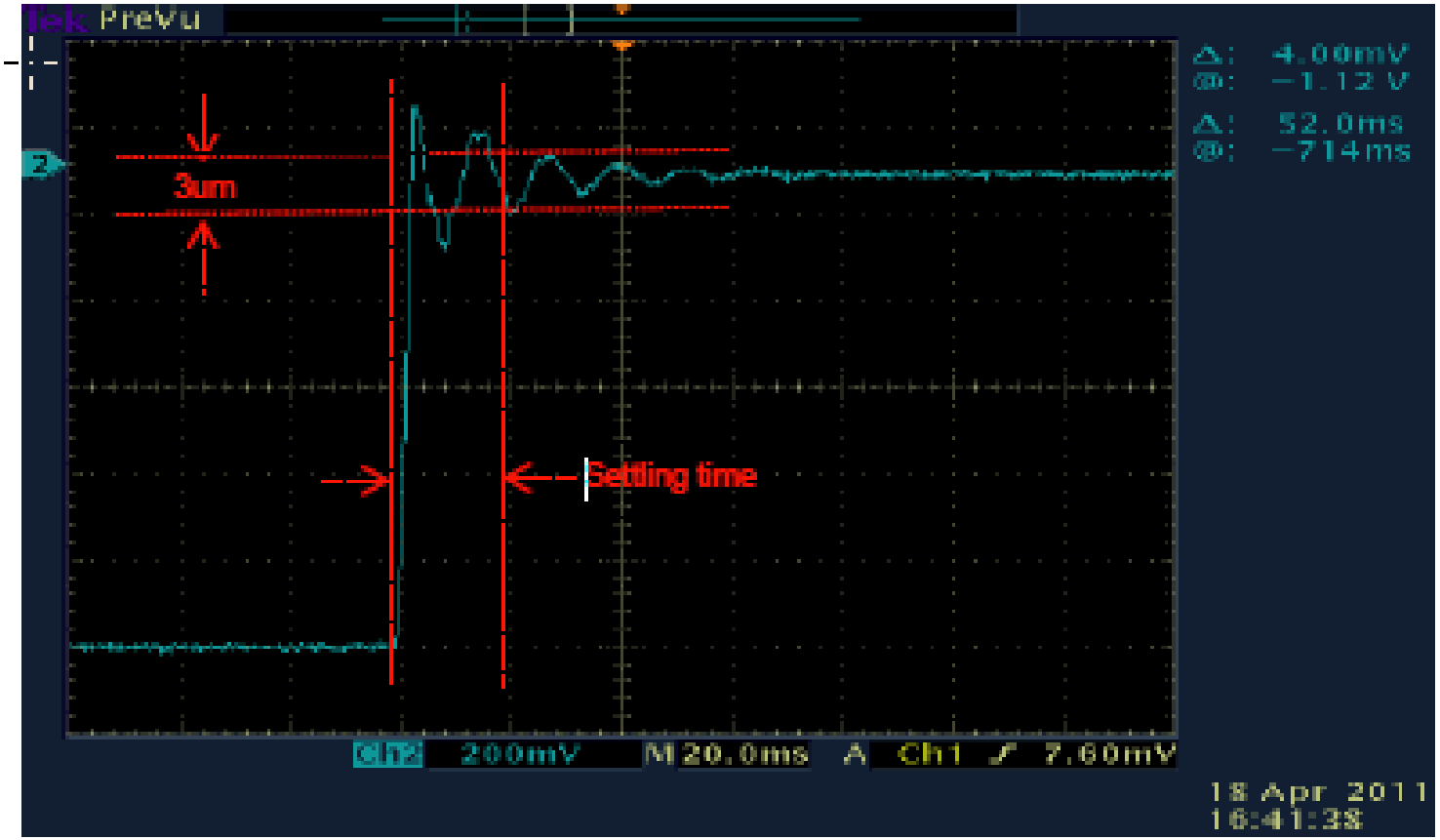
AF Tuning Document List

- 80-N5126-1_N_Camera_Mod_Selection_Calibration_Data.pdf
- 80-NV125-1_J_PDAF_Module_Calibration_Guide.pdf
- 80-NN841-1_B_AF_Tuning_Guide.pdf
- 80-NK872-11_C_Camera_3A_v5_0_Tuning_Guide.pdf
- 80-NV647-1_A_3A_ Improvements_MSM8996.pdf
- Camera Tuning Journal

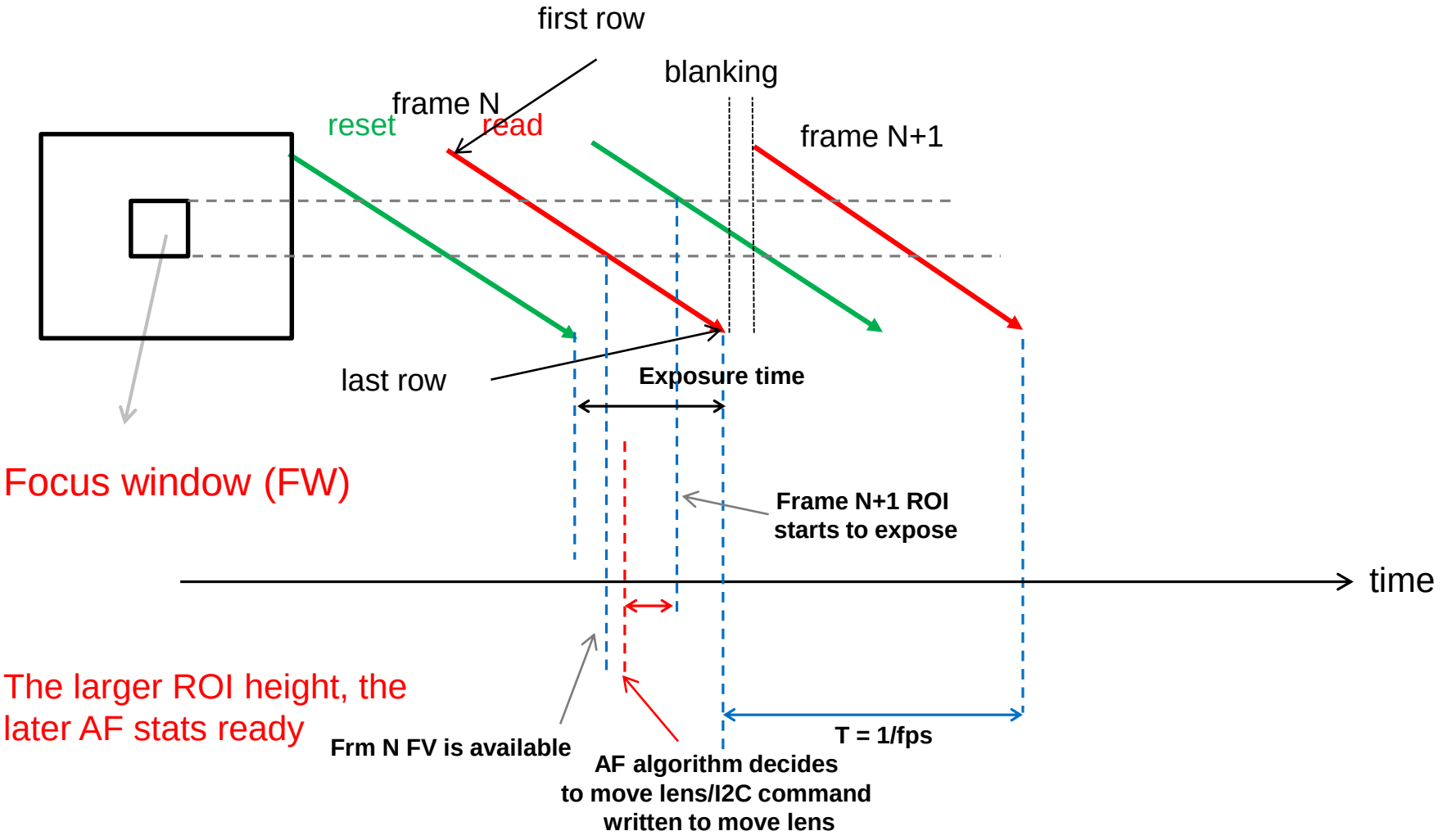
Basic AF tuning

Ringing

- The FV value will not be reliable if the settling time of ringing is long.
- To get rid of ringing influence on FV, we need to fine tune damping or consider adding frame delay.



FV Timing – short exposure



Exposure table tuning for AF

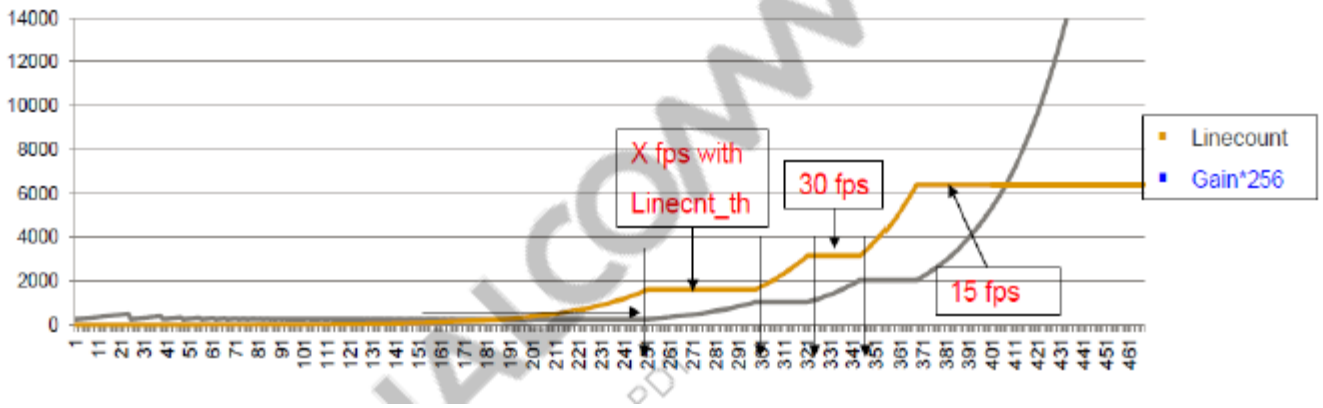
When tuning the AEC exposure table, follow these recommendations:

$$L_{th} = \frac{(0.033 - T_{8um} - R_{HeightPercentage} * 0.033)}{0.033} * L_{30FPS}$$

where:

- `L_th` – Line count threshold to use
- `T_8um` – Time it takes for 8um lens movement
- `R_HeightPercentage` – percentage of the Height of the ROI to the CAMIF height
- `L_30FPS` – Linecount for 30 fps

The constructed AEC table should look similar to the following figure.



Contrast AF Tuning

CAF Triggering -- FV Triggering

Parameter	Description	Default value	
		Camera	Camcorder
Scene_change_detection_ratio	Ratio of FV to determine a scene change ▪ Lower value indicates more sensitive ▪ Higher values indicate less sensitivity	4	4
Panning_stable_fvavg_ to_fv_change_trigger	Ratio of FV to determine a scene change with regard to average ▪ Lower value indicates more sensitive ▪ Higher values indicate less sensitivity	5	5
Panning_stable_trigger_count	Number of frames to wait after FV is stabled ▪ Lower value indicates that search starts quicker ▪ Higher value indicates that search start lags	8	8
Base_delay_adj_th	Threshold (in ms) to check while adjusting base delay from FPS info ▪ Lower value indicates that it is easier to adjust/add delay ▪ Higher value indicates that it is harder to adjust/add delay	0.34	0.34

CAF Triggering -- FV Triggering

- Trigger:
  - condition 1: (cur_fv-max_fv)/max_fv > scene_change_detection_ratio
  - condition 2: (avg of last two - ave_fv)/ave_fv > panning_stable_fvavg_to_fv_change_trigger
    - if (1&2): unstable_cnt++
    - if !2 stable_cnt++
  - You could tune scene_change_detection_ratio and panning_stable_fvavg_to_fv_change_trigger to make AF more sensitive.

CAF Triggering -- SAD Triggering

- SAD refers to the Sum of Absolute Difference in luma values between two frames. The luma values obtained in the AEC statistics engine is passed to AF and AF computes SAD in order to infer whether a scene change has occurred. AF computes SAD as the luma value difference of the current image frame versus the last image frame.
- IN addition, Reference SAD is computed from the luma difference of the current image frame versus the last focused image frame. SADR provides an effective way to determine a scene change in cases where the camera is moved slowly resulting in a small frame to frame SAD.
- The threshold values with which the SAD values are compared to assess the indication of scene change and scene stable conditions is dynamically adjusted based on the scene brightness as inferred from AEC gain. The tuning parameters dictate the minimum and maximum limits of the linear interpolation used in computing SAD and Reference SAD theresholds.

CAF Triggering -- SAD Triggering

- SAD threshold related parameter.
  - Trigger:
    - condition 1: sadr > sadr_stable_th
    - condition 2: sad > sad_stable_th
    - if (1||2) unstable_cnt++
    - if !2 stable_cnt++
    - You could tune sadr_stable_th and sad_stable_th to make AF more sensitive.
  - Panning:
    - stable_cnt > frames_to_wait
    - You could tune frames_to_wait and sad_stable_th to make device become stable easily.

PDAF Tuning

Verify PDAF functionality (1)

- Verify PDAF functionality when target is in focus
  - Verify PD, defocus and confidence level when target is in focus
    - Make sure that the lens is accurately focused on the test chart in the stated test conditions.
      - Use touch AF.
      - 5000K light source
      - Use the vertical stripes chart
      - Object target is 20cm
    - When the lens is focused on the test target, obtain this information for each Region of Interest (ROI) from the log:
      - Log: "af_pdaf_proc_pd: grid(%d) pd=%0.2f, defocus(dac)=%d, conf=%d, weight=%0.2f“
    - Information from the log should meet the following criteria for each ROI
      - Absolute value of phase difference should be less than 1
      - Defocus should be less than 10
      - Confidence level should exceed minimum threshod

Verify PDAF functionality (2)

- Verify PDAF functionality when PDAF is working
  - Verify PD, defocus and confidence level when PDAF is working, as follows:
    - Establish these test conditions:
      - 5000K light source
      - Use the vertical stripes chart
      - Object target in 50cm
    - Force AF to focus on a near object, e.g., business card, then quickly remove the object to allow camera to see the vertical stripes test chart.
    - Obtain the following information from the log while the AF is working:
      - Log: “af_pdaf_proc_pd: roi(%d) lens_pos=%d index=%d, pd=%0.2f, defocus(um)=%d, conf=%d, is_conf=%s, not_conf_cnt=%d“
    - Immediately after the near object is removed, the following should be observed from the log:
      - PD is positive value and gradually decrease toward 0 as the lens is focused
      - Defocus is a positive value and gradually decreases toward 0 as the lens is focused
      - Confidence level should remain higher than the minimum confidence threshold, e.g., 150 for IMX230. When it shows is_conf=1, it means the ROI PD is confident and reliable.

Tune ROI configuration

- For IMX230, the ROI is middle 4 grids in the 8x6 grids.
- For 3M2, the ROI is middle 30%x30% area of the full image.
- It is recommend not to change the default ROI configuration.
- Setting a too large PD ROI may confuse the PD result and the PDAF final decision.
- Setting a toll small PD ROI may include not enough PD pixels for confident PD result.

Tune the noise gain table

PD information coming from the sensor may become noisy when a higher gain is applied. When the noise gain is higher, PDAF may get an unreliable defocus value for the jump which can cause focus failure. To adapt for a higher gain, you can increase the Min Fine Scan Range to search for the peak position based on contrast AF after PDAF.

The fine scan range can be adaptively modified according to its sensor gain.

```
Fine-step focus scan range =
Fine scan step size x Range multiplier(noise gain [dB])
```

The multiplier between two gain entries will be linearly interpolated.

- Log: "af_pdaf_get_noise_multiplier: noise_gain=%0.2f, multiplier=%0.0f“
- Parameters will be multiplied by noise gain:
  - fine search range
  - focus done threshold
  - depth stable threshold

Tune the confidence table

Each PD ROI generates two pieces of information:

- Phase difference (PD)
- Confidence level

A high confidence level means the PD in this ROI has a small variance and it probably has higher edge intensity. The confidence table is used to define a minimum confidence threshold relative to the sensor gain.

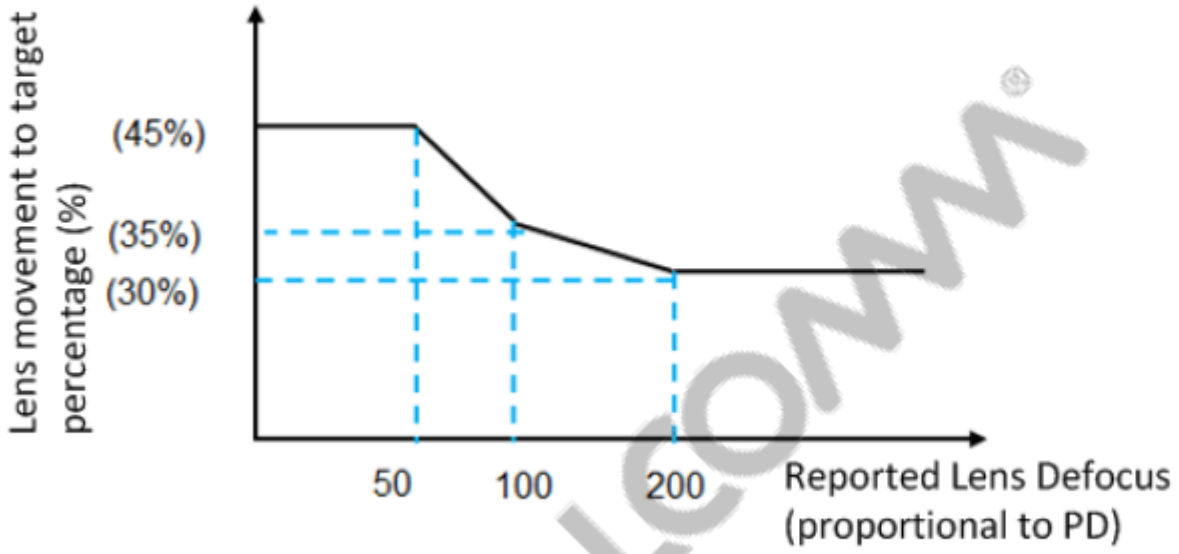
- The first `min_conf` is fully applied when noise gain is ≤ first noise gain.
- The last `min_conf` is fully applied when noise gain is ≥ last noise gain.
- The `min_conf` between the first and last entries is interpolated linearly according to where the noise gain lies between the gain of the first and last entries.
- The ROI PD confidence value is only taken into account if it is over the minimum confidence threshold.

- Log: "af_pdaf_get_min_conf: noise_gain=%0.2f, min_conf=%d soft_conf_thresh %d"

Tune the focus table

When moving from near to far or far to near with one big lens movement in one frame, it looks very jumpy and jerky. To make AF smooth, it is necessary to use iterative movements to provide a good AF converge user experience and to prevent overshoot behavior.

To provide a good user experience, the tuning parameter `move_percentage` breaks down one big lens movement into small lens movements based on the original defocus distance, as follows:



- If the reported defocus is 200, the final driving lens movement is 200*0.3 = 60.
- If the reported defocus is 40, the final driving lens movement is 40*0.45 = 18.

- Log: "af_pdaf_get_focus_pcnt: defocus=%d, focus_pcnt=%0.2f, bv=%0.2f"

Tune the frame skip parameter

To perform a more smooth AF converged speed, use the **Conv Frame Skip** parameter to extend AF converged speed. This parameter slows down AF speed but creates a smoother converged user experience.

To use the Chromatix tool to tune the frame skip parameters, do the following:

Tuning guidelines

- It is recommended to only set one frame skip for AF convergence.
- Too many frame skips cause a jerky experience and slow down AF speed.

- Log: "Skipping %d frames for focus converge CUR_POS = %d, NEXT POS = %d"

Tune the focus done threshold parameter

The **Focus Done Threshold** parameter is used to decide if PDAF is converged.

If the reported defocus value is bigger than **Focus Done Threshold**, PDAF keeps searching and waiting for entering converge state.

If the reported defocus value is smaller than **Focus Done Threshold**, then the PDAF search is ended and it enters Fine Search mode or, if fine scan is disabled, reports to `AF_ success` directly.

Tuning guidelines

The larger the number, the quicker to finish PDAF search and the easier to enter Fine Search mode.

- Log: "af_pdaf_is_focus_converge_done: defocus=%d, focus_converge_done_thres=%d, is_focus_converge_done=%s"

Tune the stable table and scene monitor

The **Defocus Threshold** determines if AF is out of focus.

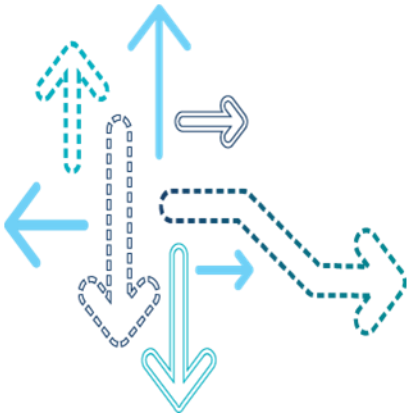
The **Depth Stable Threshold** triggers an increase to stable count.

```
/* scene_monitor */
      {
       2,    /* wait_after_focus_cnt */
       4,    /* wait_conf_recover_cnt */
       10.0f, /* defocus_threshold */
       20.0f, /* depth_stable_threshold */
      },
```

The **MinStableCount** is the threshold to determine if PD enters the Steady state.

```
/* stable_tbl */
 {
  3, /* num_entries */
  /* entries */
  {
   { 10,  0 }, /* {fps, min_stable_cnt} */
   { 14,  1 }, /* {fps, min_stable_cnt} */
   { 24,  1 }, /* {fps, min_stable_cnt} */
  },
 },
```

- Log: "af_pdaf_proc_defocused: roi(%d) defocus=%d, dof_mult=%1.1f, defocus_thres=%1.1f, defocus_cnt=%d, min_defocus_cnt=%d, is_defocused=%s“
- Log: “af_pdaf_proc_depth_stable: roi(%d) stable_cnt=%d, min_stable_cnt=%d, is_stable= %s"



Questions?

https://support.cdmatech.com