DRV2624 | Short Vibration Optimization

3/23/2020

LPAA

Initial Inquiry:

- Customer reports that long effects work well with closed loop mode, but short effects are too weak. What is the solution?

TI suggests either 1 or 2 or both:

1) Increasing the overdrive voltage. The overdrive voltage (Vp) should be greater than the rated voltage (Vrms) * 1.414 V. The overdrive voltage can be increased up to the supply voltage minus ~ 0.1 V for headroom. However, the LRA might not be able to handle that high of voltage so customer should discuss with LRA manufacturer for maximum overdrive voltage. Generally it is 1 to 1.5V higher than the rated voltage.

2) Using open loop mode, as discussed in the following slides.

Open Loop vs Closed Loop

Closed Loop: In closed loop mode, the algorithm tracks and reports the frequency of the actuator. Both the overdrive voltage and rated voltage must be set properly [overdrive voltage (Vp) must be at least 1.414 V * the rated voltage (Vrms)]

Benefits

- Automatic overdrive
- Automatic braking
- Automatically drives at resonant frequency

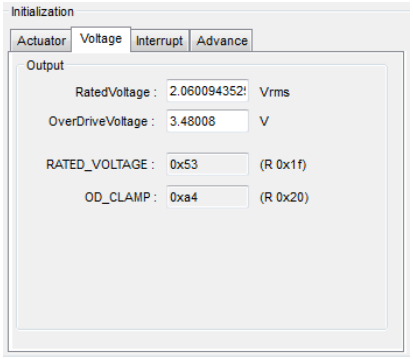
Open Loop: In open loop mode, the algorithm drives the actuator at the programmed frequency and does not sense the LRA's resonant frequency. The rated voltage is ignored and the output is determined by the overdrive voltage only.

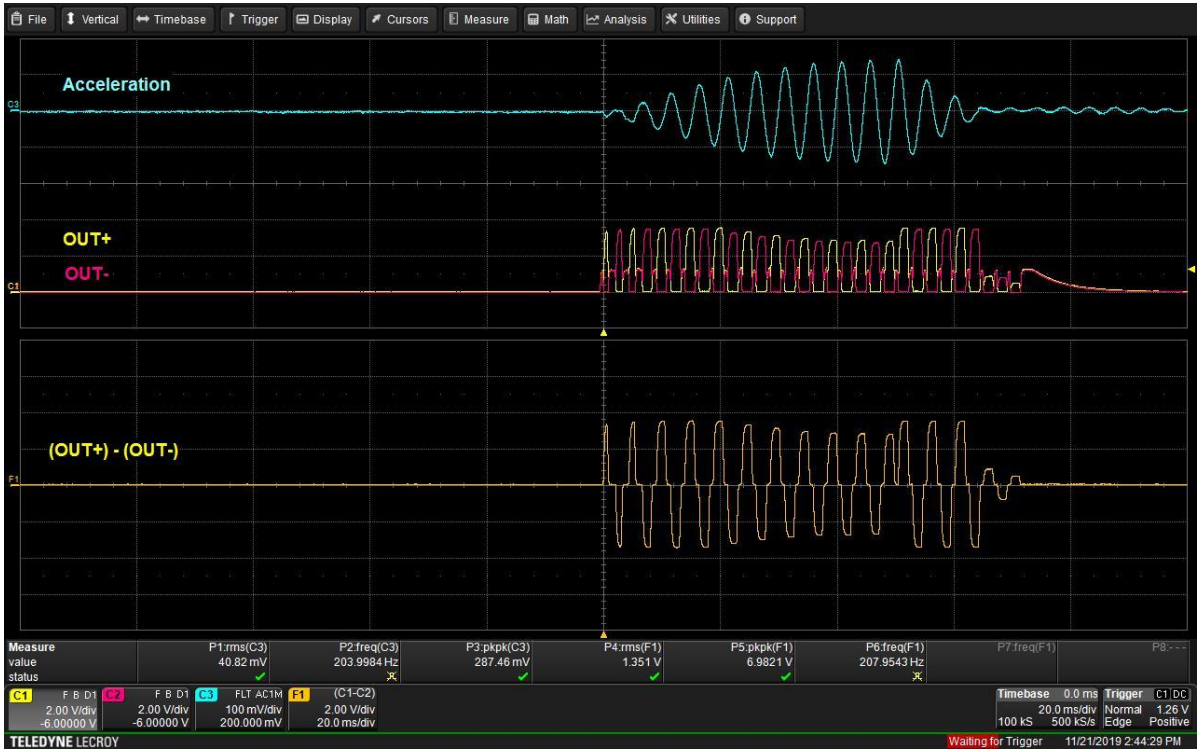
Benefits

- Selectable frequency
- Selectable duration of overdrive
- Ability to switch to closed-loop during braking automatically
- Choice of sine or square wave for output

Closed Loop Example

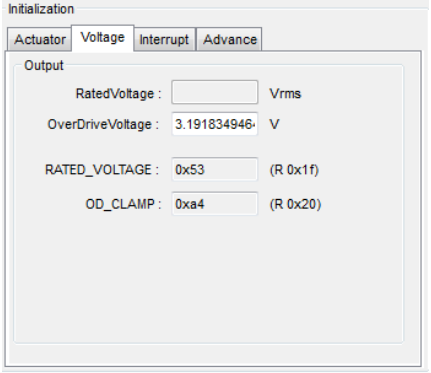
- Overdrive voltage automatically transitions to rated voltage. This generally occurs after 20 to 100 ms depending on the LRA.
- If the waveform is short enough (less than ~ 50 ms), then the output will stay at the overdrive level

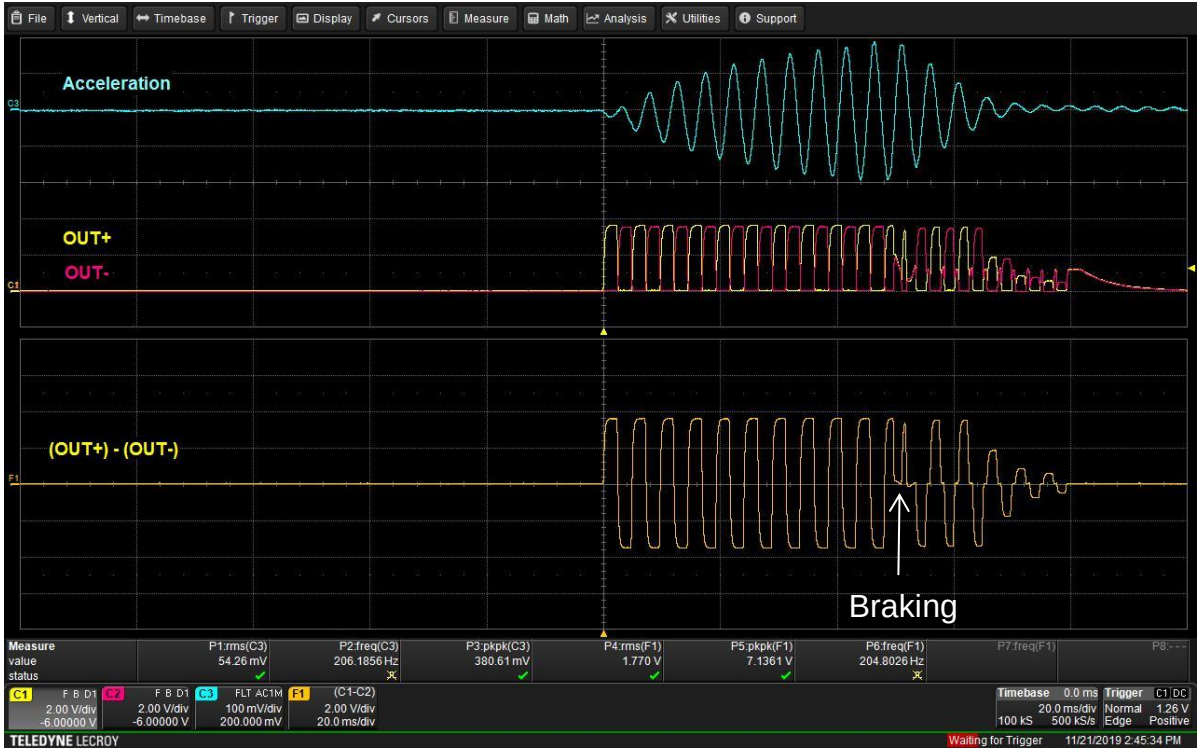




Open Loop Example

- Overdrive voltage is set by **OD_CLAMP** only (Rated Voltage is ignored in Open Loop)
- Change to output voltage must happen in the waveform (in RAM waveform or through RTP)
- AUTO_BRK_OL must be selected for braking to happen. AUTO_BRK_INTO_STBY is also frequently used.





Considerations

- For the braking to work properly, calibration must be performed. This only needs to happen once per LRA (generally on factory line) and the calibration values can be rewritten to the corresponding registers.

- Open loop or closed loop is selected by bit 6 of register 0x08. No other modifications are necessary, assuming below registers are programmed. The DRV2624 and easily and quickly transition from open loop to closed loop and vice-versa with just one register write.

- When using open loop mode, make sure the following are programmed properly:
  - OD_clamp (output voltage) (0x20) (note – can be same value as in closed loop mode)
  - Open loop frequency (0x2E and 0x2F)
  - Sine or square wave mode (0x2C bit 0)
  - Braking (0x08 bit 4 and 3)

Selecting Correct Frequency

- There are two methods for selecting the open loop frequency:

1) Use the LRA's resonant frequency according to datasheet
   - For example, if the expected frequency of the LRA is 180 Hz, then program the open loop frequency to be 180 Hz in the appropriate registers (**0x2E and 0x2F**) according to the below equation:

Table 47. Address: 0x2F

BIT	FIELD	TYPE	DEFAULT	DESCRIPTION
7-0	OL_LRA_PERIOD[9:0]	R/W	198	This parameter sets the frequency that will be used to drive the LRA in open loop. LRA open loop period = OL_LRA_PERIOD[9:0] × 24.615 µs.

   - If the LRA has a wide Q, then this method works well. If the LRA has a narrow Q and is very sensitive to frequency accuracy, then the second method is preferred.

2) Use the last stored resonant frequency in closed loop mode as the open loop resonant frequency. Whenever a haptic effect is played in closed loop mode, the measured resonant frequency is stored in registers 0x05 and 0x06. These same register values can be copied to the open loop frequency registers (0x2E and 0x2F).
   – **Note:** It is recommended to set LRA_PERIOD_AVG_DIS (0x07 bit 6) to 0 so that the algorithm reports the average of the last 4 measurements for higher accuracy.