Measuring the mechanical resonance of a camera unit within a smartphone

Image taken from `www.quadlockcase.eu`.

INTRODUCTION

For many, smartphones have become their main photo and video camera. They offer good image quality, auto-focusing and efficient sensors whilst being integrated in our most-used item. Unfortunately, the continuous development of smaller and more performant camera units can also lead to an increased susceptibility to mechanical shocks due to the miniaturized components. Image stabilization and auto-focusing can be negatively affected or even damaged by vibrations, rendering the camera useless.
Quad Lock, an Australian company developing secure mounting systems for smartphones, took this matter seriously and set out to develop a vibration damper for their mounts to better protect the sensitive camera units. SmarAct assisted by performing vibrometry measurements directly on the camera unit within the phone.

RESULTS

Camera units of smartphones include multiple lenses that are mounted on a movable stage such that motorized focusing becomes possible, see Figure 1. The stage effectively acts as a spring which, in combination with the mass of the optical elements, forms a harmonic oscillator characterized by a specific resonance frequency.

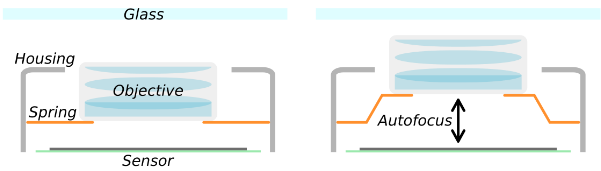

Figure 1. *Schematic representation of a smartphone camera unit. The optics sit in a flexible mount which can be moved to allow for focusing.*

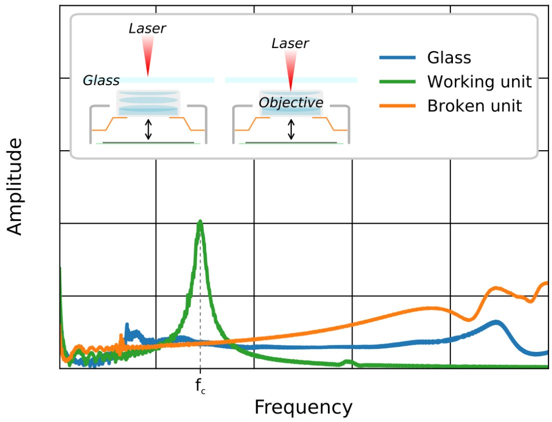

Figure 2. *Mechanical response of a smartphone camera unit. An intact camera shows a clear peak at f_C, green curve, as compared to the protective cover glass and a damaged camera unit, blue and orange curves respectively. Inset: Measurement principle showing how the confocal optics of the* ***PICO****SCALE Vibrometer allow to measure on selected surfaces.*

If the resonance frequency of the camera unit is within reach of the vibrations induced by a revving engine, excessive motion of the focusing stage can occur that, in turn, may damage the camera. To test the response of the camera unit, the whole phone was subjected to vibrations by a shaker stage with frequencies similar to what a motorbike engine can produced. Additionally, due to the confocal measurement principle of the **PICO**SCALE *Vibrometer* it is possible to measure through the protective glass cover of the smartphone housing such that measurements can be performed without having to disassemble the smartphone. Figure 2 shows the amplitude spectrum measured on an intact camera and on one that got damaged by excessive vibrations. The measured resonance frequency of the intact camera is easily seen at f_c. The broken camera however does not show a clear resonance which indicates mechanical damage to the focusing stage.

Besides the response of the camera unit itself, also the transmission of vibrations from the noise source, here a revving motor, to the camera unit is of key importance. An example of the measurement of such transmitted vibrations is shown in Figure 3. When the Smartphone is mounted on a flexible arm, the transmission of the hazardous vibrations, f_c, is halved as compared to a rigid mounting condition.

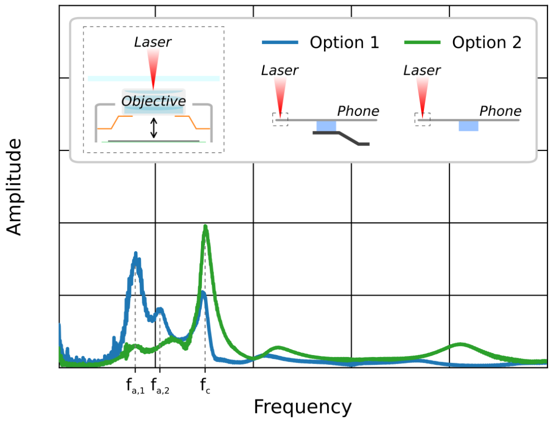

Figure 3. *The transfer of vibrations to the camera unit is affected by the mounting conditions of the smartphone onto the vehicle. When the phone is rigidly mounted, green curve, the resonance of the camera* f_c *is doubled as compared to when the phone supported by a flexible arm, blue curve. The arm itself resonates at lower frequencies,* $f_{a,1}$ *and* $f_{a,2}$*, and helps to prevent the transmission of higher frequencies. The vibration damper, developed by Quad Lock, shows even a stronger reduction (not shown).*

CONCLUSION

The unique confocal detection scheme of the **PICO**-SCALE *Vibrometer* makes it possible to characterize the mechanical resonances of camera units, even if these are mounted within a smartphone and behind a protective window. Such measurements enable a systematic analysis of the transfer of vibrations into the fragile focusing stages. With the development of ever smaller camera units, such tests are essential to evaluate the risks of vibration-induced mechanical failures.

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