ABOUT

This article is an update of my previous writing about vibration in camera support. It was first published on-line in January 2004 and this is the 4th major revision.

March 2005
Written by Charlie Kim

October 2007: Minor corrections and copyright information is revised.

INTRODUCTION

Even with some decades of advancement in camera technologies, stable support with tripod is the most promising way to get a sharper picture. Even with fancy control algorithms for vibration reduction, using tripod is the only practical solution that gives us freedom in photography.

True understanding is about a different manner of doing something. When you understand how much you lose by not using tripod, you may not be able to make a single shot without one.

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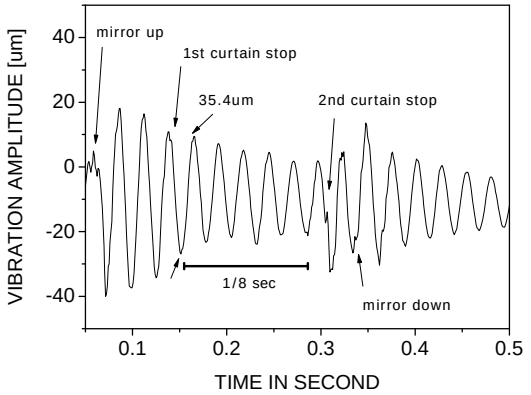
[Testing tripod-head vibration at the Markins office using Nikon D2H, laser vibrometer and data acquisition system]

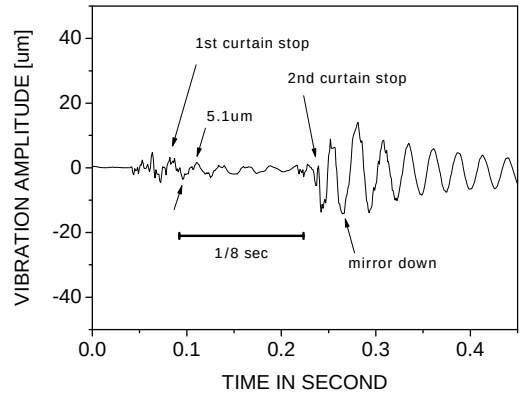
I begin this article showing two most common and well known examples of camera related vibrations. One is about MLU (Mirror Lock Up Function) and the other is about the need for a higher shutter speed.

Mirror Lock Up

Mirror and shutter are the main moving parts inside the camera. If there is no external vibration, those are the only sources of camera vibration. The vibration caused by mirror collision is quite big in most cameras.[2] Following graphs suggest how much the vibrations caused by it would be.

For this measurement Hasselblad 205FCC with standard 80mm lens was used.[3]





You can see the start and stop signs of every event. If your camera has a MLU function, there is no reason not to use it. If not, your camera should provide a really nice breaking mechanism to reduce the mirror shock. When it comes to a mirror shock issues, some cameras are good, some are bad. But it should be noted that it's

[2] John Shaw said that the camera without MLU is not a camera.

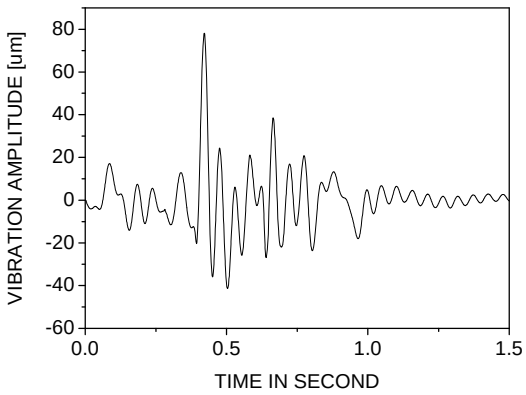
[3] It should be noted here that the signal level was big due to an improper floor-spike combination. All the vibration energy provided by mirror shock was bounced from the hard laboratory basement floor. But I still want to present this data because it shows the patterns of shock and vibration in detail. You can see the typical response of my Hasselblad 205FCC in later part of this document.

not the mirror down shock but the mirror up shock that affect the picture quality.

Everything Is Important

If you want to minimize vibration, you need to take everything into account. Virtually everything affects the picture sharpness. The performance of the whole system is determined by the weakest part. If the lens is not well built, especially the cheap standard zoom lens, the lens itself can cause a lot of vibration. Generally speaking a manual focus lens is stiffer in construction and so much stable than an auto focus lens.

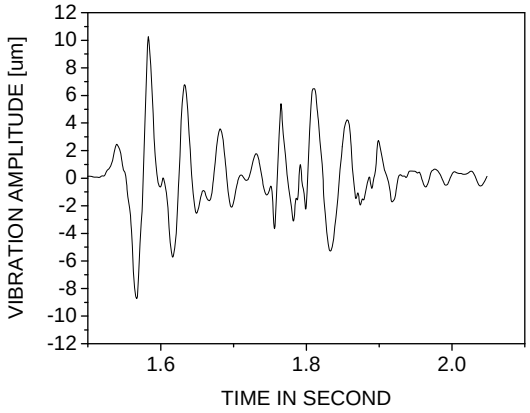
Assume that you are using a state-of-the-art Digital SLR camera and if your ball head cannot hold the camera stable, then you are going to waste your money. Assume you put your tripod on a ground thickly covered with autumn leaves. If you don't push the tripod's feet deep to the ground with spikes, then you cannot expect a stable support.



[Standard zoon lens on Sigma SD9]

Above is an example of a loosely assembled cheap zoom lens. In designing these kinds of lens, motor load has to be minimized without increasing necessary power and cost. The assembly is loose to minimize frictional load while focusing. This means that a lot of vibration inside the lens modules is inevitable.

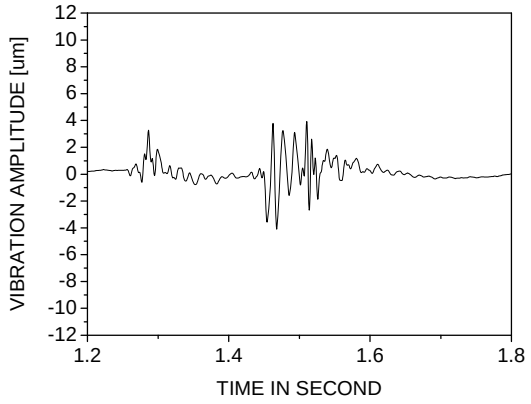
In case of a teleport lens, the quality of photo is affected more because of the larger magnification, heavier mass and longer length. VR lens by Nikon or IS lens by Canon or something like that is to minimize the vibration effect by controlling the ray trace in a fashion that is just the opposite of the lens vibration. It is quite helpful in hand-held shot. But these lenses are based on rotational vibration measurement from built-in MEMS gyro sensors, the performance would be even better if the lens is supported by a tripod. As the sensor measures rotational vibration and controls the ray based on sensing data, it can do its best when vibration occurs only in rotational direction.[4]



[Nikkor 80-400mm VR lens with Nikon F100]

Among many parameters considered for lens selection, the build quality related to vibration should also be included. And it is quite simple. Just push any positions of the lens and you can easily tell the difference. Avoid lenses that show more movement.

Nowadays the medium format camera seems to draw more attention from someone who aims for a higher resolution photo. Anyway most of the medium format camera is for professional use. It means that it guarantees a better performance in most situations. The mirror size of them is bigger but the weight of the body is enough heavy to compensate the effect so that the resulting vibration in a medium format camera is quite small and in some cases outperforms the 35mm format camera.



[Hasselblad 205FCC with standard lens]

However, from my 3 month experience with Pentax67, making a shot without the MLU function was almost impossible. For me, it was the biggest shock I've ever experienced as for the mirror shock.

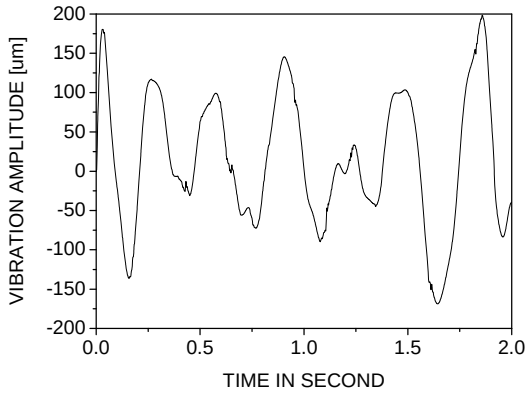
As you found here, this document contains a lot of graphs. For the people who are not accustomed with graphs or numbers, it would be better to have one number in mind as a reference. A common film scanner has a scanning resolution of 4000dpi. This can be interpreted as a minimum pixel size of 6.35 x 6.35um^2 (0.00635 x 0.00635mm^2) which is less than 10 micron in di-

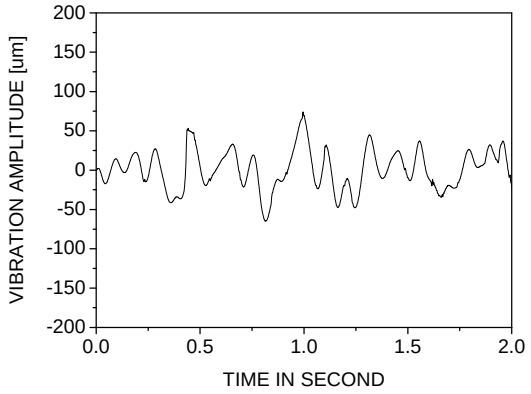
[4] You will see more data about vibration patterns in later chapters. And your vibration controlled lens system would work best if it gets a clean, nice, symmetrical pattern of vibration. By providing such environment, you give the control system a simplest set of problem.

ameter. Let this be the starting point of our argument of vibration analysis. The support system should perform at least the level of the minimum pixel size of the given camera image sensor or film resolution.

Handheld Shooting, Fast Shutter Speed

Holding a camera stable is not easy, even we want to believe that sometimes we could hold it stable. I had no idea how good one could hold. So Mr. Mah, CEO of Markins [5] and me, tried handheld shot using Leica R6.2 with Apo Macro 100mm f2.8. The first graph was my data and the other was Mr. Mah's. These are the best results from us on that day. Mr. Mah held his breath perfectly in good posture while taking the data





From above results, following argument can be drawn. Sometimes human oriented vibration is much bigger than the one caused by camera mechanism. A human oriented vibration means a shake by operator who is surprised by a sudden sound or shock by shutter and mirror.

It's widely accepted that the shutter speed, if handheld, should be faster than 1.5~2 times the angle of view of the lens, i.e., use at least 1/125s for 50mm lens and 1/250s for 180mm. By using faster shutter speed, the effect of vibration could be reduced.

Handheld Shooting, SLR vs. RF camera

I've used many RF cameras including Leica M6, black-dial IIIf and legendary Leica M3. Each of my Leica M was also equipped with the soft release [6], which really works. Even the way one presses the shutter matters when you are in the realm of RF cameras.

We normally expect a sharper picture in RF camera. But having no mirror is not the only reason. There are more dominant factors such as shorter ray travel length, tighter tolerance between assembly, less moving part, etc. The distance from front lens to the film is much shorter than SLR camera. Because RF camera uses manual focus lens, it can be built to have more tight tolerance than usual AF lens.

Some SLR cameras have bigger mirror shock and this causes an unconscious reaction. Sometimes this human oriented vibration is bigger than the actual vibrations caused by mirror. You may feel quite a strong shock in Leica R series camera but most of the shock is due to the mirror down shock that is irrelevant to photo quality.

I've used some of the Contax RTS [7] series which has no middle stages in shutter pressing action. For me, it was harder to get to know the exact timing of shutter firing compared with most mechanical shutter. However, most SLR cameras are good if they are used in handheld condition. Usually the mirror shock itself does not make much difference in handheld condition.[8]

Handheld Shooting, Vibration bracketing

So if I have to shot without tripod, I sometimes try vibration bracketing. Just like doing focus bracketing or exposure bracketing. But it's always better to get your tripod. You only have two legs, only the weird lady at the beach near Manfrotto logo has three legs.[9]

MAIN

Most of the experiments were done in well established environment, so the actual magnitude of vibrations could be greater by more than three times in the field environment. And please do not try to compare results in different environment even the systems used are identical.

Resolution or Sharpness

I have to start this journey with some talks about resolution. When we do talk about sharpness about the photo, we're also considering the contrast. But if we talk about resolution, it becomes something simply mechanical.

[5] http://www.markins.com

[6] http://rapidwinder.com/#softrelease

[7] Contax RTS I, RTS II, RTS III, RX

[8] Recent Olympus EVOLT E-300 has mirror which operates in horizontal direction. I become very curious about the feel of this kind of configuration as I guess the response of that camera will be a bit different.

[9] On page 51 of American PHOTO March/April 2005 issue

The reason I start this chapter with the word 'resolution' is simple, to set the maximum allowable level of vibration. In fact, dealing with all the physics of ray or light is beyond the level of this article. However, you are asked to accept the general idea that the light rays on film is not a point but a circular shape, i.e. donut. Erwin Puts mentioned that the minimum donut size is about 0.005mm in diameter.[10]

We are dealing with hot donuts of 0.005mm in diameter.

So we are dealing with 5um donuts, baked hot, ready to leave traces on the film or sensor. And if there are vibrations, all the sweet coverings on donuts will scatter. If you want a tasty donut, try not to vibrate the donut while moving them.

Canvas Consideration

Images of light are finally captured on film or sensor. And we enjoy the picture in various formats like print, projection, CRT monitor, LCD, etc. So what is the determining number in terms of final media of image?

We can find a good and well organized data at Norman Koran's web page.[11] Practical limit of resolution is often mentioned to be 20~25um when all the effects like film flatness, focusing accuracy and other effects are included.[12] Recent digital SLR has another problem of its own. They generate more heat which can deform the internal body structure causing thermal deformation error.

Practical maximum resolution is about 20~25um if the whole system is taken account.

According to the article on EETIMES[13] in 1999, Fuji Super CCD is known to have 4.5um pitch between pixels. And currently it is about a few microns. And with some exceptions, image sensor has multiple color channels in planar orientation. So it becomes obvious that the vibration is more dangerous in digital camera. If we regard the vibration as a sharpness killer, the 135 format digital SLR is the easiest target.

A rigid support plays an even more important role in an era of digital imaging. Especially for the digital SLR camera you should use faster shutter speed and a stable support to make your huge investment worthwhile. Even the VR, IS or AS lens[14] can perform at its best when provided with a stable support. Once you know the specifications and price of commercially available MEMS gyro sensor, you can understand the limit of these kind of vibration reduction system.

Tripod

Testing a tripod system was more complicated experiments than I first imagined. It is not simple because there are too many parameters affecting the level of vibration and these are also interconnected. It is so small to be measured by general measuring tools.

In the field, all these parameters are responsible for the final result. But to understand the nature of camera vibration, parameters have to be minimized. It took me most of the time to get to know the typical working range and error margin of various parameters.

Here some sample parameters are listed.

1. where the tripod stands
2. the method or material used on each leg's foot
3. the tripod
4. center pole or direct attachment
5. base attachment of tripod head
6. ball or 3 way head itself
7. quick shoe or bolt mount
8. fixing of camera plate and camera
9. Lens mount, shutter, mirror, body structure, body weight, etc.

Performance of the system is defined by the weakest part or the joint. If you are a long time car owner, you would understand what I mean. I can't remember the exact sentence but a copy like "90% of the Camry still on the road since first launched" which claims a quite similar situation. It means it is well balanced product with lesser or no weak point. When one is to live with something or someone for long time, having less weak points is better than having a few wonderful aspects with more weak points. At least, it is my belief in selecting or designing a product.

However, let me throw a spell to better under-

[10] See the document named 'Leica R-lenses' in official Leica homepage.
[11] http://www.normankoren.com/Tutorials/MTF7.html
[12] Robert Monaghan at Medium format club http://medfmt.8k.com/mf/limits.html
[13] http://www.eetimes.com/story/OEG19991020S0073
[14] VR (Vibration Reduction), IS (Image Stabilizer), AS (Anti Shake). Whatever the name is, they all based on miniature gyroscope sensor readout that tells how much it vibrates in rotational direction.

stand the situation. I upgraded my spell casting words from previous version.

"Locomotor mortis!" or "Petrificus Totalis!"[15]

All that's listed and shown became a single stone including the floor[16] except the camera. I think that you need this spell in very windy field. This is the ideal vibration-free camera support setup. If I remembered it right, Ansel Adams was carrying a big solid concrete block to make the support stable.[17] Precision machine tools always sit on top of the big solid epoxy granite bed.

Vibration: from where?

External: wind, wave, ground vibration, etc.

Internal: mirror shock, shutter vibration, user vibration.

Vibration: how much?

Amplitude: minimum under 3um in amplitude. Normally it can be under 20um. Even with some care, it is easy to be more than 300um.

Frequency: frequency range of the resulting vibration depends on the length and design of the camera system. Typically it ranges from 20~100Hz.

Vibration: look like what?

Rotational mode of vibration is dominant. It means that when one end of lens goes down, the film side across the tripod goes up.

Vibration: measuring equipment?

One needs to have very good and expensive setup to measure and record vibrations from the camera. I used a precision capacitive gap sensor and a laser vibrometer with an analog to digital converter board and sometimes with a spectrum analyzer.

Vibration: basics

Here is the most basic equation in vibration.[18]

$$F = m x'' + c x' + k x$$

The camera-tripod system is assembled with many parts including even the ground it stands. Every part interacts with each other. What is transferred is a dynamic energy. This energy can have different forms such as deformation, acceleration. Whatever the form is, the amount is equal. With lots of simplification, we can finally model the system with this equation.

$$F = m x'' = m a$$

$$F_{system1} = F_{system2} = F_{equivalent}$$

$$m_1 a_1 = m_2 a_2$$

So if one of the mass is big then its acceleration and the resulting vibration will be smaller.

Vibration: of which system?

The last equation is very simple. With given mirror or shutter mass, we can have smaller response when the mass of the other side of equation is big. Is using heavier camera and tripod setup the only solution? There is more.

Vibration: rigid or flexible?

The virtual setup assumed to be made of stone might be the most stable setup. Heavier tripod might be the next practical alternative. On the contrary, if your camera is suspended from a single wire, this will be the minimum mass you can get. Real world lies in between these two ideal situations.

There is a possibility of having heavier system if you can add mass effectively. You can do it by tightly and rigidly adding parts. Loose linkage along the vibration path will end this possibility.

Some of the plastic camera body and cheap AF lens are loosely assembled. It is inevitable to save battery power and keep the AF speed. Vibrations are reflected and added at these loosely assembled contacts, which makes any effort to reduce vibration useless.

More Equivalent Mass: How?

You can increase the total equivalent mass of the system by rigidly attaching each part from a filter on lens to the ground on which the tripod stands. If any part along the system fails to pro-

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[15] http://www.bellaonline.com/articles/art11045.asp http://gothlupin.tripod.com/s.html

[16] In fact, the building also vibrates but we are not going to consider that. A giant step of a heavy guy can make the floor vibrate about 5um.

[17] As I'm searching for a reference, I encountered something similar recommendation at other site. http://www.popphoto.com/idealbb/view.asp?topicID=34882 "With any 500MM lens, proper shooting technique is not optional--it's required. Sturdy tripod is Numero Uno. If possible, use a 20 ton block of solid concrete."

[18] I used " mark as a double derivatives, so x" means acceleration, x' means velocity so as not to include symbolic font in this document.

vide enough stiffness, many different vibrations occur before and after that point. Using spikes and pushing deep into the ground let the earth be included in your setup.

Use stiffer system, if you don't want additional weight. You can increase equivalent mass by using stiffer tripod and ball head.

But when the tripod stands on a hard indoor floor with hard spikes, it will not hold the ground. This differs from the case of loud speaker with spikes because such speaker has enough weight to make the contact rigid for holding the units which experience high vibration energy.

Markins Q-Ball Head

This article is not for promoting Markins products. However, as I was exploring the nature of camera vibration, I became convinced about the performance of Markins ball head. And as a mechanical designer myself, I want to share the joy of using a well design product.

With a lot of vibration experiments Markins Q-Ball head was proved to be built to have high stiffness assembled with high quality parts. It might be better to have heavier head if your tripod is heavier than usual. But the Markins M-10 shows the same top level performance in much lighter weight giving a better stability balance in most professional tripods. Putting too heavy gear on top of the light weight tripod decreases stability of the whole setup. Someone might argue that heavier head like Arca Swiss B1 gives more stability by putting down the whole setup but this is true only when the center of mass on top is in perfect position which is hardly achievable in the field.

And the durability of internal, external parts of the Markins product is just amazing. You can find more articles and opinions about the quality of Markins Q-Ball head in other websites.[19]

Studio vs. Field

In studio photography, the situation is quite different. We have plenty of chances to see the studio and it is easier to find 3 way heads than ball head in studio. We should not be misled by this scene because actual exposure time is very short in flash and studio light condition so the effect of vibration can be neglected completely.

It's Precision Measuring Equipment.

I'm in the field of micro/nano technology. What I'm doing is measuring physical parameters, especially displacement or vibration, from chattering in machine tools to MEMS/NEMS[20] resonator using STM[21].

The most worthwhile investment for a better picture is a support. What we need is a stable support for a precision system. We can find a plenty of reviews and recommendations on cameras or lens, but we can find relatively little on support system. I'd like to give information in both qualitative and quantitative manners hoping for your better understanding of situation.

DATA

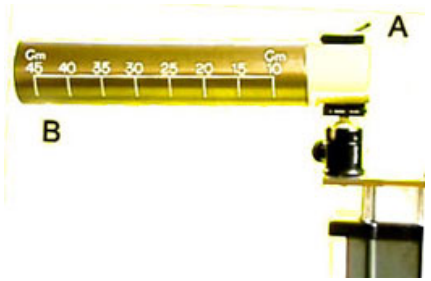
[19] Nikonians club: http://www.nikonians.org/
Dpreview: http://www.dpreview.com/
Photo.net: http://www.photo.net/
WebSiteOptimization: http://www.websiteoptimization.com/speed/tweak/ballhead/
Nature Photographic Society: http://www.naturephotosociety.org.sg/ASP/Article.asp?DBAPublishDate=7/1/2004

[20] Micro/Nano electo-mechanical system

[21] Scanning Tunneling Microscope

Simplified Test Setup

Below picture shows the simplified test setup for testing each head unit. The main reason for doing this is to give same conditions for the DUT[22]. The vibration was measured at point 'B' using a capacitive gap sensor from Lion Precision, Inc.[23] HP35670A dynamic signal analyzer was used for data saving and processing along with HP-VEE pro software.[24] With exactly the same configuration, various ball heads and 3 way heads were attached and tested. Vibration was given by firing Hasselblad 205FCC focal shutter. So as to give consistent amount of vibration, Hasselblad 205FCC body[25] was loaded on quick release at 'A' position. The shutter was fired at 1/8 second using an air release.



I'll show you the result by 3 way head which might be an old model but one of the top models from Hakuba. The exposure duration is between the front two peaks. The following vibrations are after mirror is down. What you should see in these data is the pattern and amplitude of the vibration. It will tell a general hint about the different characteristics. Mirror down shock

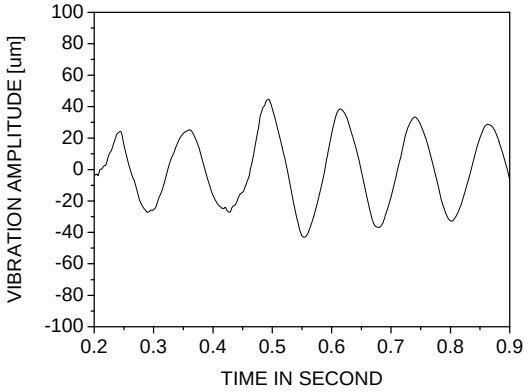
[22] device under test

[23] http://www.lionprecision.com/

[24] http://www.agilent.com

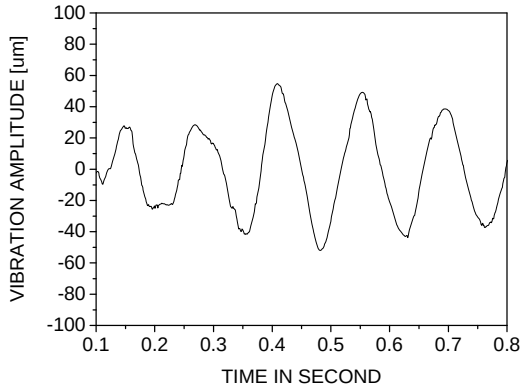
[25] One might think that it was a medium format camera, so the vibration would be greater than 135format. But the truth is that it isn't. It is superior than most 135 format camera.

was even doubled in this long-armed head.



[Hakuba 3 way]

Similar pattern was obtained for this unusual off center configuration ball head from Gitzo. While usual ball head from Gitzo will work fine, only light camera setup seems acceptable for this specific kind of head.

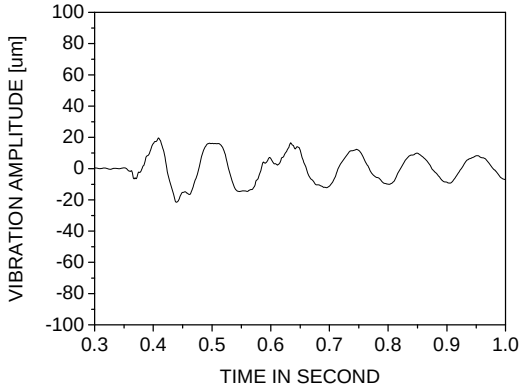


[Gitzo off center ball head]

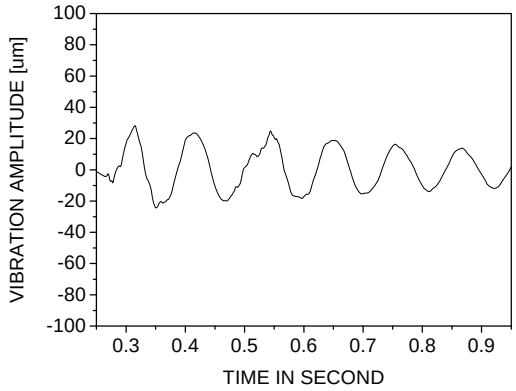
It is important to align the origin of vibration with major structure. Providing offset will work if the load on top is light and only if the vibration is coming from outside not from inside.

Available professional ball heads were tested with the same condition. All are reported to be very good from users around the world. Their performances are almost equal in practice considering individual deviation even among the same model. However there are some differences in patterns of vibration

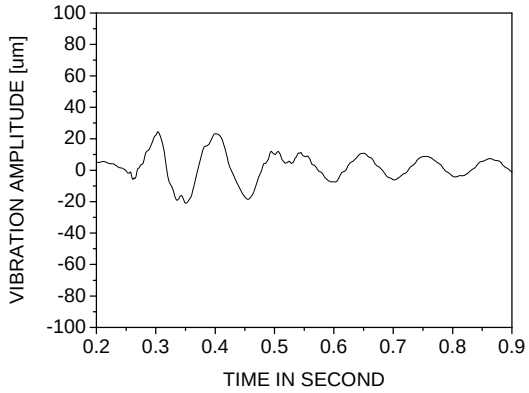
It should be noted again that experimenting with this setup was not easy. Except Markins M10 and M20, all tripod heads were sliding (rotational). The actual sliding speed was so slow that it was hard to get the feel of sliding without help of a high resolution displacement sensor. I could easily see the motion with a speed about 2~4um/sec at point 'B'. This made it difficult to release the shutter for experiments.



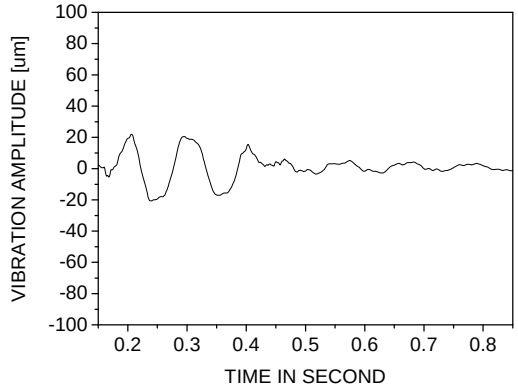
[Markins M20]



[Markins M10]



[Arca Swiss B1[26]]



[FOBA[27]]

One may get the wrong impression that the result of FOBA is the best. But remember that the mass of the M10, M20, B1 and FOBA are different, and FOBA that we used has no panning base. And what I came to know is the durability of FOBA is not that good compared with Markins or Arca Swiss. My experience of that specific FOBA ball head under test is that it was not smooth in operation. It has something close to the stick and slip feels of the cheaper ones. Recently[28] there are many new ball heads released in the

[26] CLA(clean-lubricate-adjust) by Mr. Mah
[27] Only ball head tested here having no panning function
[28] 2007

market. But the consistent performance is not an easy character to be obtained. Some may show good holding performance in fresh condition but the performance degrades very quickly.

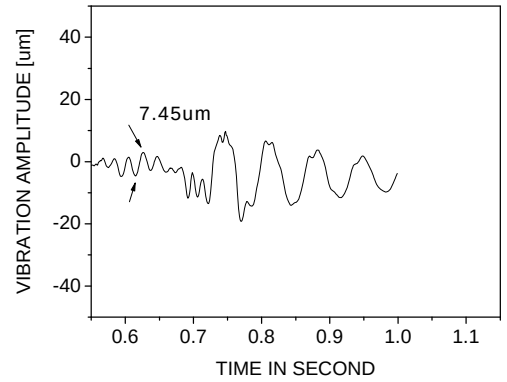
If you look into the details of the graphs, you will notice that there are big difference between Markins ball heads and others. This is due to some micro slip[29] at the contact area of the ball and its counterpart. However the Markins ball heads held the test bar firmly in any moment.

Long Teleport Lens with MLU and Self-Timer Test

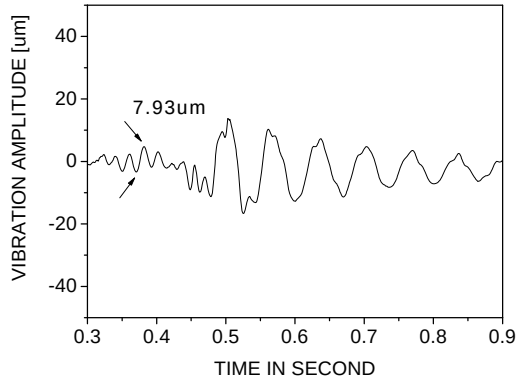
When you really want to record the image with high resolution, you should do MLU and use self-timer. Next experiments were taken using with 205FCC Hasselblad camera, 250mm f4 lens at 1/8 second after mirror was locked up.

Again I started with 3 way head. This time 3 way head performs good. There are less energy induced by mirror-up shock and it has very large holding contact surface compared with typical ball head. That means, if other situations are ideal and if the mass center of lens and camera is well balanced at the geometric center, it can perform really okay. I'll list 2 test results for each head set.

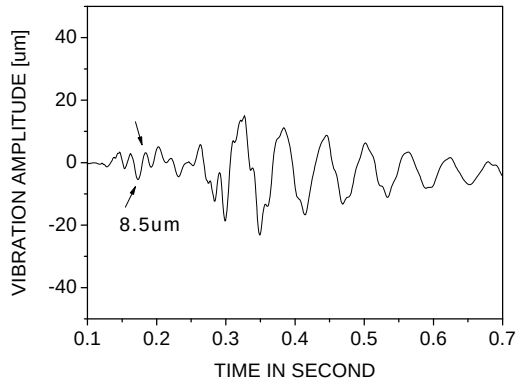
Again, these results were obtained in very ideal indoor conditions. These are probably the best result possible. If there is wind, all these differences cannot be seen. The effect of wind will dominate in image blurring.



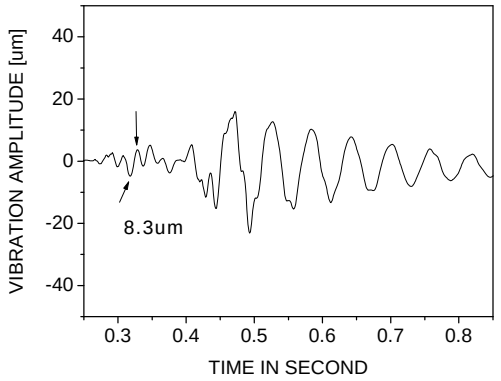
[Hakuba #1]



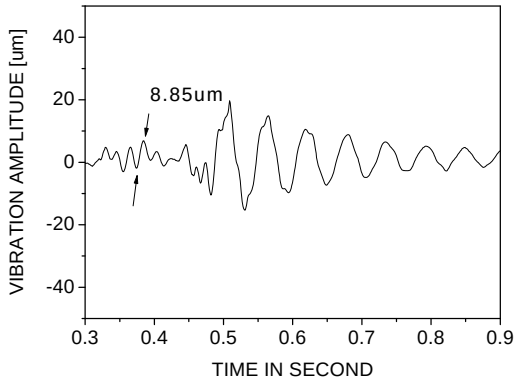
[Hakuba #2]



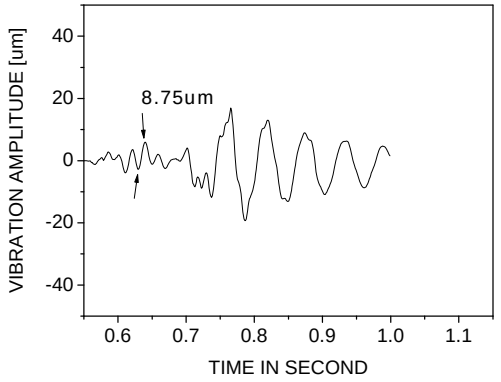
[Markins M20 #1]



[Markins M20 #2]

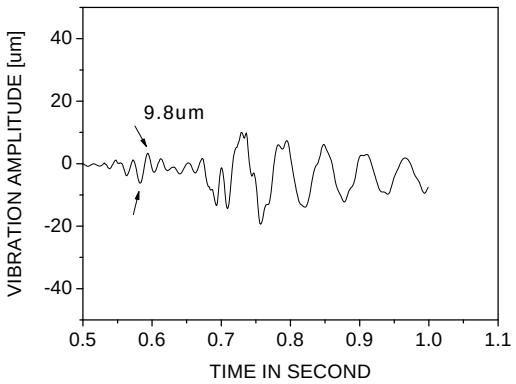


[FOBA #1]

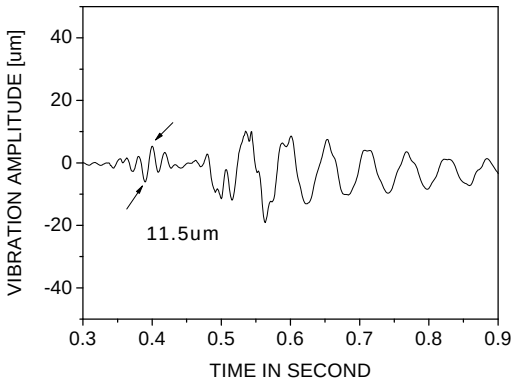


[FOBA #2]

[29] In the result of Arca Swiss B1, it looks better in dampening. But closer look of the 3rd peak reveals that it slipped a little downside. The vibration was damped by consuming a frictional energy. The following vibration decreased by frictional damping. It worked well this time, but if the impulse happens when the lens is in its lowest position, it will increase the amplitude. It depends on luck. However, Markins M20 and M10 withstand the mirror down shock and continue to vibrate in upward direction. This means that they do not slip.



[Arca Swiss B1 #1]



[Arca Swiss B1 #2]

There are so many environmental parameters that cannot be neglected. So please don't try to compare the products with this kind of not-simplified experiments. Instead, I'll give you some fun stuff using above data.

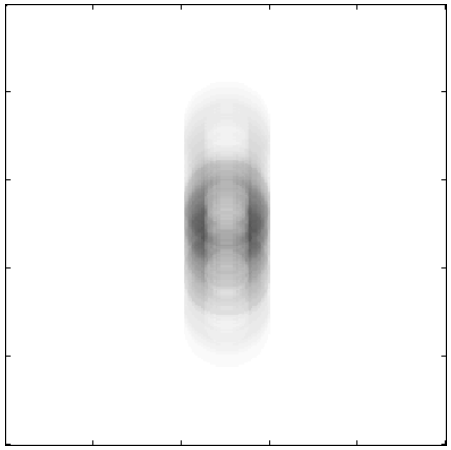
Anyway, what we can get from above data is that we should always use MLU function.

Blurred Donuts

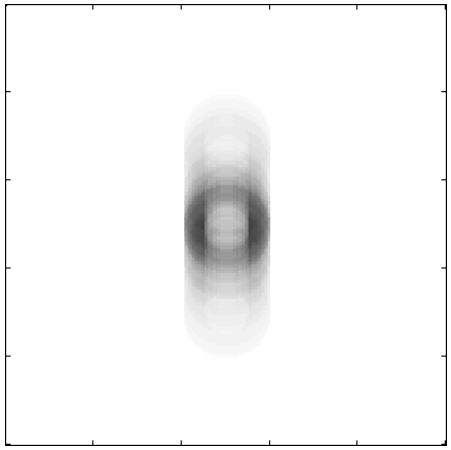
Do you remember that we are dealing with hot donuts of 0.005mm in diameter?

Motions of donuts being exposed on film is simulated for each vibration record. If there is no vibration, the resulting image will be a single black donut in maximum contrast. Because there is vibration, we have a blurred grey image of donut. It is almost impossible to get rid of the small vibration. We have to live with the blurred donuts. The only difference is the amount of blur. These are the best brushes that we have today for making photography. Narrowing your eye will help visualize the results.

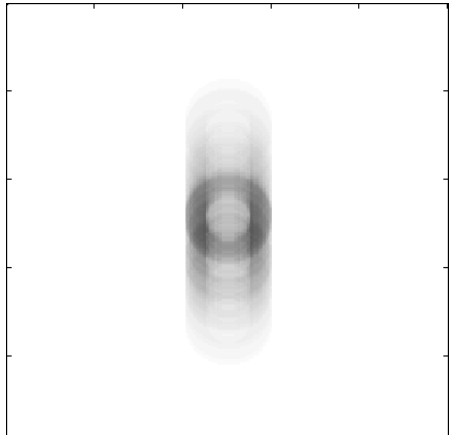
The donuts diameter was assumed to be 0.005mm and vibration signatures of previous experiments were used.



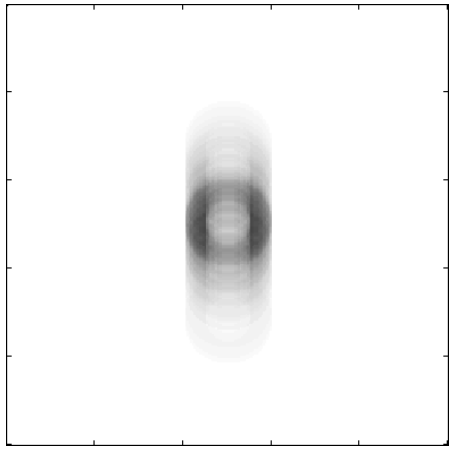
[Markins M20 #1]



[Markins M20 #2]



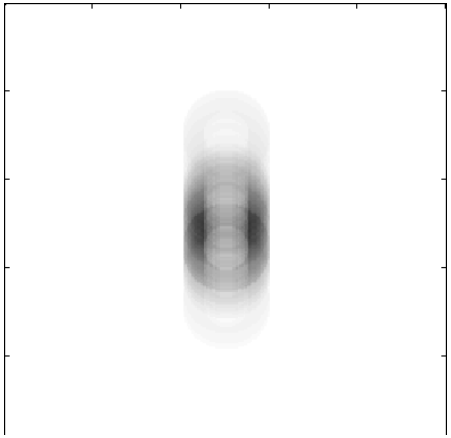
[FOBA #1]



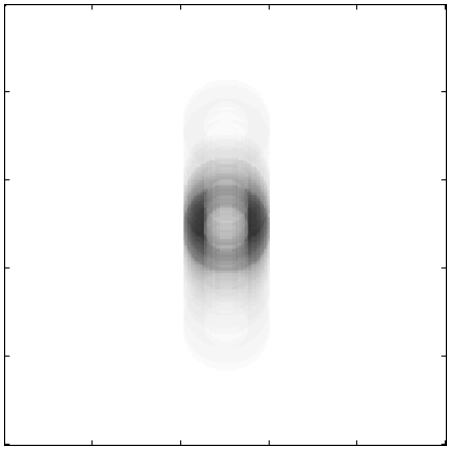
[FOBA #2]

Variations among each experiment are greater than equipment difference. This is the reason I recommend a vibration bracketing for a critical shot.

If you ever astonished by a really sharp print, then you will admit that result by assuming 0.005mm sized donuts is not an exaggeration to carry my point.



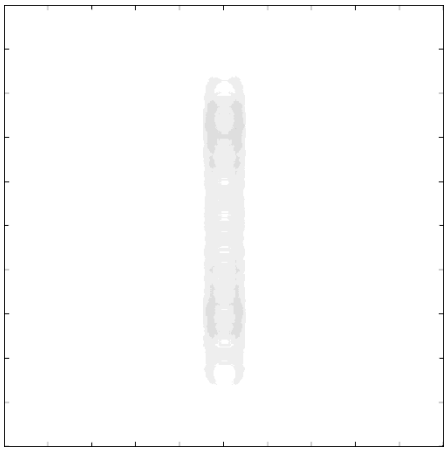
[Arca Swiss B1 #1]



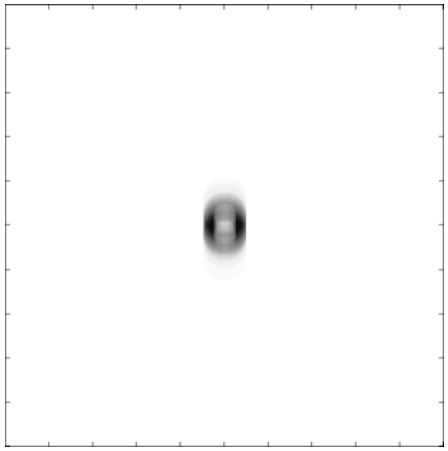
[Arca Swiss B1 #2]

After I built a simulation program with real vibration data, I became inclined to do the simulation for MLU case, too. I put the 'NO MLU/MLU' data and got following images. The vibration is not only worsening the resolution but also weakening the contrast.

As you see in the example without using MLU, all the surrounding donuts have to work together to build a visible image. So if the neighbor of one donut with red color is blue, the film will record the red donut with blue casting, resulting purple. This will pose an even more serious situation in digital image sensors.



[Without Mirror Lock Up]



[With Mirror Lock Up]

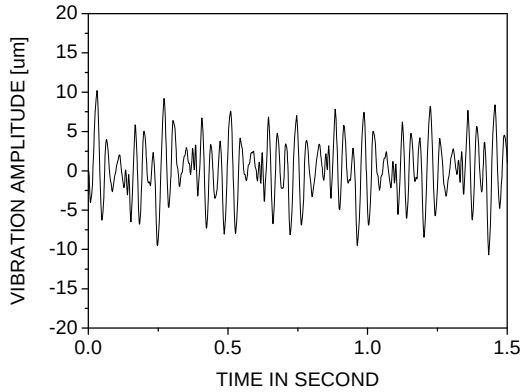
Vibration weakens the contrast a lot.

Machine Gun Test: Motor Drive

Here is another fun test. The Nikon D2H was shot continuously in two different setups. The very first photo in this article was taken while doing this experiment. The front of camera was tilted about 15 degree downward. Vibration was measured by a laser vibrometer having 0.1um/s of velocity resolution.

One setup was built with FOBA and Manfrotto (Bogen) 055 and the other with the Titan Atlas Markins M10[30] and Gitzo.[31]

Let's look at the results of Nikon D2H, the same shutter box is used in Nikon F5. Result just below is by Markins M10 setup.



Following is the result using Manfrotto 055 tripod and FOBA. I'm pretty sure that no better result could be expected with Arca Swiss B1 considering all the previous results that it shows micro slip in extreme conditions like a big load or a high frequency load.

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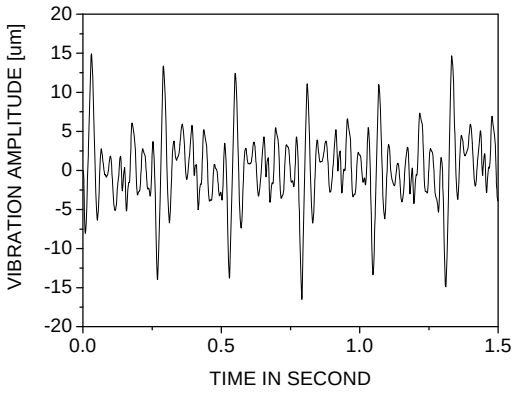
[30] Do you recognize the M10 ball head with white ball? It is the one on the test bar movie at Markins homepage that is severely tortured for years. I guess this M10 is the most unfortunate Q-Ball head ever made. Other ball heads meet great owners and share the joy of taking photography, and see the world. But this M-10 always holds the test bar, only taking cameras without film. And even sometimes, Mr. Mah hangs over the test bar to show its holding force to office visitors. So I am adding special comment for that specific M10 here.

[31] Arca Swiss B1 on Manfrotto 055 is an unbalanced setup in my opinion. Too heavy thing on weak tripod is not good. We already have Nikon D2H on it. So I didn't try that combination.

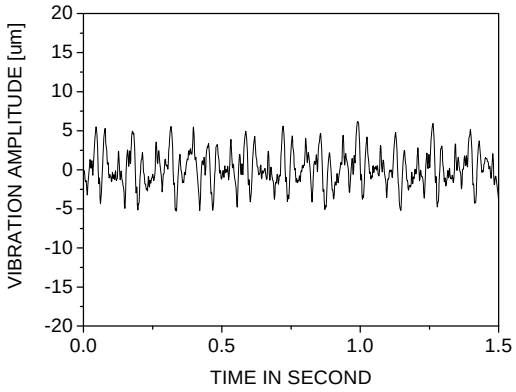


Tripod also played a role here. Tripod legs were not pulled out in both cases. So the only suspect that caused this difference is the material of each tripod. Assume you have long cylindrical rods, one in wood and the other in crystal, with same diameter and length. Now hit one end of each rod. The sound generated will be quite different. Energy propagates more easily in homogeneous material. From this ground, we can expect more dampening in carbon fiber material.

We can suspect one more reason. Because there is a gyro-force acting on the ball head caused by the motor drive FOBA tends to slip away from fixed position. It can stand static force but fails to hold its position if dynamic force such as impact is given. This is also a clue why we need very large load capacity in ball head.

You can see the very detail by zooming in this pdf document. Close examination will tell you how the slips in micro range affect the vibrations. Signal pattern in Markins M10 is very consistent while FOBA pattern contains very low frequency drift under 1Hz. This low frequency vibration is due to an insufficient holding force in presence of high frequency impact load.[32] You can also hear the sound generated by the shutter driven at full speed at Dpreview website.[33]

If you want something really sturdy, then look at the result here with the same Nikon D2H test with Markins M10 and 'Linhof Heavy Duty Two-Section Pro Tripod'.[34] The weight of tripod itself is 16.oolb (7.26kg).



[32] Assume a tightly fixed bolt or screw, to unscrew it one usually apply an impulsive load (to be specific, torque). Forcing it slowly or hitting with soft material is not enough. A high frequency impact load makes it easy to pull out the bolt. This applies exactly the opposite way in tripod ball head case.

[33] http://www.dpreview.com/reviews/nikond2h/page6.asp

[34] http://linhof.com

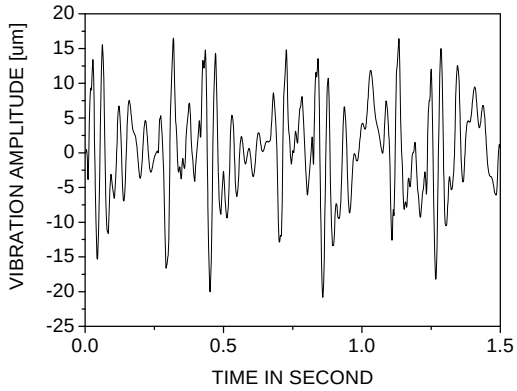
The result is also something that cannot be reached by a portable(!) tripod.

Loose Assembly: Just Not Good

Auto focus lens is convenient but not without sacrifices. You can easily locate badly designed AF lenses. For less power consumption and fast tracking speed, they give up the quality of tightness. If your lens shows a lot of playing among parts, it will never know where to put the donuts. If you want more information see the article by Robert Monaghan in Medium format library.[35]

AF lens is more apt to vibrate than MF lens.

This is an example using Sigma SD9 with standard zoom lens.

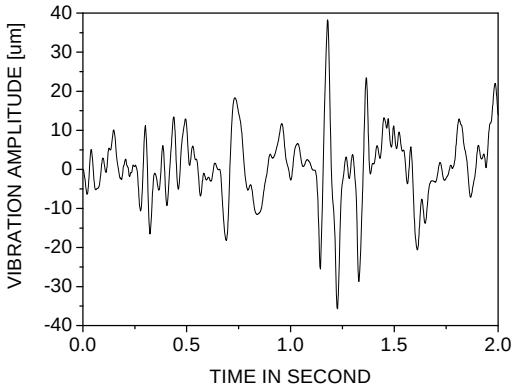


I bought this camera with the cheapest lens because of limited budget when we need a digital camera for work. I was also curious about the Foveon X3 sensor. It's true that it generates less Moire patterns[36] but it becomes worthless with a bad lens construction. It becomes like the above even with Gitzo 1227 tripod and Markins M20 ball head. Every part in zoom lens plays arbitrary colliding with nearby parts. I'm not saying that the entire lenses from Sigma are bad. The

[35] http://medfmt.8k.com/third/af.html

[36] http://www.mathematik.com/Moire/

camera system under test was so loosely assembled that it seemed just like driving an old car on an unpaved road. Top quality tripods and heads become useless. It is so easy to ruin your setup. You only need to have one minor element that is not proper. A slightly touch of your lens will result like this.



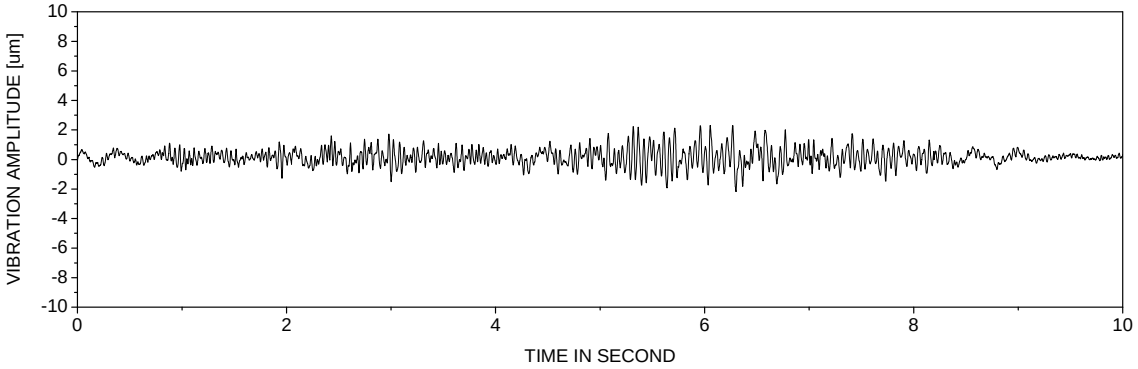
Above is another case which is not for the worst case; this is a regular situation. This signal was measured at the end of Nikon 80-400mm VR lens mounted on F100 camera. A customer who visited the Markins office willingly took part in our experiment and did operate his equipment on tripod very carefully. We can learn from this experience that we need to have a little time before actually taking shot to minimize vibrations during equipment manipulation. We can also use a self timer for the same purpose. However, it will not work if the self timer does mirror up just before the shutter release. The mirror should be at up position far before the shutter action.

Try to run 100m in 11 seconds.

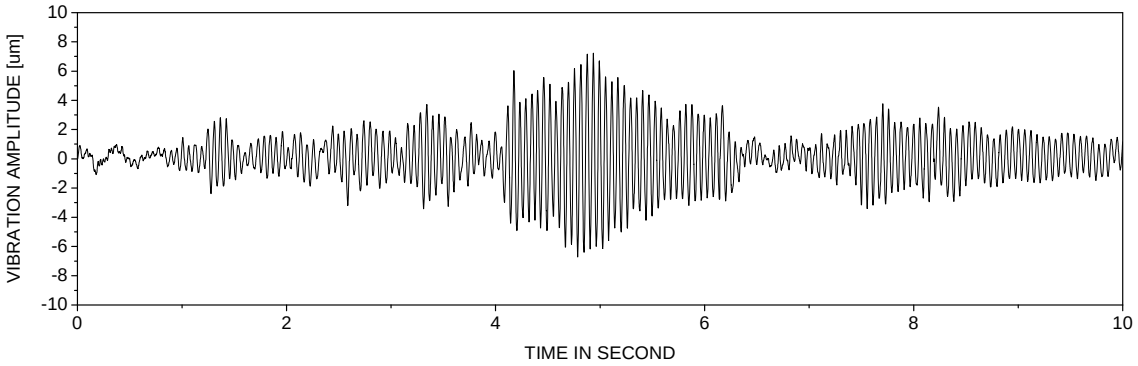
It occurred to me that a human body has so much potential that it might be possible to hold a camera very stable. If we practice, if we keep in good shape, we can hold it better than some cheap tripod. I mean something we get virtually at no cost. This is one of my conclusions. Try yourself to be a sniper if your camera has no MLU function, if you get your tripod free. There should be a situation that makes your effort worthwhile. However, don't persuade anyone that one can beat a regular tripod unless you have a third leg.

Windy Condition

Wind is often the main source of vibration in outdoor photography. A really sturdy tripod system is required. In a windy condition, the ball head is better than the 3 way head because the wind pressure would be smaller. Screw type tripod leg is better than lever type. Main structure on top also has to be designed aerodynamically.



[Gitzo 1227 1.56kg (3.03 lbs) tripod]



[Manfrotto (Bogen) 055 2.5kg (4.85 lbs) tripod]

In this setup, the direction of wind changes by the front wind guide. So the vibration amplitude was oscillating according to the wind speed and direction.

I heard much about a windy situation from Mr. Mah but I could not fully understand or agree what he said until I tested the tripod with this small fan. I couldn't believe my eyes.

Again Manfrotto 055[37] tripod and Gitzo setup with Markins M10 ball head and Nikon D2H camera were tested for comparison. At this time, only difference is the tripod. You may want to know how strong the fan can generate but I couldn't find any specifications. It is only a small desktop fan for personal use. The wind was far from being strong.

If there is no such difference, there is no reason to pay twice or three times much money on your tripod. One last comment about this test is that a Markins tripod base TB-20 was used, replacing Gitzo center column. I'm sure that this also helps a lot in reducing the wind effect.

Some other remarks

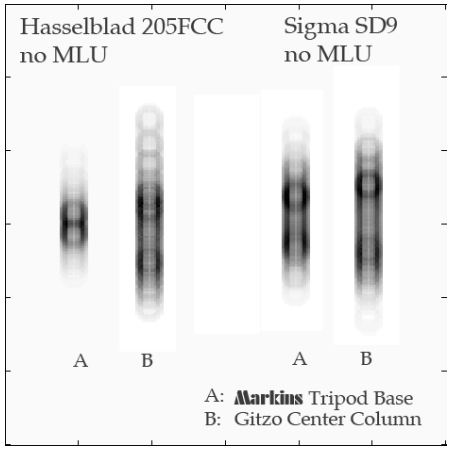
Vibration comes from so many sources. There is no simple solution.

This article is not suggesting that you must buy professional equipment to reduce the effect of vibration. Professional equipment will guarantee a higher chance of success. We don't have to pay all the prices when nobody but oneself cares about the blurred images. One can try bracketing. One can try later. But if one wants higher chances then one should learn and practice using one's equipment properly with good knowledge of it.

In the same manner, one can still be happy if one knows how much the equipment can provide. Having normal chances of success does not mean that something is impossible. But it is very important to know whether your equipment guarantees higher chances or not. So use faster shutter speed when your tripod and head are not for professionals. This kind of practice will guarantee you the similar quality of image. What I want to emphasize is that there is a difference and we need to know the difference. Finally we should think and act based upon it.

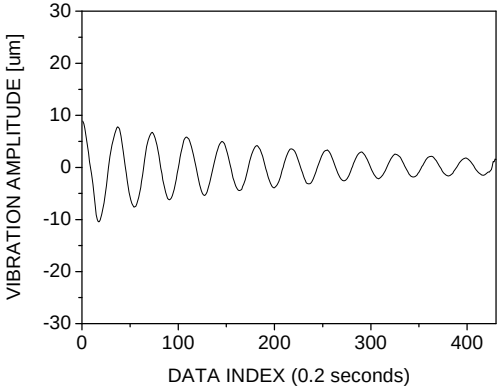
Tuning Tripod: Markins Tripod Base TB-20 and TB-30

Having too many adjusting parts is not good in terms of vibration reduction because it might be the reason for an excessive vibration. Markins recognized this and provides a simple but great solution.

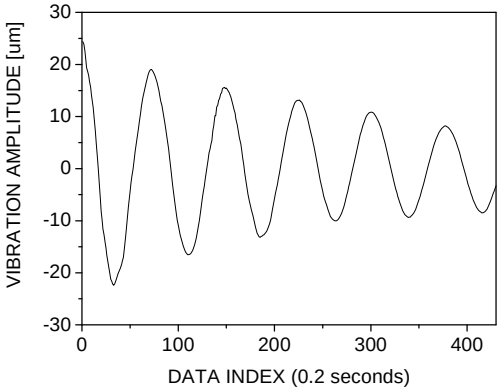


With a Markins tripod base, the vibration was decreasing more rapidly. In other word, using Markins tripod base, the camera becomes more stable than with the original center column.

You can also see that without the center column you get a higher natural frequency and a narrower envelop, which means a stiffer system.



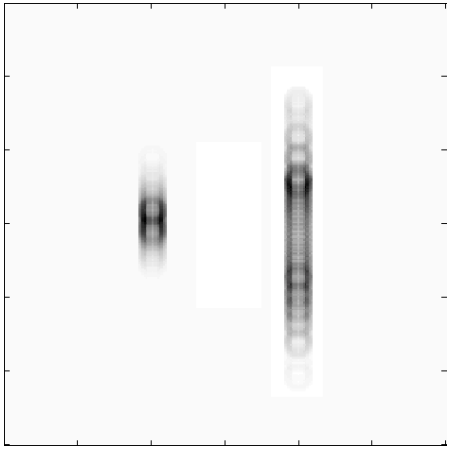
[With Markins tripod base]



[With Original center column]

[37] I have no malicious intention on Manfrotto tripod. I also used Manfrotto 190 for a long time before I upgraded to Gitzo. Manfrotto 190 or 055 are the most common tripod selections when one first considers getting one. Availability is the only reason.

Previous results are the vibrations in different setup using a Hasselblad with macro bellows. With above measured data, we can visualize the difference, again by assuming donuts of 0.005mm in diameter.

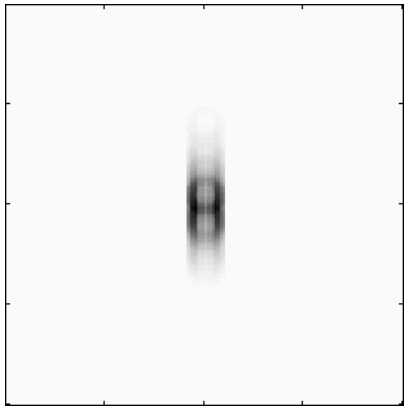


[Resulting brush size: Base vs. Column]

I've tested and compared with several cameras and lenses in different situations. And I can easily conclude that using a Markins tripod base is simply a better solution. Also to get a stable support, avoid using any soft material along the support. So avoid plate or any modules with cork, rubber on top. It will increase the amplitude and decrease damping. Soft materials will not work as a damper unless your gear is really light as in case of a point–n-shot camera.

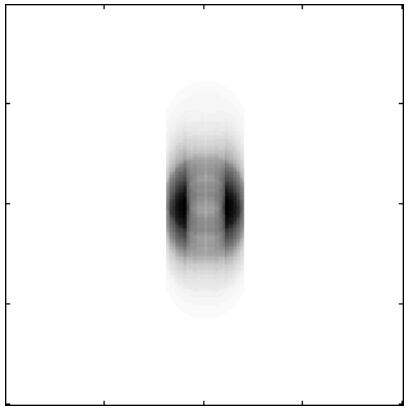
Vibration Visualization Procedure: How to draw donuts

This part is to explain the procedure to draw each donut image. The image is a simulated result with the experimentally obtained real vibration data. I assumed a donut size of 0.005mm in diameter as a basic feature. Then actual vibration trace during exposure was extracted. In next image, the total data number during exposure is 430, and the time is about 0.2 seconds. So if there is no motion, the result will be a 430 for each black pixel. Then the pixel with value of 430 will be saved as black in image file and value 0 will be saved as white.



[0.005mm donuts, same as the donuts image on the left column]

And as the aperture changes the size of donuts will also change. In next example the donuts diameter is set 0.01mm. Both are simulated with the same vibration traces.



[0.01mm donuts, same as the donuts image on the left column]

In Erwin Puts[10] document, he mentioned that "In normal conditions and at a distance of 25cm the eye can discern about 3 to 6 Lp/mm. This means we need an enlargement between 8x and 32x to see the detail in the negative."

This again means that in 20"x24" enlargement you can see the difference. And if you record your image with a very stable support, you will see the detail which you cannot see in a smaller print. A whole new world is just in front of you. It's not just about resolution; the whole things are different including contrast or color definition.

FINAL NOTE

This report can be written and posted with a great help and advice from Mr. Mah, who designed the Markins Q-Ball head series. I tried to visualize what I learned from him through his words and photos using my knowledge and background.

With a small (considering the amount we spent on lens and body upgrade) investment and effort, we can get much better pictures. And we should believe that we can make a better picture using current cameras and glasses. They can perform better if we provide them with a more stable support.

I'm a usual guy. I used and upgraded a lot of gears since I started taking photography. Until I changed my main gears to Hasselblad from Leica, I paid little attention to my tripod. Mr. Mah opened my eye with the prints having stunning sharpness and contrast. It was an astonishing experience to see some subtle details in a big print that could not be seen in film even with the best loupe.

As a general guideline, I referenced that the maximum obtainable resolution is about 20~25um. But what I encountered in so many

prints of Mr. Mah suggests that we can capture more in our film. However, I could not make similar print. His tripod is much better than mine. And I'm far behind him about the technique and the photographic eyes. But I think that the following is a more important reason: the techniques or practice of using the whole equipment like a fine musical instrument.

I'll try to convey my experience with Mr. Mah but it will be hard. Once you know the difference it brings, you cannot take a single photo without tripod. I mean a real good tripod and a head.

Spend money for a good support system is worth more than upgrading lens frequently. It is just like putting cheap OEM tires on your Porsche or Lamborghini. You cannot expect a real performance with such combinations. And you also need to learn how to drive them up to the maximum performance level.

Special Thanks to Mr. Mah at Markins

Mr. Mah's main interest is to make a good photograph. He first made his own ball head after having spent huge money on many heads and tripods available in market then. And he is an experienced and admired engineer and designer. He is also a professional photographer. And even I'd rather not follow his practice but the fact that he had used and tried almost all the top level equipment will explain the utmost quality of the Markins product.

From the beginning, Q-Ball heads are destined to be 'The Borne Supremacy.'

In 2003, I read a book about product design published at Oxford as I was giving a lecture about engineering design. The book claims that only 20 percent of the products since the Industrial Revolution were successful in fulfilling following statement.

A product has to be something that helps people.

I sometimes argued with him that he was doing over-engineering. What I mean is that he redesigns or upgrades materials without thinking about the cost. I believe that the M10 is enough for most situations but I guess he wants more. What he was doing is like an endless journey to get a perfect one. Little by little, I came to understand that he was keeping the first mind and sticking to the basic.

I believe that Mr. Mah is someone who wants to make products that can help people. This is also the reason I write this article. Better understanding of the phenomenon might help photographers use their gears in right way.

The conclusion that this document is written for is simple.

Use good tripod.
Use good ball head.
Know how much you can get.

As I'm preparing the final part of this document, I found an interesting article.[38] A long review with a title of 'Technology and Happiness: why more gadgets don't necessarily increase our well-being' attracted my eye. It's very sophisticated review, but I want to cite one of the bold lines.

Considering how many decisions about new technology are based on little evidence, it seems plausible that people can get stuck with technologies that don't make them happy but are hard to get rid of.

I think we should stop and ponder upon what the technology brings. Nowadays we have too many new products and all are changing so fast. We become hard to resist the new technologies and bigger or better numbers in specifications.

It's time to slow down, and reduce vibration.

Thanks for your interest and patience up to this last line.

[38] Technology Review, MIT, January 2005