

## **ST-4, ASCOM Pulse Guiding and PEC**

This document attempts to address some of the more commonly asked questions about guiding and the use of PEC in combination with guiding. There's no axe to grind here, no product to push etc. just an attempt to give objective explanations of the issues involved so that folks decide what autoguiding options best suit their particular requirements.

### **Is ST-4 more responsive than ASCOM Pulse guiding?**

Some instinctively believe that ST-4 guiding must deliver more responsive control than ASCOM Pulse Guiding because it is a “direct” hardware override of the mount. The reality is that if you want to consider the responsiveness of a control system you need to look at all lags present in that system. Typically an autoguiding set-up will involve:

- The capture of a star image,
- processing of that image
- Centroid calculations made to determine star movement
- Application of a control algorithm to determine corrective action
- Correction of the mount.

The greatest time lags in this set-up are related to image capture and processing by the autoguiding software. The method of initiating a correction to the mount, be it ST-4 or Pulse guiding, is not a major factor.

Also just because a mount can take a direct ST-4 input doesn't mean that it will instantly respond to that input. The firmware in the mount controller may be fully occupied in supervising motor control and those inputs may have a relatively low priority.

Equally the implementation of ASCOM Pulse guiding is driver dependent and there may be differences in the methods of implementation between different vendors.

Some folks believe that because their guide camera has an ST-4 output this makes for more responsive guiding. This would only be the case if the camera itself is performing the autoguiding algorithm. However if it is the case that the ST-4 port on the camera is simply controlled by the camera's driver and that the PC must first communicate with the camera to initiate ST-4 signals then there really is no advantage other than possibly tidier wiring.

In summary there is no reason why ST-4 guiding should offer any significant performance increase compared to ASCOM Pulse Guiding. However the implementation of both methods is highly vendor specific. For the Synta mounts using the EQASCOM driver and a PC based autoguiding program you are unlikely to not any difference in performance between ST-4 or ASCOM Pulse Guiding.

### **Is there any advantage in using PEC if I'm autoguiding?**

PEC is an open loop method of control and simply seeks to correct for repeatable mechanical error in the RA drive by “playing” a fixed correction signal. PEC is therefore predictive and seeks to correct error before it occurs. Autoguiding on the other hand is a closed loop control method that works by measuring an existing error and calculating an appropriate corrective action.

If your mount exhibits a periodic error signal that is repeatable both in period and amplitude then PEC alone could theoretically serve you very well. However in reality there are likely to be variations in the error signal perhaps due to manufacturing tolerances and the interaction of non harmonic components such that PEC alone is not sufficient for long exposure work. Also there may be non periodic errors that you wish to correct, for instance slight flexures between guide and imaging scopes. The only solution to correct for these is to adopt autoguiding. So if Autoguiding is to be adopted anyway you may well question whether there is any point in using PEC?

The “standard” answer to this is that as autoguiding can only correct errors that already exist your image is potentially “compromised” by the time an autoguiding correction is made. By using PEC you can hope to remove more of the total error before it happens.

Although this sounds a convincing argument in reality things are never that straight forward. It is usual practice for autoguiding measurements to be made at a higher resolution than that of imaging and as a result it could be that this “compromising of the image” never actually occurs as the guider errors occur at a sub pixel resolution to the imaging camera. Also in the real world there are likely to be other more significant errors present such as those caused by seeing fluctuations.

One area where using PEC+Autoguiding can give you an advantage is when using very faint guide stars that require exposures of over 1S to capture. Whilst the exposure is being made the autoguider is inactive so by using the predictive correction of PEC we can seek to keep the mount on track during this period. For many folks however this simply isn't an issue and it probably only is of benefit to those using off axis guiders where the choice of guide star is limited.

One effect you will notice if you run PEC in combination with autoguiding is that the number of autoguiding corrections required drop. This of course is to be expected. Some folks on seeing this assume that this must be “good” as the autoguider is having to “work less hard”. However, the mount is working just as hard to correct its tracking and the fact that the task is now split between PEC and Autoguiding doesn't in itself lead to better overall control.

So in summary using PEC in combination with Autoguiding does have some advantages in some specific circumstances.

- When using low resolution guiding compared to imaging
- When using faint guide stars
- Where the guiding only error exceeds the seeing conditions

It is wrong to give the impression the using PEC in combination with guiding delivers a guaranteed improvement to image quality..

### **I've heard PEC and Autoguidng fight, Is this possible?**

In theory there is no reason why this should be the case.

Running PEC and autoguiding simultaneously should deliver the best of both worlds. The PEC keeps the mount on track. The only errors observed are non periodic ones which the autoguiding makes corrections for. Many folks are successfully using PEC and autoguiding.

So where does the widely held opinion that PEC and Autoguiding fight come from? The answer lies in how ST-4 and/or Pulseguidng has actually been implemented for your particular mount – here's why:

Consider the case where PEC is doing its job and keeping the guidestar centred. To do this PEC is overriding the mounts tracking rate. The Autoguiding software however is totally unaware of any rate corrections made by PEC it assumes that the mount is tracking perfectly by itself.

Now consider what happens if a "non periodic" error occurs. The Autoguiding software sees the error and when it deems it significant will calculate a pulse duration needed to correct it. Remember this correction is being made in response to an error observed with PEC already active and potentially already making a significant correction of its own. The Autoguiding software issues its correction by setting the appropriate ST-4 signal. This is where it all goes wrong. As soon as the mount sees the ST-4 override it moves at a fixed "preset guiding rate". Any existing speed correction made by PEC is immediately lost and, because the autoguiding software has no knowledge of PEC, the ST-4 correction made will not be sufficient to hold the guide star on track. Effectively we have introduced a step change into the closed loop autoguiding system. In due course the autoguiding software should be able to recover the situation by making further corrections but now it is having to correct for periodic error as well. Eventually the guidestar is brought back on target at which point control passes back to PEC.

Now some folks make the assumption that all that is happening is that PEC is lost for a short period whilst autoguiding takes over and that having PEC operating 80% of the time must be better than not having it at all. What they fail to take into account is the level of disturbance to the control system that occurs whenever ST-4 corrections are made. This can result in a greater error than would have occurred if simply using autoguiding alone.

Although ST-4 is used in the example above the same problem could also apply to ASCOM Pulse Guiding. The key is in the implementation. In order for Guiding and PEC to operate together the guiding rate corrections must be made as relative corrections to the PEC tracking rate rather than as absolute rate overrides.

If your mount or driver cannot provide relative corrections then my advice would be that PEC is not worth while using in combination with guiding (those selling PEC applications may try to convince you otherwise, but then they wouldn't they!).

For those using the EQMOD EASCOM driver I can assure you that the Pulse Guiding implementation has been carefully designed to work alongside PEC. I would not however advise the use of PEC with ST-4 guiding for the Synta mounts.