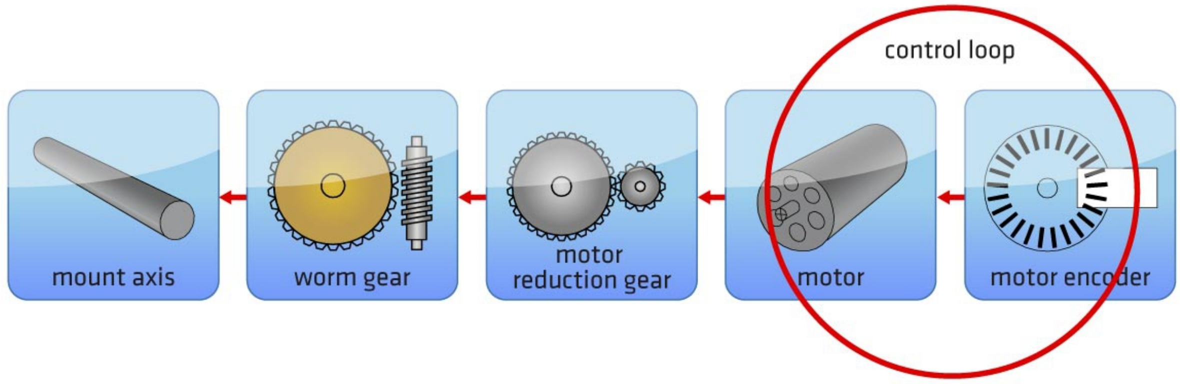
Differences between mount drives

Learn more about the technical and electronic control aspects of 10Micron mounts in relation to contemporary mount drive systems. For further reading also refer to a very indepth mount comparizon performed by a Swiss astro amateur that owned several different mountmakes and directly compares their virtues here: www.astroimages.ch

Typical 10Micron customer statement (**Bernd Hartwig**): *Finally – I´m having dinner while guiding!*

Conventional mounts with worm gear drive (10Micron QCI)



Schematic control loop rendition of 10Micron QCI mount

10Micron QCI mounts are being driven „conventionally“ by the time proven worm/worm wheel technology by means of DC-servo motors with precision motor-axis encoders and watch maker quality grade motor reducer gear case between motor and worm.

Advantage:
With slip clutches engaged, mount-axes in RA and DEC are permantly coupled onto their motors and the worm gear combo works as „natural brake“. Means: When power is off, the telescope will precisely keep it´s position - even in case of gross imbalance or power failure. Such drive systems are in use for decades and can supply excellent accuracy for very long exposure imaging with conventional autoguiders.

10Micron mounts are especially known for their exceptional mechanical workmanship and high precision drive components, featuring lapped and individually paired worm gears and ultra-precise centering of axes and worm wheels, attaining extremely small mechanical errors of +/- 4 arc seconds at maximum. Combined with proprietary motor control electronics imbedded into the onboard Linux-system computer, the maximum periodic error is reduced to +/- 1,5 arc seconds. This value is well below the treshhold of average seeing conditions. A well polar aligned 10Micron QCI mount therefore regularly enables up to 10 minutes of unguided imaging at <1000mm fl´s or several minutes with longer fl´s.

Alike other worm driven mount-systems, 10Micron QCI mounts especially feature quick and easy polar alignment routines which allow speedy set-up ideally suited for a portable mount system. Built in intelligence - supplied by the industrial Linux-computer is the crucial feature here. This mount knows it´s a mount!

Disadvantage:
When aiming at guiding intervalls above 10 minutes even a 10Micron QCI mount will inevitably require assistance of an autoguider system. At the same time the „drive train“(consisting of: worm drive/motor encoder/reducer gear) will create a mechanical „base noise“ that causes minute drive variations of +/- 0.5 arc seconds (measured for 10Micron mounts). For lower priced mounts, having mediocre gear systems, this mechanical „noise“ may easily be 10 times larger – to be called an erratic behaviour.

Another common problem known to plague all worm driven mount systems „more or less“ is called „static friction“. Very small guiding correction impulses may remain left unnoticed until the drive train has built up enough torque to cause a sudden „jump“ (an arc second-sized correction overshoot). This is caused by mechanical friction building up in all drive components once they come to rest for a short moment.

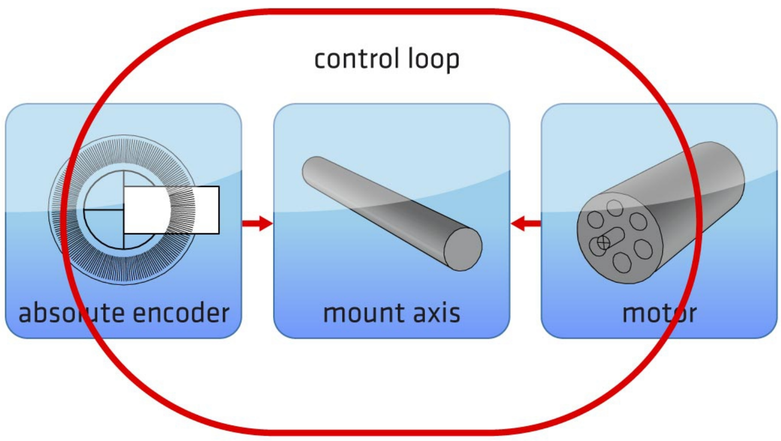
In all 10Micron mounts this physical stiction effect is compensated almost completely by an ingenuous motor control in the firmware, built into the onboard Linux computer.

Customer quote **Mario Weigand**, owner of a GM2000 QCI
(see results at www.Skytrip.de):

After having stopped my car, it takes me 35 minutes with my 10Micron mount to start serious imaging – including setting up my autoguider.

Note on autoguiding:
In recent years autoguiding has lost a lot of it´s former hardships – due to the advancement of stand alone autoguiders, highly sensitive CMOS-chips, rugged Off-Axis guider bodies and always more advanced software. Recent standalone systems won´t require external computerized support, enabling ultraprecise guiding of classical astronomical objects with very little effort. Autoguider setup, calibration and starting sequence (hard & soft) can be a matter of minutes. This control loop now offers a simple and reliable solution for a complex problem and is well apt to replace true on axis absolute encoders with their extremely high prices per unit. With the only downside not being applicable on fast moving objects like comets, satellites or for highend echelle spectroscopy.

Direct Drive mounts with high-precision encoders



Schematic diagram of the control circuit of a direct drive mount

Such mount systems are recently being made available to amateurs by several manufacturers. There is no clutch, no worm nor worm wheel, no reduction gear case and no motor encoder present. The mount axis itself becomes the engine. All movements of the mount, being it high speed positioning or tiniest guiding correction movements are effected only via the highly complex electronic manipulation of the motor magnetic field. This degree of control is only made possible by adding two ultra-precise absolute encoders directly onto the RA and DEC axis.

Advantage:
This mount design produces the smoothest tracking curves and the smallest errors (close to zero-arc seconds) – once the mount has been painstakingly setup and polar aligned.

Once achieved, such a mount offers long exposure times and extreme guiding accuracy without autoguiders even with long focal lengths.

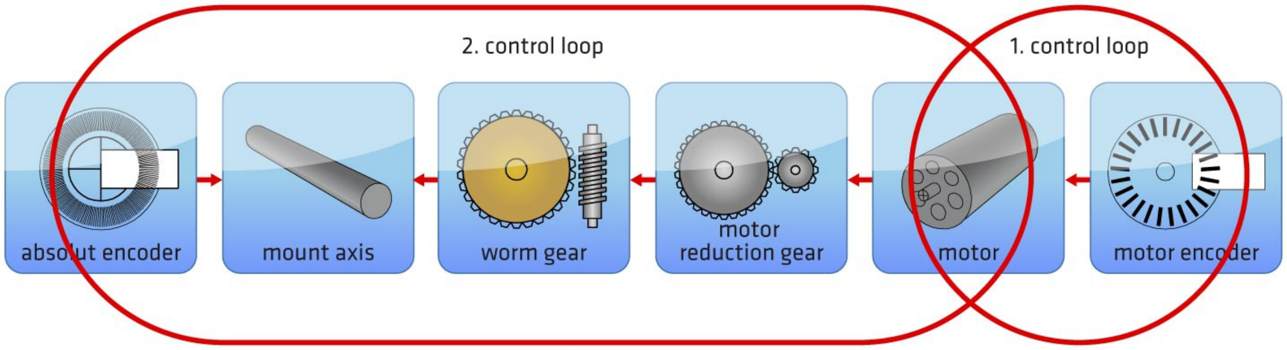
Disadvantages:
Precise parameterization is time consuming and demanding – particularly with portable mount systems. Correct setting of motor parameters and the finalization of a suitably precise pointing/guiding model requires at minimum 1.5 hours of concentrated labor with a portable mount in the field – according to various internet reports of highly knowledgeable users. Thus - during mobile operation - a multiple of precious imaging time is lost, compared to a mount simply controlled by an autoguider device. Each smallest change of instrumentation or change of backend accessories or cameras will make the parameterized pointing model obsolete and require to again define the pointing parameters. Slightest imbalance may cause the mount to stall (and become undone) because the complex changes in torque become impossible to be equalized only with software, manipulating the motor coils magnetic fields.

Any power off (voluntary or accidental) will abruptly subject the telescope to follow the forces of gravity - in the very moment when the locking magnetic field dissolves.
For these reasons all telescope components as well as the entire payload must be balanced with extreme care (in all pointing directions) in order to avoid accidental damage.

Unlike a relatively simple, self-locking worm driven mount, the motor management of an all purely magnetic manipulated direct drive mounts requires an extreme accumulation of algorithms – and inevitably a separate PC or laptop computer. This leads to the core of the problem.:
The typical direct drive mount presently offered to amateurs „doesn´t know it´s a mount“...
Tripping over the USB-cable will render the mount to keep on running into the ground entirely decapitated (not discussing the usefulness of USB-connections outdoors).

The entire behaviour rather resembles an admirable primadonna ballerina, demanding unimpaired love and attention – while the user only had demanded a faithful workhorse.

The golden middle – a conventional worm driven mount – but with direct absolute encoders precisely matched onto RA and DEC axis



Schematic drawing of the control loops of a 10Micron HPS mount

10Micron HPS (High Precision and Speed) mounts feature the same mechanics as 10Micron QCI mounts. In addition to common „servo-drive“ motor encoders, two ultrahigh precision so called „Absolute“ encoders are permanently mounted onto RA and DEC-axes.

Each of these electronic control devices is carefully factory matched and calibrated for each mount axis, to ultra-precisely divide one 360° rotation into more than 10 million increments. Such encoders cannot be added onto an axis at later date because the truely individual calibration process requires the comparative presence of an encoder of even higher accuracy, to permanently inprint that very encoder/axis electronic rotation model into the onboard Linux computer (each encoder/axis electronic model of each mount delivered will remain stored at the factory).

Given this amount of care the classic worm driven mount in important aspects attains the same properties as the direct drive mount.

Advantage:
This drive control loop combines the virtues of a conventional mount (self-locking mechanics, tolerance against gross imbalance, easy change of accessories, fast set-up, handling simplicity) with the ability of long duration, highly accurate tracking without guiding. The classic mount becomes apt for advanced high speed satellite tracking applications, for differential tracking of asteroide trajectories, for precisely locking a star onto the slit of a high resolution spectrograph.

Any error arising along the drive train between motor and absolute encoder is being recognized and instantly remedied. For instance: errors caused by inevitable mechanical inaccuracies; errors caused by non-erratic flexure of the instrumentation; temperature related changes in responsiveness; the influence of atmospheric refraction in relation to temperature; humidity and air pressure – all these sources of erroneous behaviour are cancelled out by the various compensation models permanently stored in the mounts onboard memory.

In addition: the mount always knows it´s position – even after power off. Even when the mount is being pushed accidentally by hand during guiding, the mount will return to the required position with „absolute“ precision. Other external influences (for instance wind gusts) are being reliably compensated – even during high speed satellite tracking.
This combination of control systems works unbeatably robust and „invisible“ in the

background. The HPS-mount does not require any additional user input compared to a regular QCI mount and it offers exactly the same ease of use.
And in addition – it can be operated for effortless indefinite duration guiding sequences in conjunction with any astroguider -just like any 10Micron QCI-mount.

Customer quote **Rolf Geissinger**, owner of a GM2000 HPS mount
(see results at: www.stern-fan.de)

„... the difference simply is that one can take a 10Micron HPS mount anywhere and can get it going while only caring about the essentials. That is – I do not have a place for a permanent set-up of my mount. Just I have my tripod standing on my balcony and I do use my mount with various telescope configurations according to the object I want to frame. From the decision to go outside and start imaging until the actual initialization of the CCD-camera it takes me 15 to 20 minutes. This time frame also includes to put the mount outside, initialize, polar align, run electronic balancing, select the suitable one of various mount models stored in the mount´s memory, install the camera, look after all cabling, start up the software and care about precise focus. In a wink - I can manage to collect photons for 2 or 3 hours and go to work next morning after a good nights´ sleep.“

Disadvantage:
Residual „mechanical noise“ (as detailed initially) is being reduced to +/-0.25 arc seconds by the HPS-technology. However this tiny amount of hysteresis „noise“ cannot be reduced to zero – in spite of the absolute encoder accuracy.
However – in reality - an „error“ of +/-0.25 arcseconds does not matter:
This size of amplitude remains completely meaningless – even during very long exposures – even during a satellite tracking sequence, since atmospheric „seeing“ conditions always will have a markedly larger influence.