The basic autopilot uses an enhanced PID filter to form a feedback loop. Various gains can be adjusted to improve performance and vary depending on the boat, seastate, and rudder drive motor

The gains are as follows:

1. P - proportional - heading error
2. I - integral - based on the accumulated error
3. D - derivative - rate of turn
4. DD - derivative' - rate of rate of turn
5. PR - proportional root - square root of heading error
6. R - reactive gain - reverse of command delayed
7. FF - feed forward - change in heading command

It is recommended to use the opencpn plugin, or openplotter control for tuning the gains because visual feedback is provided.

To get started retuning from scratch (or on a new boat) set all of the gains to zero, except the P and D gains. It is possible to have a fully usable (but less efficient) autopilot using only these two gains.

Set the P gain to a low value (say .003) and the D gain to .01. Typically on larger boats, you will need higher values, but it really depends on how fast the drive motor turns the rudder.

The hard over time is how long it takes to turn the rudder from end stop to end stop. This is typically 30 degrees for each side. If a smaller motor is geared down more, and takes, say 16 seconds, then these gains should be doubled to P=.006 and D = .02 as a starting point.

If the boat takes too long to correct the course and spends a long time to one side of the correct heading, increase these two gains. If the motor is working too hard, and frequently crosses the correct heading, decrease these gains.

P - proportional gain This value should normally be set low. If it is set too high, the boat will constantly turn across the desired heading. If it is too low, the boat may fail to maintain course. As it is increased a higher D gain is needed to compensate (prevent overshoot)

D - derivative gain This is the gyro gain, and the main driving gain of the autopilot. Most of the corrections should be as a result of this gain. Once the best value is found it can typically work in a range of conditions, however, in light air, it can be reduced (along with reducing other gains) to significantly reduce power consumption especially if the boat is well balanced.

PR - proportional root gain This gain can be really useful preventing oscillation especially upwind. To use it, increase it until it takes effect, and gradually back off on the P gain. You will still need some P gain, but it may be less than half of before if a sufficient PR gain is used.

DD - derivative' gain This gain is useful to improve reaction time. It can allow for corrections sooner than they would occur from the D gain alone. To use it, gradually increase this value up to 1.5x the D gain value without changing other gains, and compare the results.

FF - feed forward gain This gain is only useful when making course changes. For holding heading it has no effect. Following a route can cause course changes. It can be very useful in improving the

response time since a low P value is normally desirable, this gain is the main contributor when the course is adjusted.

I - integral gain This gain does not need to be used to hold a course, however it can compensate if the actual course held is different from the commanded course. If following routes, and the boat tends to follow along a line parallel to the route, this will compensate for that error. It is best to start at zero, and very carefully increase it until the results are improved. If the value is too high, it will simply increase power consumption.

D2 - derivative squared gain This gain is not very well proven, but the intention is to compensate for large yaw rates from wave action. Typically set it to zero unless you want to experiment.

Hints:

upwind - less D gain, more P (or PR) gain downwind - more D gain, and possibly add DD gain light wind - less gains - save power strong wind - more gains - needed to operate correctly

For sailing in protected waters, steering a less straight course is a tuning error, and will only increase power consumption.

If you can tolerate less straight steering it may save power in waves. Generally you just want to keep the sails pulling, and the average course that you desire. This was always the goal with a wind vane anyway, and can save power consumption as well as wear on the autopilot drive motor.