TradHeli Autotune V2

BACKGROUND

The autotune for tradheli is completely different from multicopter autotune. In this version of tradheli autotune, it can tune any combination of feedforward, the rate gains (Rate P and Rate D), or Angle P gain. The tuning for rate gains was added in this version and consists of finding the maximum allowable value for the rate gains and then tuning them. Knowing the maximum value enables the autotune feature to keep from creating an instability.

Test Descriptions

The first test is the feedforward test. The maneuver for this test is a single oscillation. For example in the roll axis, the aircraft will bank 20 deg in one direction and then roll the aircraft at 50 deg/s to 20 deg in the opposite direction and then return to wings level. The first time it will calculate a VFF gain from the maneuver. Following attempts will determine whether the gain was correct and make minor adjustments to the VFF gain until it determines the aircraft response meets the desired criteria (50 deg/s +/- 2%). During this test, if you move the controls away from center, then the autotune will stop and wait for you to return the controls back to center for ½ seconds before the autotune resumes.

The Rate P and Rate D tests are combined. First though, the maximum allowable gain is determined to ensure that the Rate P and Rate D gains are not raised to a point of instability. This is done by first conducting a frequency sweep with rate P and rate D gains set to zero to determine the approximate frequency for phase of 180 deg and 270 deg. Then dwells are conducted to accurately determine the response gains at a phase of 161 and 251 from which the maximum allowable rate P and rate D gains are determined. Next a frequency sweep is conducted to identify the response gain at a phase of 161 deg. Rate D gain is raised until the response gain no longer decreases. Then the rate P gain is raised until the response gain achieves the gain given by the parameter (AUTOTUNE_MAX_GN).

The angle P test has changed slightly. Initially a sweep from the min sweep frequency to the max sweep frequency is conducted to determine the approximate frequency for the maximum response. Then constant frequency oscillations are conducted to determine the frequency of maximum response. This maneuver is an oscillation at a constant amplitude for 10 cycles. For the first 5 cycles, it is waiting for the oscillation to stabilize at a constant amplitude. The amplitude is then measured during the last 5 cycles. It then determines the response gain (output amplitude divided by input amplitude) and the phase between the output and input oscillations. It is looking for the

frequency which causes the maximum response gain by starting with the approximate frequency found during the sweep and then using dwells to more accurately determine it. Then it will increase angle P by 0.5 increments until the response gain is greater than AUTOTUNE_MAX_GN parameter. It will then stop and interpolate to find the Angle P value that gives a response gain of AUTOTUNE_MAX_GN. During this test, you can make inputs to the pitch and roll axes to keep the aircraft from drifting. The inputs are limited to +/- 5 deg. If you go beyond these limits, you will notice that the aircraft will stop oscillating. At that point, you will have to center the stick and wait for the autotune to resume before you can make inputs again. I have found with the new default ANGLE_MAX parameter of 30 deg vice 45 deg that it takes a bit more stick input to stop the oscillations and cause it to reposition.

INITIAL PREPARATION

PLEASE CHECK YOUR AUTOTUNE PARAMETERS

The version adds parameters and may change autotune parameters on upgrade. Please verify all autotune parameters are correct

Control Signal Noise

Prior to starting the autotune, you will want to make sure that you have reduced the noise in the control signals as low as possible. The best way to do this is to use the harmonic notch filter. The recommended settings are below. Initially you will set INS_HNTCH_ENABLE to 1. Then reload the parameters to see the options for the harmonic notch.

For those that don't have an RPM sensor, use these settings
HNTCH_MODE - 1
HNTCH_REF - 1
HNTCH_FREQ - rotor speed in Hz
HNTCH_BW - 10
HNTCH_HMNCS - 11 (for two bladed rotor system)
HNTCH_ATT - 30

For those with a RPM sensor, it will need to be set to use RPM 1. Use the following settings
HNTCH_MODE - 2
HNTCH_REF - 1
HNTCH_FREQ - ½ the rotor speed in Hz
HNTCH_BW - 10
HNTCH_HMNCS - 11 (for two bladed rotor system)
HNTCH_ATT - 30

The best way to see if the harmonic notch is working to reduce the noise in the control signals is to look at the RATE.Pout, RATE.Rout and RATE.Yout signals in the log.

Logging
Next add FAST ATTITUDE and PID to the LOG_BITMASK in addition to the default logging selections.

SETUP FOR AUTOTUNING
PLEASE CHECK YOUR AUTOTUNE PARAMETERS
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Autotune Setup
I have changed the autotune settings. I have removed the Multicopter only settings and added a few new Heli specific settings.

AUTOTUNE_AXES
I ask that you test one axis at a time and provide separate log files for each axis. The AUTOTUNE_AXES parameter has the same values as the multicopter parameter in the copter wiki.
Roll axis - 1
Pitch axis - 2
Yaw axis – 4
I suggest you tune the pitch axis before tuning the roll axis. You can tune the yaw axis at any point.

AUTOTUNE_SEQ
This parameter lets you select what tests you want to perform. It is a bitmask so you will have to add up the values for the tests you want it to perform
Feedforward test – 1
Max Gain, Rate D and Rate P - 2
Angle P - 4
I would suggest doing one at a time for a given axis. You might be able to combine the Feedforwad with the Max Gain, Rate D and Rate P test but you will probably be out of battery by the end.

AUTOTUNE_MIN_FRQ and AUTOTUNE_MAX_FRQ
These are the starting frequency in radians (MIN_FRQ) and the ending frequency in radians (MAX_FRQ) for the frequency sweep used for all tests except the VFF test.

For 600-800 size heli's you will not need to change the MIN_FRQ and MAX_FRQ parameters. For 450 size heli's and smaller, I recommend you increase the MAX_FRQ to 120.

AUTOTUNE_MAX_GN
This is the maximum response gain you want to use for tuning RAT_P, RAT_D and ANG_P. This isn't the limit for the RAT_P, RAT_D and ANG_P gains themselves but the limit for the Output/Input of the response to tell the autotune when to stop increasing the RAT_P or Ang_P gain. I recommend the following
Pitch/Roll
Max Gain/RAT_D/RAT_D tests 1.4
ANG_P 2.0

Yaw
Max Gain/RAT_D/RAT_D tests 1.1
ANG_P 1.4

Transmitter setup
Be sure to put the Autotune flight mode as one of the flight modes on your transmitter flight mode switch. You don't want to be reaching for the GCS to switch out of the autotune if your heli is not behaving properly. You want to be able to switch modes instantly.

Attitude Controller Setup
For the first autotune, set your attitude control parameters to the defaults
ATC_ACCEL_P_MAX 110000
ATC_ACCEL_R_MAX 110000
ATC_ACCEL_Y_MAX 27000
ATC_ANG_RLL_P 4.5
ATC_ANG_PIT_P 4.5
ATC_ANG_YAW_P 4.5
ATC_INPUT_TC 0.15
ATC_RAT_RLL_P 0
ATC_RAT_RLL_D 0
ATC_RAT_RLL_VFF 0.15
ATC_RAT_RLL_I 0.1
ATC_RAT_RLL_ILMI 0.08

ATC_RAT_PIT_P 0
ATC_RAT_PIT_D 0
ATC_RAT_PIT_VFF 0.15
ATC_RAT_PIT_I 0.1
ATC_RAT_PIT_ILMI 0.08

ATC_RAT_YAW_P value you determined that doesn't cause instability
ATC_RAT_YAW_D value you determined that doesn't cause instability
ATC_RAT_YAW_VFF 0.0
ATC_RAT_YAW_I 0.05
ATC_RAT_YAW_ILMI 0.08
*********Do NOT fly yaw axis with the ATC_RAT_YAW_P gain set to zero**********

Attitude Controller Filter Setup

As far as the attitude controller filters, I recommend making them as large as you can and in some cases disable them by setting them to zero. These really depend on how clean the control signals are after the harmonic notch filter. Below are my recommendations.

ATC_RAT_RLL_FLTD 0
ATC_RAT_RLL_FLTE 0
ATC_RAT_RLL_FLTT 20

ATC_RAT_PIT_FLTD 0
ATC_RAT_PIT_FLTE 0
ATC_RAT_PIT_FLTT 20

ATC_RAT_YAW_FLTD 0
ATC_RAT_YAW_FLTE 0
ATC_RAT_YAW_FLTT 20

AUTOTUNE FLIGHTS

Safety

The safety of you and your vehicle is important to me. Please conduct your test flights in an open area (50m x 50m) with no one else in the vicinity. Don't let the vehicle get too close to you while it is tuning. Be prepared to take control at any time. Remember that you can make inputs (a little bigger inputs when it is oscilllating) to stop the autotune maneuver and reposition the aircraft. If the aircraft loses control or not behaving as expect, just switch the flight mode out of autotune to resume control.

Procedures

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Be sure to test on a low wind day. PLEASE restart (cycle power) to your controller before autotune for each axis. It will be nice to only have one log per axis

- Power up the controller
- Set the flight mode to either stabilize or AltHold (Althold recommended)
- Enable motor interlock and allow rotors to complete runup
- Lift off and establish stable hover approximately 3-5 meters above the ground
- Switch into Autotune and center all sticks
- Autotune will start conducting the maneuvers (if you don't see anything happening then your sticks are not centered)
- VFF Tuning:
    - During VFF tuning the aircraft may drift, reposition the aircraft as needed to keep it from drifting. Making any inputs during this test will stop the tuning and won't begin again unless the sticks are centered.
- Max Gain, Rate D and Rate P
    - During this tuning, you can't make any inputs to hold position during the tuning. If you make any inputs, then it will stop the tuning and wait until you center the sticks before it begins again. The aircraft will drift some but shouldn't drift too far (< 50 m). The sweeps are 23 seconds.
- Angle P Tuning:
    - During Angle P tuning, you may make small inputs in the pitch and roll axes only to keep the aircraft from drifting while it is oscillating. Try to just bias the stick in one direction (slow inputs) to keep the aircraft from drifting. Don't make inputs to counter the oscillations.

- After the tuning is complete, a message will appear in the GCS saying Autotune complete
- To test the settings, switch out of autotune and then back into autotune and you will be able to test the settings that were tuned.
- Once you are finished, descend and land in AutoTune. Once the aircraft has landed, the engine will shutdown on its own. At that point flip your motor interlock switch to disabled and disarm the aircraft. You have to keep the aircraft

in the autotune flight mode when you disarm for it to save the settings which is what I want you to do.

- Power down the flight controller
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POSTFLIGHT

Provide the following information with a link to your logs
Heli Size (i.e. 450, 600, 700…)
Number of main rotor blades
Main Rotor Diameter in feet or meters, just specify
Tail Rotor Diameter (ft or m)
Takeoff Weight in lbs or kg, again specify units
Rotor Speed (RPM)