Close Encounters

The Throttle Jockey – an intelligent low cost engine governor

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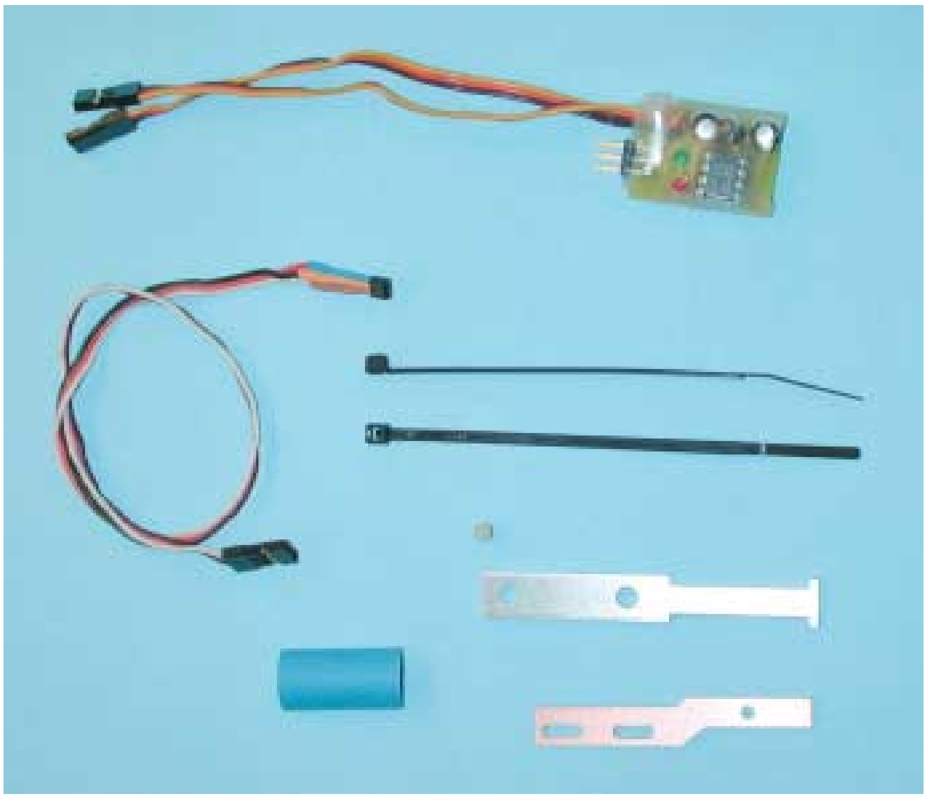
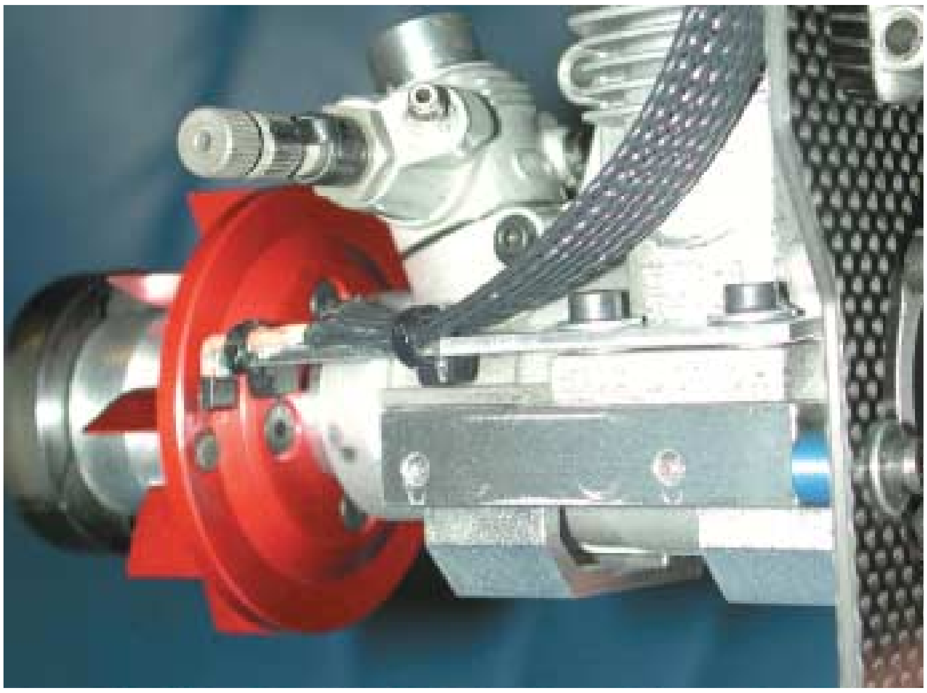


The components that make up the Model Avionics Throttle Jockey rotor speed governor

This is the completed sensor installation on the review TT-50 engine with Raptor 50



Governors have seen great favour in the USA for some time, but in the UK, we have been surprisingly slow to catch on to the benefits of these units. So after becoming a recent convert to governor operation for 3-D flying, I could not resist the opportunity to review the Model Avionics Throttle Jockey.

The basic idea of this or any other governor is of a unit that senses engine rpm and self adjusts to retain a pre selected rotor speed. So the careful and sometimes painstaking burden of matching pitch and throttle curves to achieve a constant main rotor speed is removed from the pilot. In addition to this no 'cyclic to throttle' or 'tail rotor to throttle' mixes are required to retain rotor speed through aerobatic manoeuvres. Other benefits are that small changes in mixture, glow plug condition, temperature, humidity, cyclic throws and rotor blades will not affect the main rotor speed. Thus an engine rpm governor is a self-adjusting unit that will not only adjust for changing flight conditions, but also compensate for small changes in operating conditions. Another often overlooked benefit is that you do not have to fly advanced aerobatic manoeuvres in order to assess the rotor speed and make adjustments to suit. Once active, the governor does all of this allowing you to concentrate on learning new manoeuvres.

However, whilst I am a truly convinced that governors are extremely beneficial devices for 3-D flying, I certainly recognize that they are not totally infallible. Governors can not make allowances for poorly adjusted engines and can only match the available engine power. In addition to this, they react to a demand rather than pre-empting it as in the case of the conventional pitch/throttle curve. Thus governors tend to suffer from a lag in engine response to aggressive collective/cyclic demands and this can give the pilot a feeling of lost performance.

This lag in engine response is generally masked by the current generation of high power 90 size engines, but the smaller 30/50 size engines never seem to fare anywhere near as well. So the following report is based on my personal experience with the Throttle Jockey and how it performed in two specific sizes of model helicopters.

Specifications

The Model Avionics 'Throttle Jockey' is an engine speed governor that employs a digital adaptive feed-forward control algorithm. The control algorithm monitors and adapts to the frequency of the throttle commands made by the pilot. Fast changing collective commands required for 3-D manoeuvres naturally relate to fast changing throttle demands. The electronics sense this and under-damp the control loop, thus increasing the speed of the throttle response. In opposition, when the slower changing collective commands used for precision FAI hovering manoeuvres are sensed, the unit will over-damp the control loop to smoothly regulate the throttle. Of further delight is that the Throttle Jockey measures just 30 x 22 x 10 mm, weighs less than 10 grams and draws just 17 mA at 4.8V. rpm sensing is accomplished via a hall-effect sensor mounted on an engine bracket that detects a magnet mounted on the underside of the cooling fan. An auxiliary channel is then used to adjust the rpm via the Transmitter ATV values.

Installation

The Throttle Jockey is supplied complete with two styles of engine mounting brackets, two magnets, a hall-effect sensor, all necessary JR/Futaba compatible leads and full instructions. My first task was to install the magnet into the aluminium Quick UK upgrade fan fitted to the review Raptor 50. This could have been achieved without removing the engine, but the clutch lining was finally starting to show signs of wear. So I elected to remove the engine and perform both tasks at the same time.

Once the engine was removed, I then needed to find out which way round the magnet had to be installed into the cooling fan. This was easily achieved by plugging the Throttle Jockey in to the receiver, turning on both the Tx and Rx and by passing the sensor over the magnet. A bright flash of a red LED on the Throttle Jockey module indicated the correct side of the magnet and I marked this side of the magnet with a permanent felt tip pen. The orientation of the Hall effect sensor was also noted in preparation of a 90° bend to allow horizontal sensing when mounted to the supplied bracket. To fix the magnet to the fan, I cleaned up the pre-machined recess in the underside with methylated spirit and then roughened the surface slightly with a needle file. I then glued the magnet into the recess with a 1-hour 2-part epoxy glue.

I now turned my attention to the sensor mounting to find neither of the two brackets suited the TT 50 engine bolt hole spacing (this has now been amended by Model Avionics). After a minute of pondering, I elected to drill an extra hole in the larger of the two sensor brackets and relieve the back edge of the bracket to allow the engine crankcase to clear. I then mounted the modified bracket to the engine with a washer between the engine and sensor bracket on each engine bolt. From here, I made the necessary 90° bend in the sensor and checked the maximum gap between the sensor and magnet to allow the unit to work. This ended up at about 2.5 mm, so I cable tied the sensor to the bracket with a gap of about 1 mm from the magnet and then used a drop of CA (cyanoacrylate) glue on both cable ties to ensure a permanent mounting.

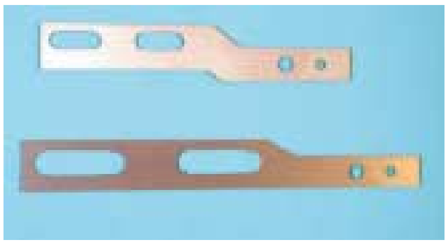
Setting up

The Throttle Jockey is controlled by just one switched auxiliary Tx channel. This is used to perform the initial calibration when you first install it or move it to another model. Thereafter, the unit is inhibited at the neutral 0% output, whilst plus and minus 5 – 100% ATV will activate an engine speed setting of 9500 to 18500. So this single channel is used to initially set up and then inhibit/control the desired target engine rpm. My JR 3810 transmitter allowed me the choice of the switched Gear channel, Aux-2 that operates via a rotary control or Aux-3 that is recognized by the Idle-up switch. Gear was already in use as my gyro channel, so I elected to use Aux-3 and set the ATV's to an initial 100% as advised for setting up. I ensured the throttle trim was at the fully down stop position and then turned on the Tx/Rx and toggled the Idle-up switch within two seconds. This kicked the unit into the calibration mode and was clearly indicated by a flashing green LED light on the control module. The throttle stick is then raised to full high stick and lowered to full low stick before the auxiliary switch is toggled. The green flashing light will then go out, thus indicating that the settings have been successfully stored in the Throttle Jockey memory.

The Throttle Jockey activates at 25% stick position, thus idle-up flight conditions should have a minimum value of above 25% throttle to ensure the unit cannot de-activate in flight. I checked the operation of the governor by moving the throttle stick above the switched 25% value in normal to clearly see the green governor active light come on. I then engaged the idle-up flight conditions to reveal that my initial set up meant the governor was active in normal, off in the centre Idle-up 1 position and active in Idle-up-2. I initially zeroed the Aux-3 value in normal to deactivate the governor for this mode of flight. I then used the rpm conversion chart on the Model Avionics web site to calculate that a JR Aux-3 ATV value in idle-up 2 of 81% would release a calculated main rotor speed of 1845 rpm on the Raptor 50. The previous Idle-up 2 throttle-curve was retained and the operation was checked so that the governor

The small electronic item mounted on the front of the review Raptor 50 is the Throttle Jockey control module. Yes it really is barely larger than the RX battery checker mounted to the rear

The mounting brackets have now been amended to suit all popular 30/50/60 and 90 model helicopters



A close up of the Throttle Jockey magnet and sensor orientation

active light remained on at all throttle stick positions. I then checked the governor active green light went out when the 'throttle hold' flight condition was activated. I lastly ensured that the transmitter failsafe function was memorized with the Throttle Jockey deactivated in the throttle-hold flight mode and visually checked the failsafe operation by turning the transmitter off from the Idle-up 2 flight-condition. The green light instantly went out every time I turned the Tx off leaving me satisfied that the failsafe function was set correctly.

First Impression

The model was sat on a level piece of ground and Idle-up 2 was engaged. The previous throttle curve ensured a quick rise in rpm until the engine note changed and settled thus indicating the governor was now operative. I then pulled full negative pitch whilst studying the throttle arm. Sure enough the throttle arm visibly responded and self adjusted, so I lifted off and hovered for a while before gently exploring forward flight. Throughout all circuits, the Throttle Jockey performed flawlessly and the rotor speed sounded totally consistent. Conventional loops and rolls were then performed to find that the unit retained rotor speed perfectly at all times.

With an ever-increasing confidence in the Throttle Jockey, I explored stationary flips and rolls to find that the unit had not only matched my conventional set up, but also had seriously enhanced the consistency of the main rotor speed! The model appeared to be less hesitant through consistent manoeuvres and even the mechanics seemed to smooth out dramatically. At this stage I became highly intrigued with the governor reaction time to sudden collective inputs. So I landed the model and retained Idle-up. From zero pitch, I then punched in full collective as fast as I could. To my surprise, the Throttle Jockey appeared to be capable of responding almost instantaneously and gave no audible lag of throttle response! So with the rare commodity of a near smile, I landed the model to re-fuel in preparation of some serious testing.

Aggressive Flight Testing

With a full tank of fuel, I set off with the clear intention of finding the limit of the Throttle Jockey's ability to keep up with constant 3-D manoeuvres. This started with the time old favourite of sideways loops and this showed a dramatic performance enhancement. The model no longer lagged at a lower rotor speed, but went round and round continuous examples very consistently. From here, the model was pushed round tumbling loops and the rotor speed retention was once again clearly enhanced. Next in line were pirouetting flips and the model not only held the manoeuvre

The performance of the TT powered Raptor 50 has been seriously enhanced! The model now locks into a very constant rotor speed regardless of the situation

Coming in for another low level sideways loop, the TJ certainly inspires pilot confidence

So just how many more stationary flips do I have to do to prove a point

And now for constant stationary rolls…

cleaner, but also allowed me to climb and descend easily within the power limitations of the engine. Pie-dish manoeuvres and stationary death dive were also tried and both showed similar improvements. From here, I tested the ability of the Throttle Jockey to hold the engine back in long tail first descents and the rotor speed held with no over-speed on the way down.

I then just let rip and threw a constant barrage of manoeuvres at the Throttle Jockey. Within the restrictions of the available engine power, this unit just kept on trucking through all of the abuse in the most impressive manner. Within the limitations of engine power, the Throttle Jockey retained rotor speed and cyclic/collective response far better than my previous conventional set up.

In a More Conventional Sense

Once the initial testing was over, I decided to heavily modify the Aux-3 values by trial and error so that I could have the throttle Jockey active in all three flight-conditions. The final result was that I had to reduce the sub-trim value all the way down to –220 for Idle-up 1 so it saw the value as an active rpm setting of about 1700 rotor rpm. I then adjusted the normal flight condition to a value of +123% to give an estimated 1550 rotor rpm and Idle-up 2 value was tuned by ear until a value of 15% gave about 1850 rotor rpm. Whilst this process was initially confusing and would not be necessary on a more advanced transmitter, it actually worked out very well with the governor functioning safely in all flight modes.

In the normal flight mode the Raptor 50 was incredibly smooth and predictable and retained a low purr throughout all easy going hovering manoeuvres. Raising the collective stick to the max saw the model gently accelerate vertically at an identical rotor speed. I did think that descending at low stick with the governor disengaged may cause some interesting moments when powering back on. However, the governor kicked back in with the minimum of fuss and at no point did I feel that this could have endangered the model.

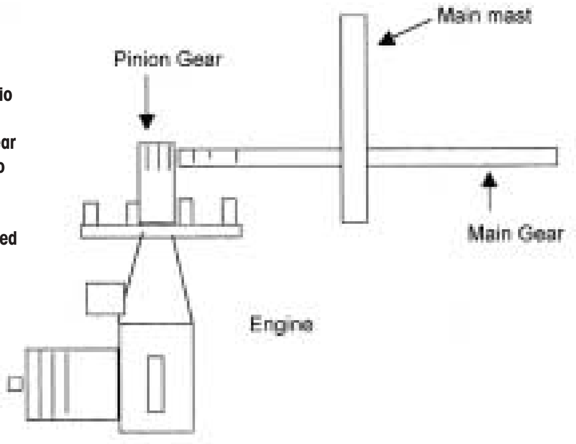
Dia. 1: How to Calculate Main Rotor Speed

Gear ratio = Main gear / Pinion gear

Rotor speed= Engine speed / Gear ratio

Gear ratio example: 90 tooth main gear / 10 tooth pinion gear = 9-1 gear ratio

Rotor Speed example: 15000 engine rpm / 9-1 gear ratio = 1666 rotor speed



At the slightly higher rotor rpm of 1700 in idle-up 1 and full retention of the governor at low stick via the raised throttle curve, the model was really sweet! The model climbed and descended cleanly and cruised round the sky with an audible consistency throughout. Coming back in to the hover rapidly showed no over-speed and I felt the consistency of the rotor speed enhanced this flight mode just as much as it had done for the others.

Subsequent Testing

Since the initial flight-testing in the Raptor 50, the Throttle Jockey was installed in a set of 3-D NT based mechanics powered by an OS 90 engine. The previous governor sensor was removed and replaced by the Model Avionics unit, whilst the tiny control module was fixed to the side-frames via a self-adhesive foam pad. The servo leads were then connected up in seconds, the unit was calibrated and its operation/failsafe operation was fully tested a couple of minutes later.

In flight the Throttle Jockey retained a perfectly consistent rotor speed throughout conventional flight at all times. Moving into loops and rolls showed an identical consistency with the tone of the model remaining identical at all times. Turning my attention to 3-D flight showed a very smoothly governed rotor speed with incredibly little audible change throughout some very aggressive testing. As with all governors, the Throttle Jockey could sadly not extract any more power out of the engine than the engine was capable of providing, thus when using large values of collective and cyclic, it was still possible to find the limit of the engine power output. However, what the Throttle Jockey did appear to be capable of was extracting the very best from what performance the engine had to offer. It appears to achieve this by reacting instantly to sudden pilot cyclic/collective demands with no hint of response lag. The most noticeable of this was once again when the model was at rest at zero pitch in idle-up and then aggressively punched off into a take off manoeuvre. The Throttle Jockey was capable of responding with no audible lag to the throttle response in a manner that I felt capable of matching the response time of a conventional set up.

Glossary of Terms:

3-D Flying: A general description used for a style of advanced aerobatics that includes full inverted, backward and pirouetting flight.

CA: Cyano Acrylate glue, known as ‘super glue’ or ‘cyano’. Available in various grades and types from thin to thick and sets instantaneously or within a few seconds. Special types are available for plastics etc. Beware: some will melt plastics and all will instantly bond skin and should be used in a ventilated area as the fumes can be harmful.

Idle up: A switch on the transmitter which activates programming so that the throttle and collective movements can be set to suit particular flying styles. Various ‘points’ are provided for both throttle and pitch range relating to the Tx stick position (know as ‘curves’). Thus the collective pitch range can be chosen and the throttle set to maintain rotor rpm when zero or negative pitch values are used.

RPM: A common form of measurement used to show how fast an engine or rotor system is turning, i.e. Revolutions Per Minute.

Verdict

The Model Avionics Throttle Jockey has brought governor technology up to a level where it can match the response time of a conventional set up, whilst offering all the benefits of governor operation! The unit is small and light and once you have become accustomed to the procedure, it is incredibly quick and easy to set up. Overall, the Throttle Jockey enhanced the overall flight performance of both test models and I have nothing but praise for this economically priced product.

Spec Check

Product: Throttle Jockey
Market place: Beginner to Advanced
Manufacturer: Model Avionics, Silicon Valley USA, www.modelavionics.com/
US Distributor: Heliproz USA (877) 435 4776 www.heliproz.com
UK Distributor: Direct Distribution
Dimensions: 30 x 22 x 10 mm
Weight: 10 Grams
Power Consumption: 17 mA at 4.8 volts
Radio Requirements: Single switched auxiliary channel
Special Features: digital adaptive feed-forward control algorithm
Engine rpm Range: 9500 to 18500 rpm (2-Stroke), 4250 to 9250 (4-Stroke/ Gas)
US Recommended Retail Price: $69

We Used:

TT Raptor 50, RC Models Distribution 3D-NT based mechanics, JR X-3810 transmitter, JR PCM receiver, JR 591 and Futaba 9202 servos

Likes:

Compact Dimensions.
Quick set up.
Low Purchase price.
Impressive ability to maintain rotor speed.
Rapid throttle response.

Dislikes:

Lack of graphic rotor rpm display.

Figure 1: Example of ATV/Rotor rpm

Raptor 30: 9.56-1 gear ratio

RPM	JR	FUT	HITEC	SANWA
1500	76	56	81	78
1550	80	59	85	82
1600	84	63	89	86
1650	88	66	94	90
1700	92	69	97	94
1750	96	72	101	98
1800	99	75	105	101

Figure-2: Example of Engine rpm for ATV Values

ATV	JR	FUTABA	HITEC	SANWA
10	9480	9600	9420	9420
20	10140	10380	9840	10020
30	10620	11200	10380	10500
40	11280	12240	10920	11100
50	11900	13700	11640	11820
60	12720	15000	12420	12600
70	13500	16500	13200	13500
80	14700	18060	14100	14520
90	16080	18500	15240	15720
100	17340	18500	16620	17160