Calibrating your outputs in OpenTx

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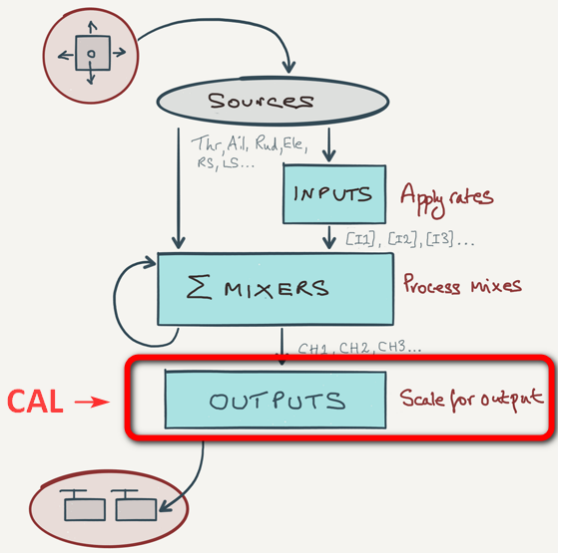
Introduction

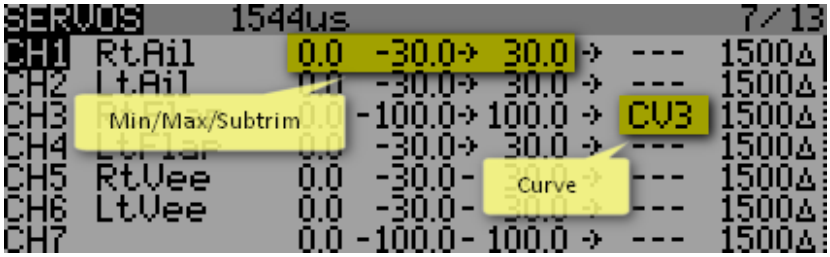


In this article, I explain how to calibrate your servos. It may sound simple, but there's a little more to it than meets the eye.

Doing a calibration will allow you to simplify your setup, keep your model in trim, and make your life wonderful for ever! So let's get started...

What is calibration?

You probably already know how to adjust your servo travel and centres: you go to the Outputs menu and adjust Min, Max and Subtrim, and/or set a curve:



CH1 calibrated via min/max/subtrim
CH3 calibrated via curve

But what's is actually happening?

In fact, Min, Max and Subtrim define a 3-point curve. You can also set a custom curve using the curve option.

Whichever way you define the curve, its job is the same: *it maps channel values from the mixer stage, to PWM values.* These PWM values represent servo deflections. Put another way, the curve marries the *logic* of your setup, to the *geometry* of your model.

Min, Max and Subtrim

This is how the mapping works, in the case of Min, Max and Subtrim:

- *Min* defines the PWM value for a mixer value of -100%
- *Max* defines the PWM value for a mixer value of +100%
- *Subtrim* defines the PWM value corresponding to a mixer value of zero.

- *Direction* reverses the effect

Since mixer values can't exceed +/-100%, *Min* and *Max* represent absolute travel limits. Think of them as electronic end stops. Also, in order to visualise the servo limits, you need to supply mixer values of +/-100%. This is a key aspect of calibration.

Percentages and PWM units.

Now here's a potential source of confusion: Min, Max and Subtrim represent PWM values, and these are normally expressed in microseconds. However, OpenTX often displays them as percentages. The conversion is as follows:

- −150% = 732 µs
- −100% = 988 µs
- 0% = 1500 µs
- 100% = 2012 µs
- 150% = 2268 µs

Standard servos usually have a nominal range of 1000 to 2000µs, so you can think of these percentages as 'percentage of the range of a standard servo - roughtly!'. To reinforce this notion, PWM values outside the range 988 - 2012 µs are only available if the'extended limits' option is enabled (MODEL menu).

Summary

Okay, so this is what we've learned so far:

- The MIXERS layer assigns a percentage value to each channel, representing % of available travel.
- The OUTPUTS layer maps the percentage value to a PWM value. The mapping is defined by a 3-point curve (-100, Min), (0, Subtrim), (+100, Max). Instead, or in addition, a custom curve can be specified.
- The final PWM value represents an actual servo deflection.

Calibration prerequisites

The purpose of the calibration is to set the optimal values for Min/Max and Subtrim. To carry out a calibration you'll first need.

- the actual model (doh!)
- a way of generating mixer values of -100, 0 and +100. My Calibration Mode does this on demand. If that's not possible, then set all your input and mixer weights to 100%, and centre your trims.
- The last column of the OUTPUTS menu displays the Subtrim mode. Leave this at the default (Delta) mode (we'll see why later).

Performing the calibration

So now you're ready to start the calibration. Your goals will be:

- Set safe limits to servo travel
- Equalise control surface movements on left and right sides
- Linearise resposes

Okay, so let's get calibrating!

Calibrating ailerons, elevator, rudder, V-tail

Calibration is really simple, you're just setting the 'never-exceed' limits, and balancing up the left and right sides. In more detail:

1. Open the OUTPUTS menu
2. Activate Calibration Mode
3. Adjust Subtrim for correct neutral.
4. Adjust Max and Min for each servo:
    - First, adjust thee for *maximum possible* control surface travel

- Next, refine so that control surface travel is equal up/down (or left/right).
- Finally, refine so that left and right surfaces match.

5. Exit from Calibration mode

The outputs are now calibrated.

Calibrating flaps

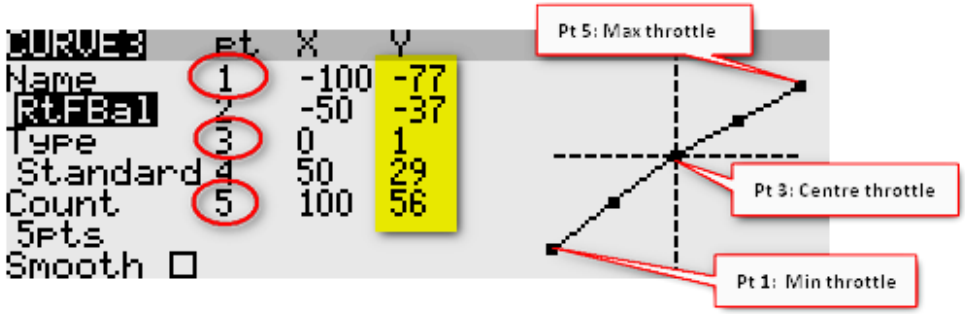
Flaps present a greater challenge. They are characterised by grossly asymmetric movement. Also, flaps have large deflections, and it's important that they track precisely.

Fortunately OpenTX allows these to be calibrated with great precision:

1. Calibrate one flap with a 2-point curve, setting the end points only. This flap will be the reference for calibrating the second flap. The servo centre will be at some arbitrary camber position, and we'll use an offset mix to deal with this.
2. Calibrate the second flap with a 5-point curve, to track the first flap.
3. Set the neutral position using an offset mix.

Here's the procedure in detail:

1. **Set Min, Max and Subtrim to 'pass thru' values**
    1. Open the OUTPUTS menu
    2. For each flap servo, set MIN, MAX and SUBTRIM to -100, +100 and 0 respectively (or -150, +150 and 0 if using extended limits).
2. **Calibrate the LEFT flap**
   First, calibrate the left flap. The aim is to (a) set the limits of servo movement, and (b) to obtain an approximately linear response. The flap neutral is not considered in this step.
    1. Go to the CURVE column, and define **a 2-point curve** with points (-100, -20) and (100,20). The low point values ('20') are to avoid accidental damage to your linkages before finalising the adjustment.
    2. Enter CAL mode
    3. Adjust the two points for *maximum possible* travel (limited only by the linkages). The flap deflection should vary more or less linearly with the calibration input. If necessary, you can add an extra point to the curve.
    4. Exit the CURVE menu
    5. Exit Calibration mode
3. **Calibrate the RIGHT flap**
   Now we adjust the right flap to match the left flap, and we do this using a multi-point curve.
    1. Go to the CURVE column and define **a 5-point straight line curve**
    2. Enter calibration mode
    3. Move the stick to the 0/25/50/75/100 % positions; at each position, adjust the corresponding point so that the right flap exactly matches the left flap. (Depending on the linkage geometry, it may be necessary to go back and reduce one or other end point on the left flap.)



    4. Exit the CURVE menu
    5. Exit Calibration mode
4. **Set an offset mix**
   The flap servos are now calibrated, and the flaps should track perfectly. However the flap neutral is

floating. To fix this we need to apply an offset at the *mixer* level as follows:

1. Exit CAL mode
2. Create a mix in each flap servo channel.
3. For each mix, set *src* = 'MAX'. This generates a fixed offset.
4. Adjust the weight of 'MAX' mix, until the flap is at the correct neutral

Other mixes can of course be added to the flap channels, for example for roll control, camber etc.

Adjusting the inputs

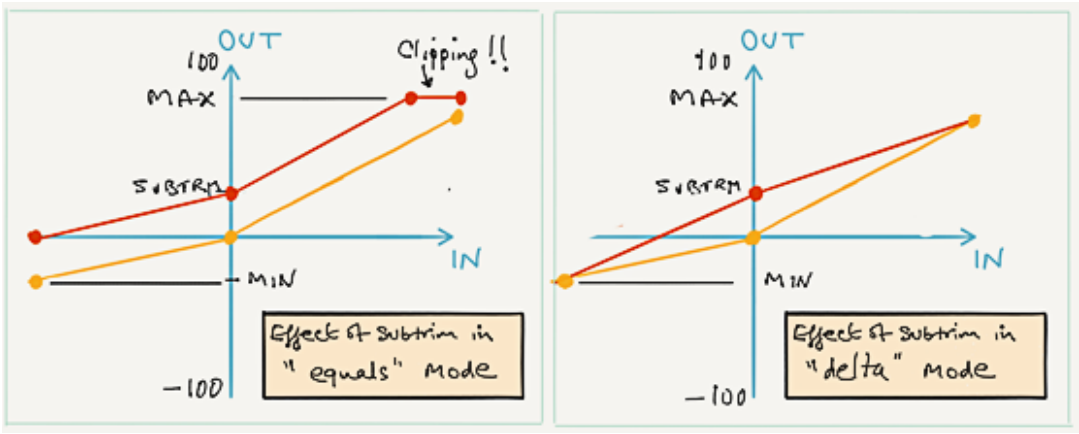
After calibration, you can finalise the control travel in the INPUTS and MIXERS menus. Good practice is as follows:

1. For the flight controls (elevator, aileron and rudder): adjust travel in the INPUTS menu and leave mixer weights at 100%.
2. For all other interactions: adjust in MIXERS menu. If the calibration has been carried out correctly, then the mixer weights can equal on the left and right sides.

A closer look at Subtrim Mode and PPM Centre

There are two options for Subtrim mode:

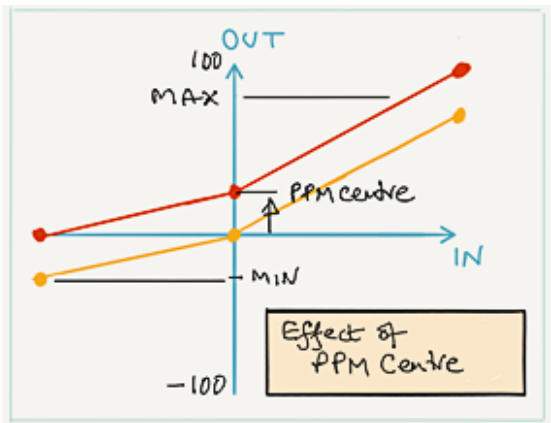
- *'delta'* (default) - Subtrim adjustment does not affect end points
- *'equals'*: Subtrim adjustment shifts end points. So the end points are MIN+SUBTRIM and MAX+SUBTRIM. The output is clipped to MIN and MAX.



Delta mode allows independent calibration of centres and end points, and is therefore recommended.

Changing between "equals" and "delta" modes will cause your end points to jump, so start with delta mode and stick with it.

If later on you need to shift the whole curve with a single adjustment, then use the PPM Centre adjustment. The effect is simillar to 'equals' mode, but with less aggressive clipping.



Correct drifting control surfaces

Most models suffer from drifting neutrals a few times during their lifetime. You can check for drift by entering CAL and seeing if the calibrated centres have changes. If the drift is small, simply adjust PPM Centre (do this while still in CAL mode). Once you exit CAL mode, any trim offsets will be restored.

Trims => Subtrims - AVOID!!

OpenTx allows you to re-centre your trims, by moving the offsets to SUBTRIM. Obviously, using this feature will trash your calibration. Avoid!

Calibration-centred design

Even greater benefits can be achieved by designing your setup with calibration in mind from the start. I call this 'calibration-centred design'. There are two main aspects:

Incorporate a CAL flight mode

The first step is to reserve FM1 as your CAL mode. That way, you can check the calibration at any time for drifting servos, bent linkages and so on.

Use GVARs and cascading mixers

A key goal of calibration is to match up responses between the left and right sides at the *servo* level. This means that paired (left/right) mixers can have identical weights. By using *GVARs* and/or *cascading mixers*, you can have a *single menu point* for each pair of adjustments. This results in:

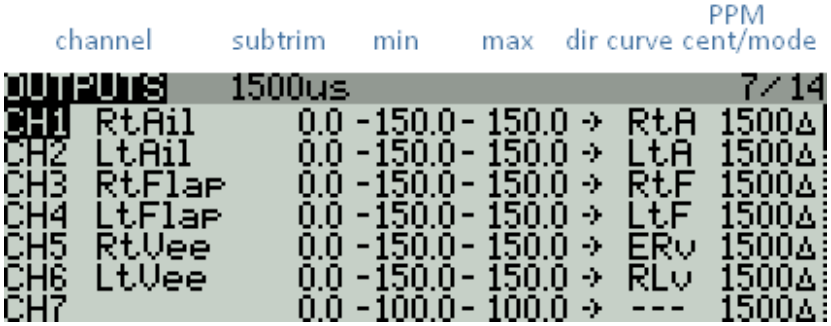
- cleaner logic
- quicker configuration
- reduced data entry errors

Calibration the easy way

All the canned setups published on this site have CAL mode already built-in, protected against accidental operation.

Appendix

The OUTPUTS menu



Outputs menu

Columns as follows:

- *Channel label* - 6 character channel name
- *Subtrim* - centre adjustment
- *Min* - end point 1
- *Max* - end point 2
- *Dir* - direction
- *Curve* - response curve (alternative to Min/Max/Subtrim)
- *PPM* centre - pulse width (microseconds) corresponding to centre command
- *Subtrim mode* - subtrim added/not-added to end points

The key fields for calibration are **Min**, **Max**, **Dir**, **Curve** and **Subtrim mode**.