Analogue, digital and coreless servos

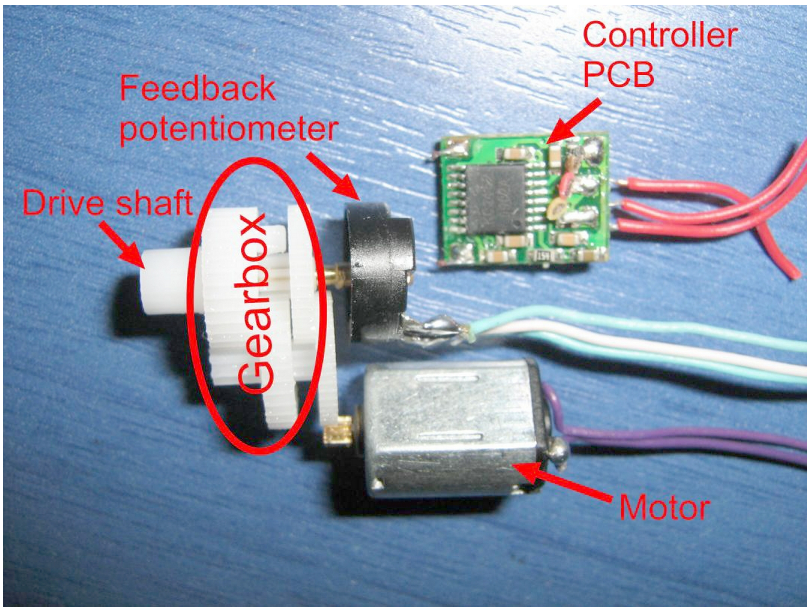
All rotary model aircraft servos work the same way. Unless coreless, the only difference between analogue and digital ones is one small piece of electronics.

Servos use pulse width modulation (PWM) and feedback.The receiver (Rx) splits each second into fifty ‘windows’ of 20 thousandths of a second (milliseconds ms) each. Inside each window the Rx sends a pulse of voltage, between 3.3 and 5 V, down the signal wire (yellow or white) to each servo, evenly spaced out. These pulses are fairly rectangular in shape and vary in length (width) between 1.0 and 2.0 ms. The length is determined by the position of the transmitter stick, rotary or switch position for that channel. So full up elevator might be 1.0 ms and full down 2.0. Neutral will be 1.5, with small changes to it being set by trim or offset. A two-position switch will change the width from one extreme to another. A three position switch will add a 1.5 ms mid-point. That explains the words **pulse** and **width**. **Modulation** means a change that carries information in this case a move from 0 to 5 V or vice versa.

Most servos don’t use all of their possible movement so you can send signals outside the normal range and get more movement. However this is risky as you don’t know how much more is safe for a particular servo. FrSky Taranis users have to be careful as the amount of movement can be set in at least three ways and they add. A good head for arithmetic is needed and good ears to hear the buzzing from an over-run..

Inside the servo case there are four things – a motor, some gears, some electronics and a variable resistor called a feedback potentiometer (pot). You can see these in Picture 1.

I don’t need to explain what the motor does. The gears do two things. They slow down the motor rotation and they increase its turning force (torque). Torque is measured as a force times a distance. For servos the unit is usually kg cm. A 10 kg cm servo can make a force of 10 kg at the end of a 1 cm arm, 2 kg at the end of a 5 cm one and so on. The pot is turned by the final drive from the gears. Because it is a variable resistor, as it turns it produces a varying voltage, so the position of the servo output shaft is turned into a voltage that can be read by the electronics.



Picture 1: pcbheaven.com

The servo electronics PCB measures a pulse and turns it into a desired position for the servo. Remember the pulses come once every 20 ms. It reads the voltage from the pot, known as feedback. If the pot voltage shows that the servo is already in that position it does not send a voltage to the motor. It the servo is out of position it sends a voltage to move it one way or the other until it is in the right position. This means that the servo can only move once every 20 ms. Rapid small movements of the stick can be confused. The effect can be that the response might feel sluggish or weak.

What's different about digital?

The electronics is where digital servos are different. The PWM pulses from the Rx are the same. However digital electronics 'remembers' the pulse size and produces voltage pulses at a greater rate than fifty per second, in fact 300 or more, so they are effectively continuous. This means that the motor starts sooner and produces more torque. It also means that the servo responds instantly to any external force on the control surface that moves it from the correct position. If you push the servo it feels 'solid' rather than mushy. I am not clear why such servos are called 'digital'. They are not, but I suppose it sounds modern and there is no better alternative. High-speed or high-pulse-rate could be misleading.

Analogue servos switch off when they get no signal so can be moved by external forces. Some digital servos hold their last position and firmly lock it. The only downside to digital is that the servos use more power so you must use a bigger capacity battery to drive them.

One last word to explain is 'deadband'. Its true meaning is the amount of signal change needed before a servo reacts. In a car it is how far you need to move the wheel before the steering takes effect. However sometimes it is used loosely in RC servo descriptions to mean sluggishness.

When I started using digital servos I noticed that some buzzed slightly. Being used to analogue servos this worried me, as buzzing often indicates a fault, meaning that I wouldn't fly. I was assured that slight buzzing is normal with some digital servos.

Coreless digital servos

If you watch a highly aerobatic model the speed of the control surface movement is impressive. It can be less than 0.1 second to 60° deflection. To achieve this, coreless servos have very light moving parts. There is no moving iron core, hence the name, just a light wire cage of windings shown copper-red in Picture 2.

Picture 2: rchelicopterfun.com

A conventional servo motor has an iron core armature wrapped in wire that spins inside magnet. In a coreless servo, the armature is a cylindrical thin wire mesh that spins round outside a magnet. There is no iron core. Ordinary servo motors have three or five magnets. When the coil is between two of these the force drops. There are no gaps in a coreless motor magnet, so they are smoother, more constant, and stronger.

Current consumption

A word of warning. Digital servos use more current than analogue ones, because they are working all the time. If they also produce a lot of torque, and are high speed coreless types, they might need more current than your receiver can provide, especially if there are two on a Y-lead. For digital servos above say 10 kgcm torque, try to find out what current it uses and what your receiver can provide. To be safe (and I broke a receiver finding this out) use a power distribution board for this kind of high power setup.

Good and bad points of digital servos

Good

- Fast reaction to control and deflection
- Smaller deadband
- Probably lock in position rather than switch off

Bad

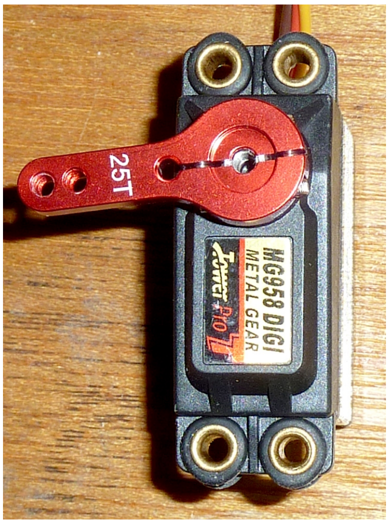
- Use much more energy so must use larger, or twin, batteries or replace them regularly as you do flight batteries
- Likely to need a power distribution board

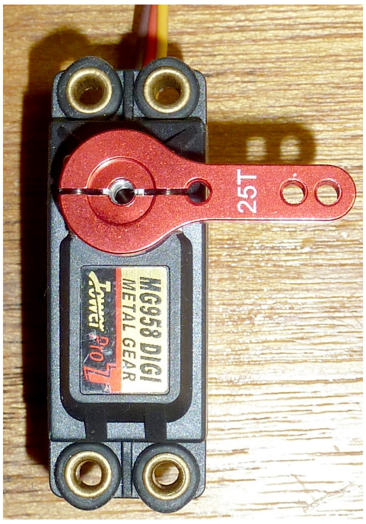
For further information and some excellent pictures by Jan see https://www.pololu.com/blog/17/servo-control-interface-in-detail

Servo arms

Haven’t we all struggled to find a servo arm to fit on a servo we are re-using, having thrown away the box and failed to label the bag into which we put the spare arms? They differ in size and the number of splines or grooves. Some have a square hole. I now stick to Futaba-style 25-spline servos for more powerful servos. I like the alloy arms that have a slot that allows them to be locked on with a side screw. You can see these in Pictures 3 and 4. Other makes that use 25 spline arms include TowerPro, Hitec, Turnigy, Aerostar, Corona, Bluebird, Savox and Traxxas. You need to check before buying a particular servo.

I do find the choice of an odd number of splines rather illogical. It means that, in its neutral position, you can only fit the servo arm at right-angles to the servo body on one side of the servo. On the other side it will always be slightly out as you have to move it round to find a groove. The splines are 360/25 degrees apart. So you have to move half this, or about 7°, one way or the other. You can see this in Pictures 3 and 4.

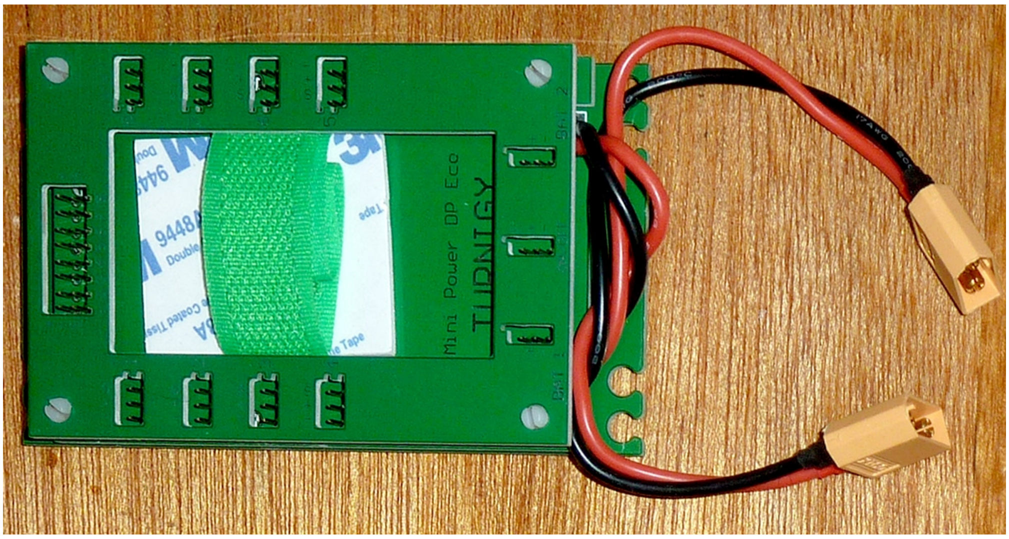




Picture 3 Picture 4
Pictures: Peter Scott

Servo power distribution boxes

As mentioned above, digital servos use more power. A high torque one, say starting at about 15 kgcm, can use 2.5 A and of course the more powerful and high-speed coreless ones use even more. A receiver might be overloaded and will either break or give weird signals. The solution is to use a power distribution box, like this one from Hobby King for £25 ($32), weighing 80 g. It is also sold as a badged product by UK dealers such as 4Max for a slightly higher price.



Picture 5
Picture: Peter Scott

The receiver is strapped (or velcro'd) into the middle. The servo signal outputs from the receiver plug into the pins in a row at the top (left side in Picture 5). The servos plug into the sockets down each side. The box just passes on the PWM signals but supplies the servo power itself. Two servos can be plugged into each channel. One or two receiver batteries are connected either through the XT60 connectors for 2S lipos or, if 4.8 V or 6 V NiMHs, plugged straight into the board.

The box shown above can manage eight channels. At a much higher price you can buy boxes that handle many more or you could use two boxes. The supplied switch need not be used as the box defaults to on, but if used it plugs into the middle socket. If you want an LED display for battery charge you can plug one into an unused servo output.

The only downside that I can see, apart from the weight and cost, is that these boxes cannot be used where you want a single wire into a wing holding a FrSky S.BUS converter or other S.BUS servos. However you could feed an S.BUS signal into one or more input sockets and plug the wire to the S.BUS devices into one or more sockets so removing one of the potential overload dangers when using S.BUS with powerful servos. Make sure you use thick enough wires to carry the current. Or of course you could power the servos using wires separate from the signal ones.

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