Servomechanisms in RC

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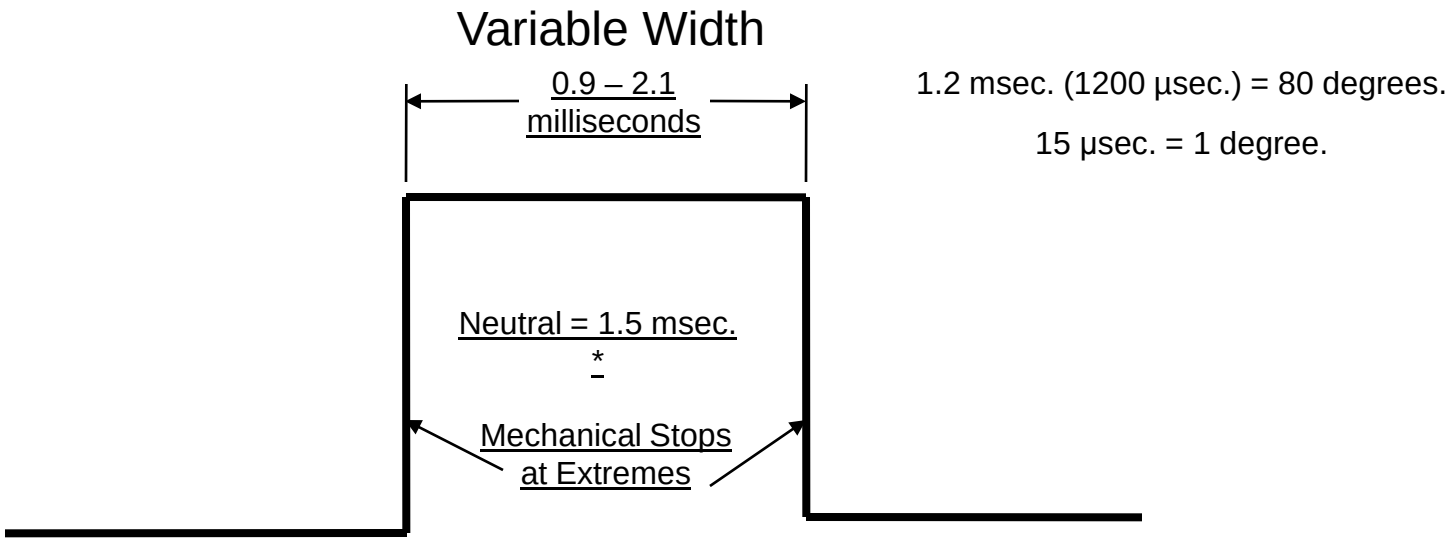
Scope of Presentation

- Function.
- How they work
- Characteristics/specifications.
- Choosing servos for a plane.
- Only talk about conventional motor/geared servos (no coil actuators, etc.)
- Conclusions

Function of a Servo

- Convert an electrical input signal into mechanical motion.
  - Rotary
  - Linear
- Respond proportionally to the input signal.

Typical Servo Input Signal Pulse



Channel signals are in sequence.

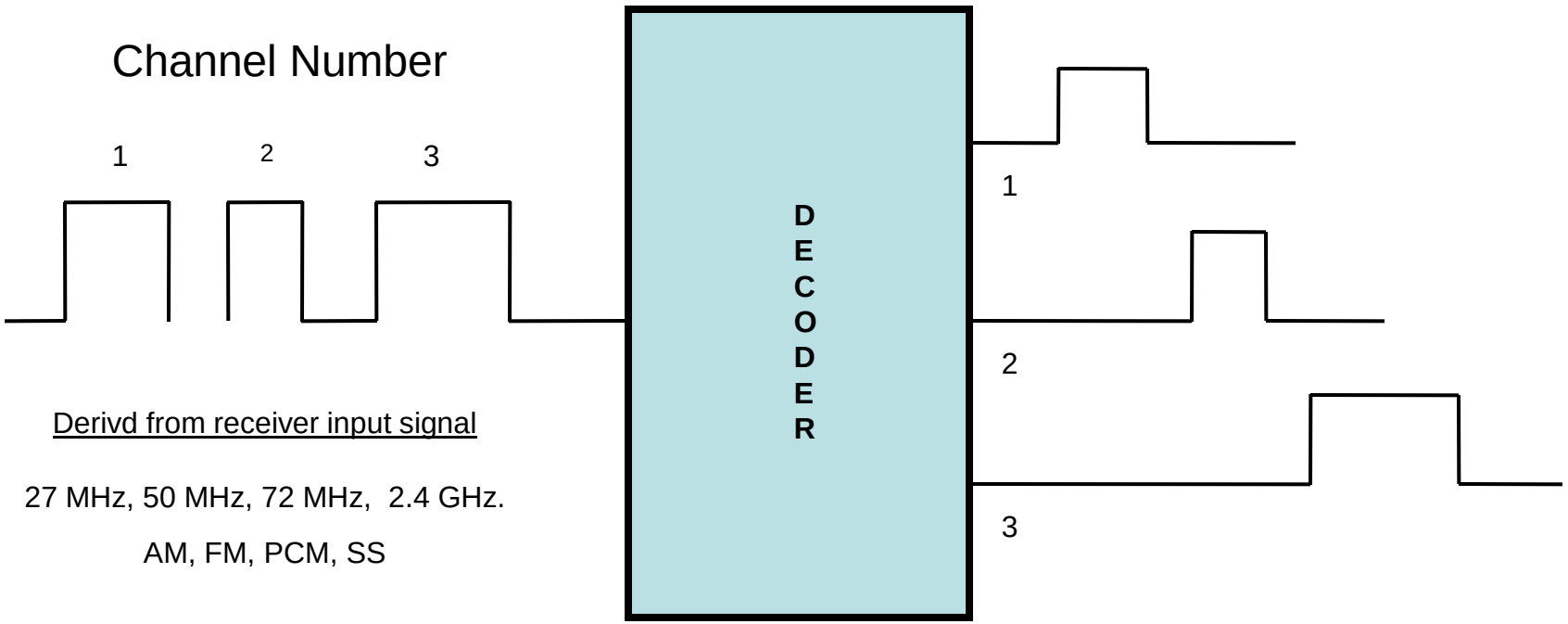
Each channel signal repeats every 20 msec. or ~ 50 times/second.

* Transmitter Trim function modifies width at neutral

Receiver Output

Repeated ~ 50 times/sec.

Every 20 millisecomds (ms)

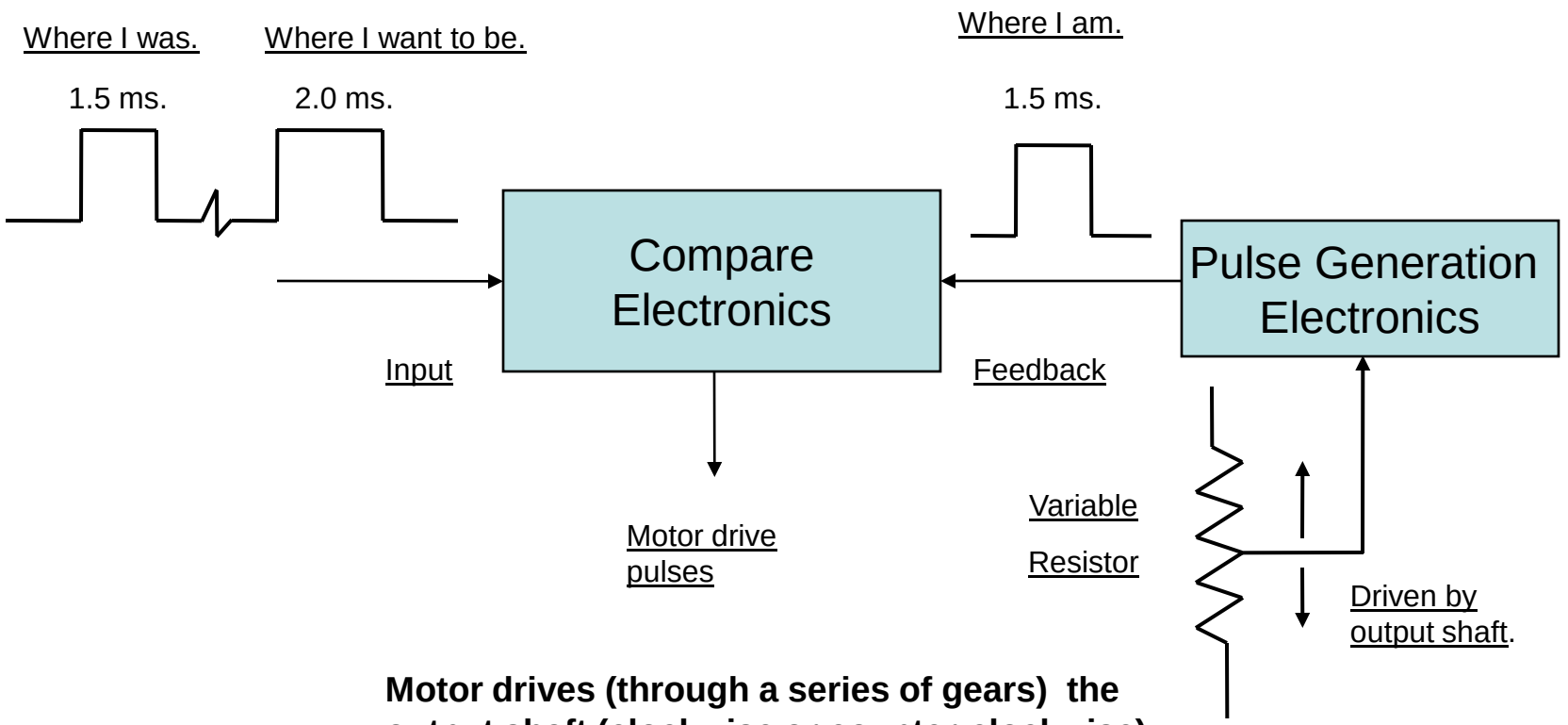


Derivd from receiver input signal

27 MHz, 50 MHz, 72 MHz, 2.4 GHz.

AM, FM, PCM, SS

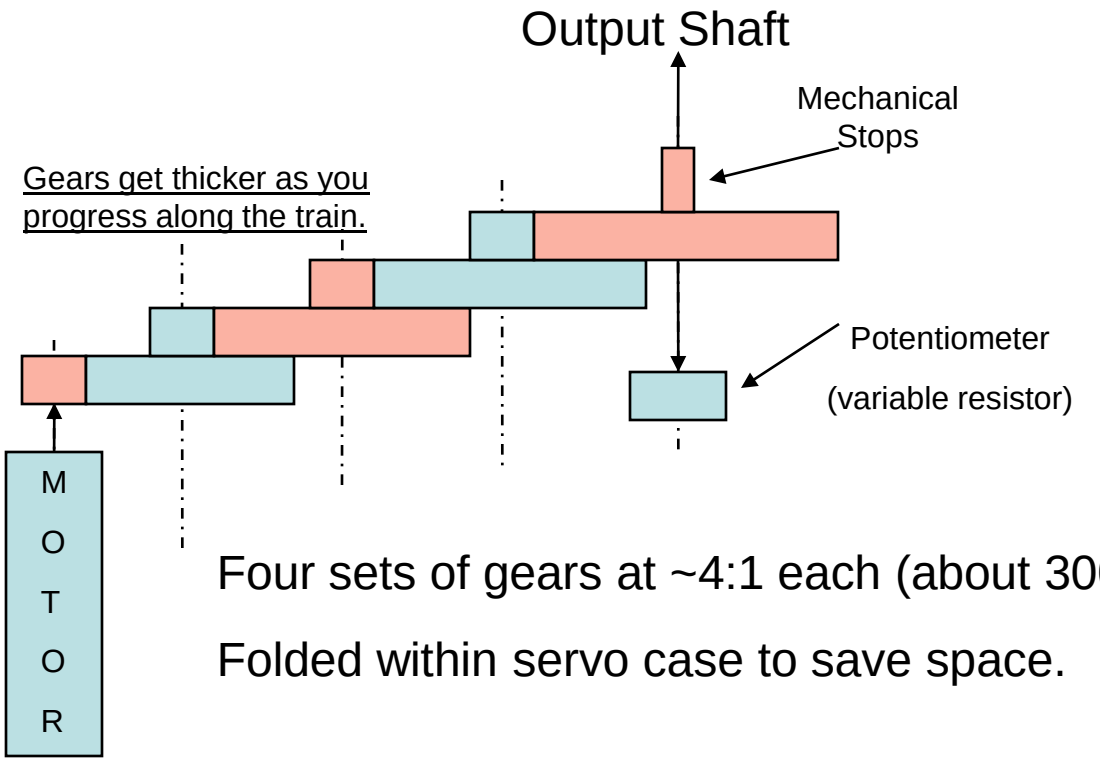
How a Servo Works
Analog or Digital



Motor drives (through a series of gears) the output shaft (clockwise or counter-clockwise) to make pulse widths equal.

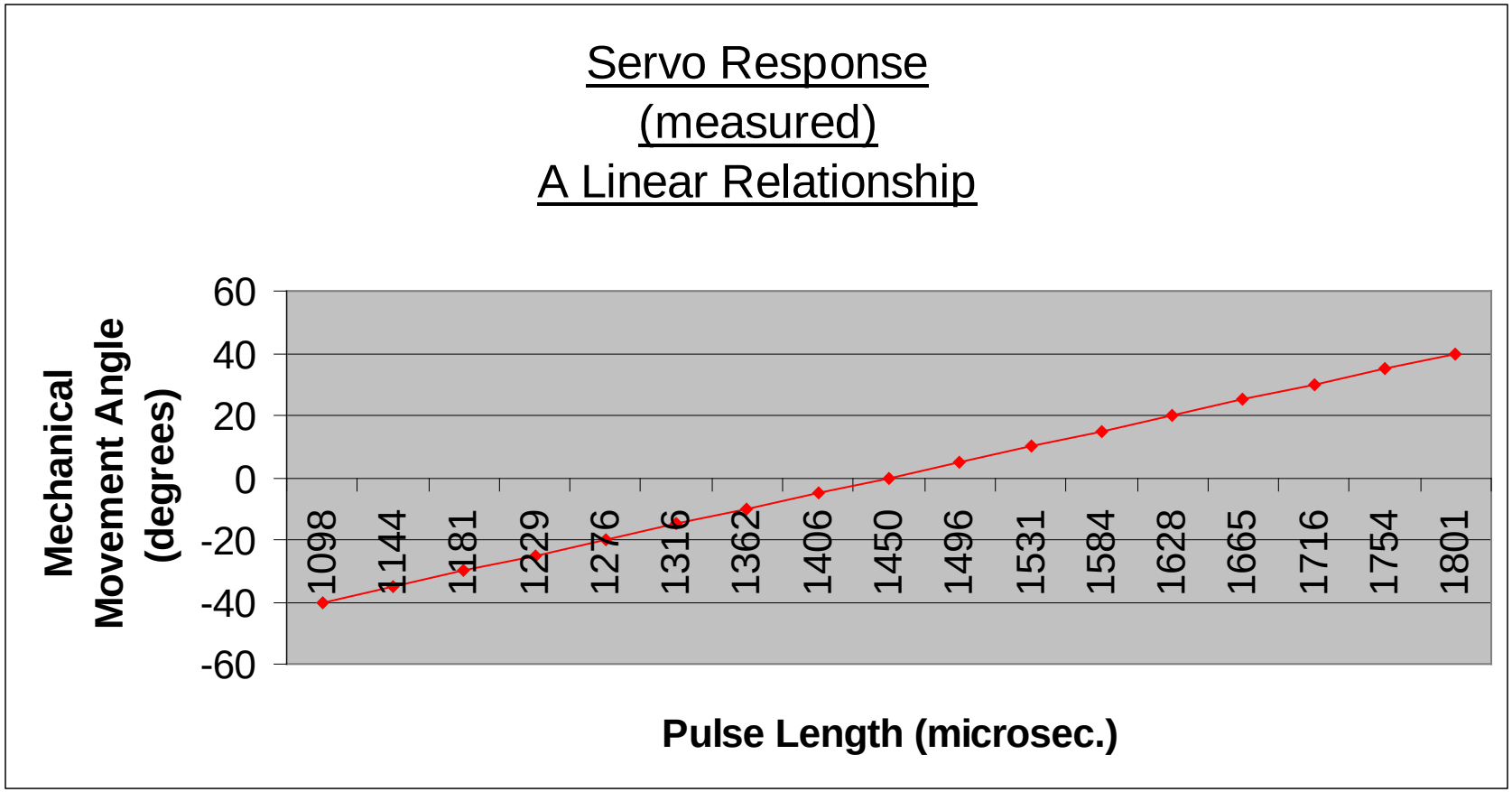
So that "Where I am" = "Where I want to be"

Typical Servo Configuration/Gearing



Four sets of gears at ~4:1 each (about 300:1 total).

Folded within servo case to save space.


Servo Response
(measured)
A Linear Relationship
Mechanical Movement Angle (degrees)
60
40
20
0
-20
-40
-60
1098
1144
1181
1229
1276
1316
1362
1406
1450
1496
1531
1584
1628
1665
1716
1754
1801
Pulse Length (microsec.)

Servo Characteristics and Specifications

- Design (coil actuator, motor/gear w. feedback)
- Analog or Digital (Refers only to internal electronics in servo.).
- Output Torque (spec.)
  - Measured in ounce inches (not ounces/inch)
  - Range for Hitec servos is 12.5 to 275 (at 4.8 volts battery voltage).
  - About 20% more at 6.0 volts.
- Transit Time (speed) (spec.)
  - Time to move through a 60 degree angle at 4.8 or 6.0 volts.
  - Range is < 0.1 to > 0.3 sec. at 4.8 volts.
  - About 15 – 20% faster at 6.0 volts.

Characteristics (cont.)

Centering (generally not specified) affected by:

- Electronics design (potentiometer quality & digital electronics)
- Gear slop
- Output Bearing slop
- Load Applied

- Size (spec.)
  - Coil actuators (< ½ inch in diameter)
  - Smallest “regular” about 0.73 x 0.3 x 0.59 inches (Hitech Ultra Feather).
  - Largest about 2.3 x 1.1 x 2.0 inches (1/4 Scale).

Characteristics (cont.)

- Weight (0.15 – 5.4 oz. or more) (spec.)
- Movement Range (not spec. except for 180 degree units.
  - Typically +- 40 degrees or more (80 degrees total) for aircraft servos.
  - Up to 180 degrees (+-90 degrees) for landing gear/sail control servos.
- Ball Bearings or Bushings on output shaft affect:
  - Lifetime (bearings last longer)
  - Position Accuracy (better for bearings)
  - Upgrade kits available to add bearings.

Characteristics (cont.)

- Coreless vs. Poled Motor. (brushless motors are now available).
  - Coreless motors have less inertia (start and stop quicker)
  - Coreless are more expensive to manufacture
  - Coreless less popular now with better poled motors and digital servo availability

Characteristics (cont.)

- “Plastic” or Metal Gears.
  - Brass, Titanium, etc.
  - Nylon, Karbonite, etc.
  - Metal for high torque, high impact areas (generally noisy and wear quicker).

More on How Servos Work

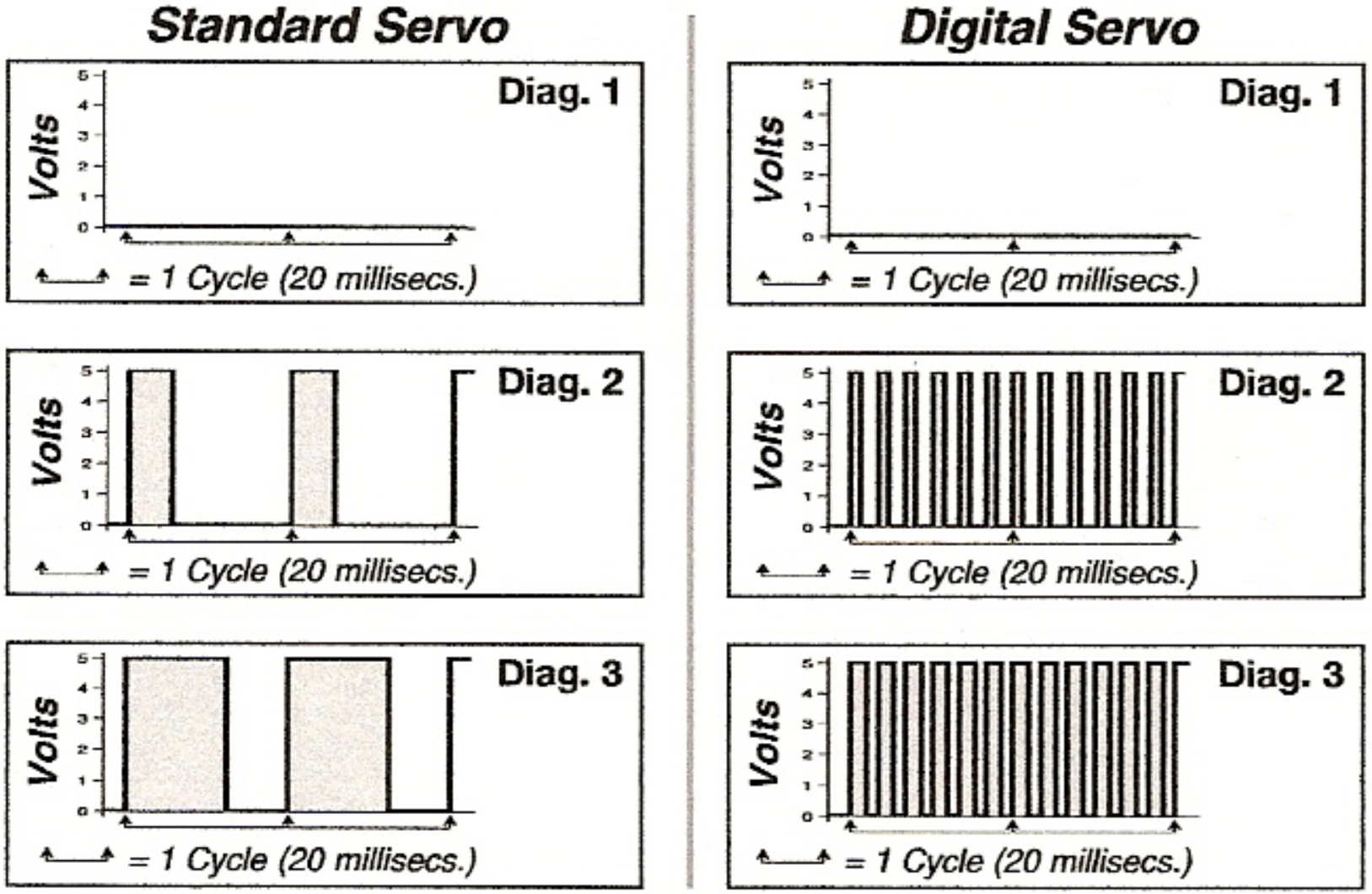
- One pulse doesn't do it. Somewhere between 5 and 15 pulses will come along before servo reaches destination.
- As servo reaches destination, less and less power is delivered to the motor. (None when at destination and no load applied.)
- An error is required before power is again delivered to the motor. Power delivered related to size of the error.
- Design tradeoffs exist in motor power, gear ratio, transit time, motor type, output torque, etc.

Digital Servos

- Input identical to analog servos.
- Digital refers to the electronics that process the error signal and drive the motor.
- Microprocessor does this and controls
  - Rotation direction
  - Range of rotation
  - Speed of rotation
  - Neutral point
  - “Dead band”
  - Fail safe point

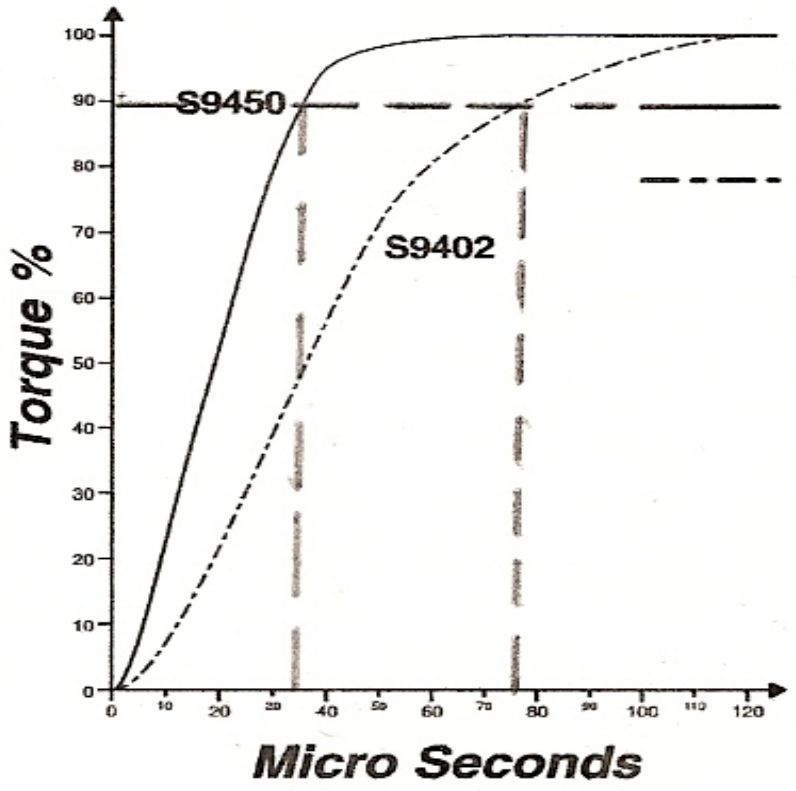
Analog vs. Digital Servo Internal Operation

(From Futaba Web Site)



From Futaba Web Site

Comparison between Digital and Standard Servos



Key:

- **S9450 - Digital Servo**
- **S9402 - Standard Servo**

This is a comparison graph showing the deadband between two Futaba servos with the same specifications. As you can see the S9450 has a far smaller deadband and applies more power far earlier than the S9402.

Practically, this means that if you tried to move the S9450 servo arm, its opposition response would be significantly quicker, more power/voltage would be applied earlier, resulting in greater holding power/torque and more accurate positioning.

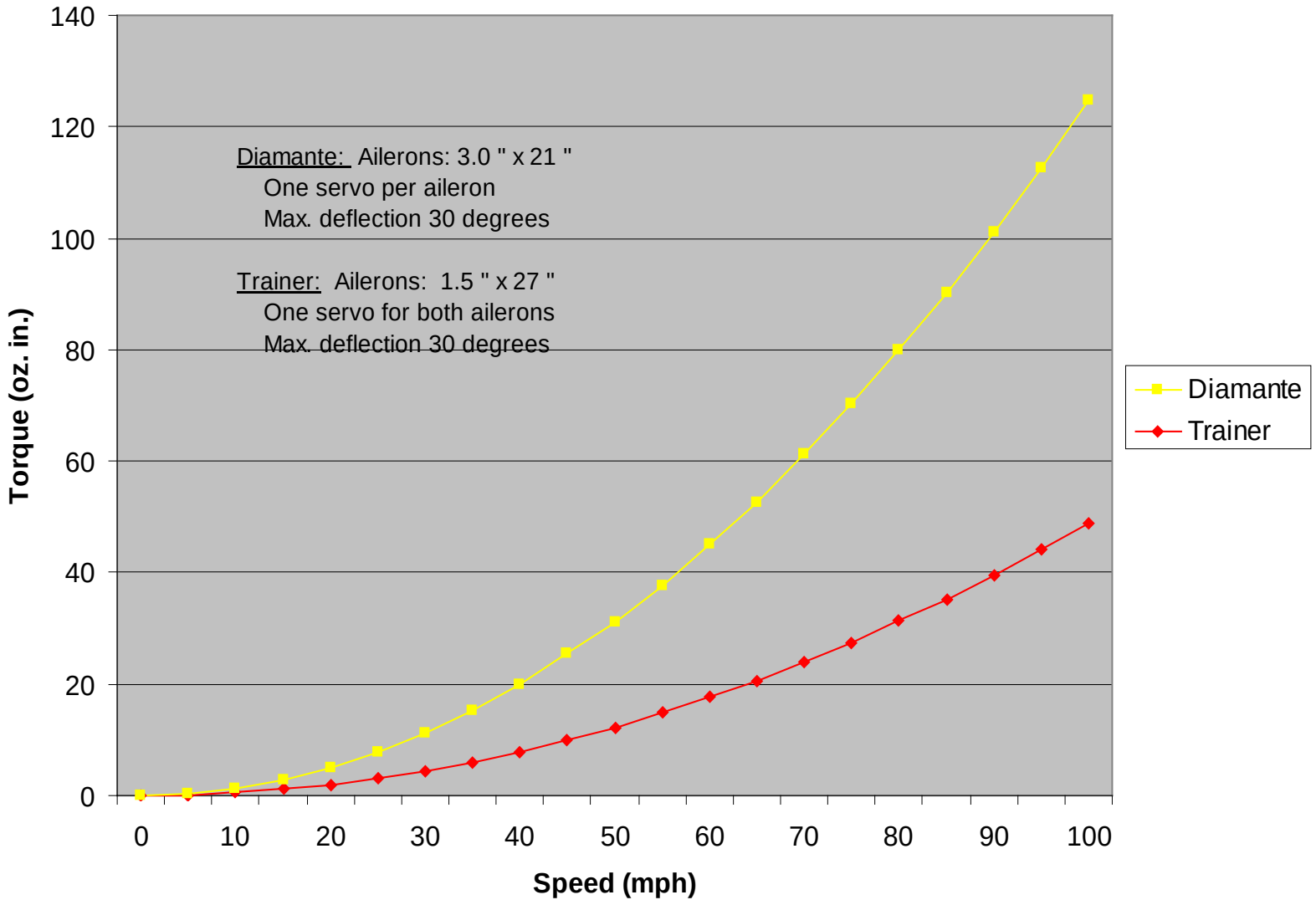
Mechanical Considerations

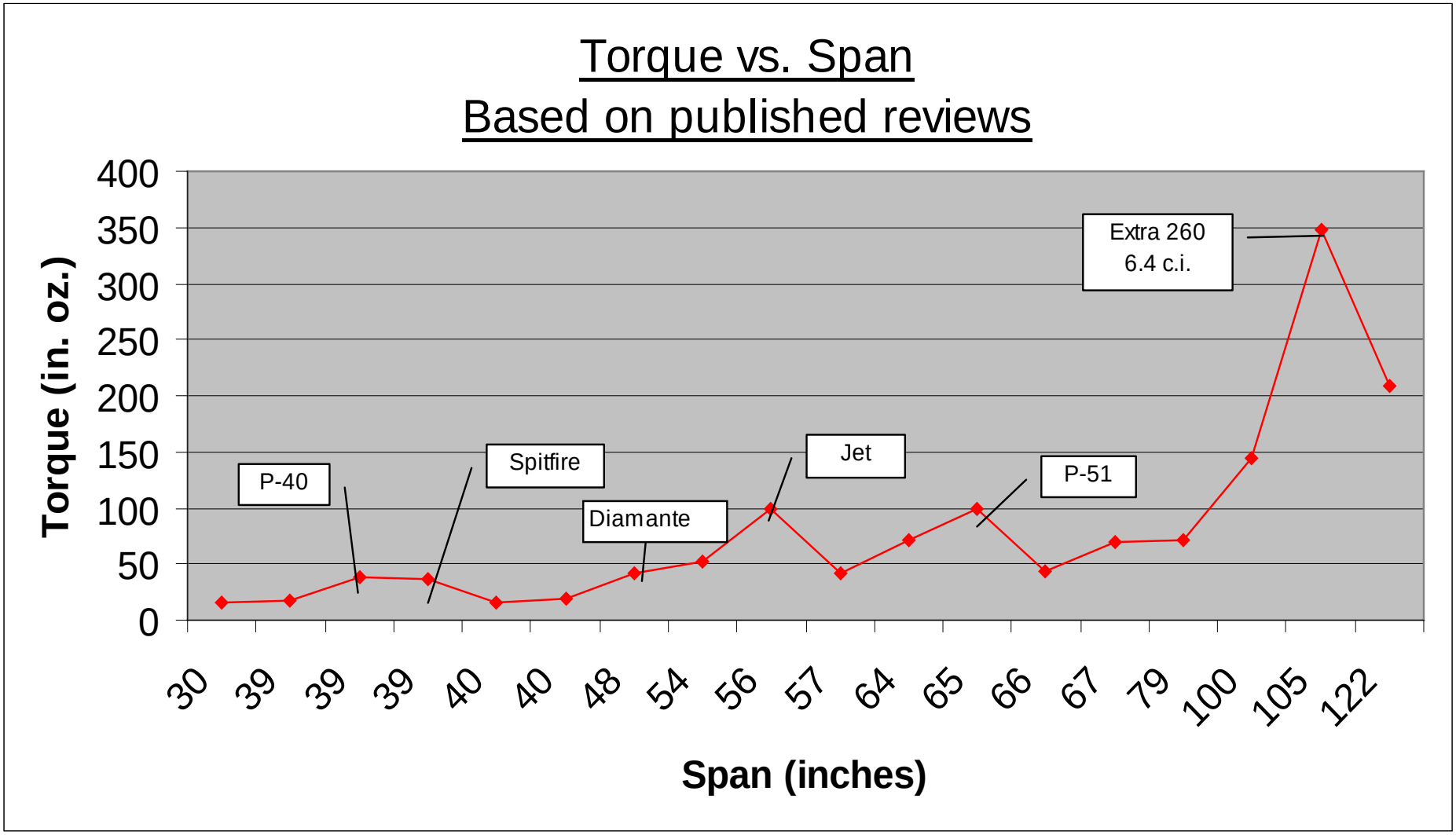
- Mounting
  - Screws/grommets
  - Double-sided tape
  - Hot glue
  - Etc.
- Linkage
  - Geometry
  - Pull pull
  - Multiple servos (per control surface, ganged.)

General Considerations for Choosing Servos

- Wing Span
- Flying Speed
- Control Surface
- Type of Flying
  - Precision (Need good centering &linearity)
  - 3-D (Need torque for maximum deflection)
  - Heli (Need high speed – tail rotor)
  - Scale (Need torque & possibly metal gears)
  - Boring holes in sky (Need cheap)

Calculated Servo Torque vs. Speed
From Electric Flight in Colorado Web Site




Torque vs. Span
Based on published reviews
Torque (in. oz.)
400
350
300
250
200
150
100
50
0
P-40
Spitfire
Diamante
Jet
P-51
Extra 260
6.4 c.i.
30
39
39
39
40
40
48
54
56
57
64
65
66
67
79
100
105
122
Span (inches)

Conclusions

- Theoretical torque calculations may get you in the ballpark but may be low because of assumptions made.
- Servo specifications are very useful, but not the only considerations in selection.
- Pay attention to the type of flying you will be doing and the specific control surface.
- Talk to other pilots flying similar airplanes.
- Heed the manufacturer/distributor's recommendations regarding servos.