Is It Here Or Isn't It?

by Al Doig

Interest in proportional radio control has rapidly increased during the past year. The reason for this interest is the current ability (if you have the money) to buy some equipment, to read about other systems, and to listen to flying field scuttlebutt about many more. The gestation period has been lengthly. Equipment has been appearing bravely on the field and retreating painfully to the laboratory. This is a perfectly normal procedure, but this time it has been carried out under the glare of spotlights!

When you finally lay out your hard-earned and considerably large bundle of scratch and take delivery on your shiny new Zilch Simultaneous Proportional — just what are you getting? How can Joe Modeler evaluate one system against another?

There are, in general, two kinds of control systems — digital and analog. In a strictly digital system the control information is carried as a number. That is, if a representation of the number 3 were transmitted, it might mean that an inclination of 3 degrees was desired, or that a **change** in setting of 3 units was wanted, depending upon the individual system. An analog design carries the information in a form that is generally measurable. That is, the measure of voltage represents the precise setting desired — or the frequency of a tone might represent the same thing. As the **measurable quantity** changes, the control changes in direct proportion.

The mechanization of these two types of systems is quite different. In general, circuitry for the digital system is capable of being in one of only two states. It is either **on** or **off**. A light switch is typical of digital circuits — it is either on or off. The light **dimmer** is representative of analog proportional control. Here, the angular position of the knob describes what brightness the light should be.

We might ask as a result of this explanation, "Does the analog system automatically mean a more smooth control?" No! Our light switch gives a very coarse control because we designed it with two numbers, 0 and 1 — that is, on and off. If we were to provide the operator with many more numbers to select from, the control could be made as finely defined as desired.

The previous discussion is, however, somewhat academic because there are no known truly digital systems designed for the model hobbyist. The discussion was useful, however, to describe types of circuitry used in each system. All so-called "digital" systems are a combination of digital and analog. They may be classified as digital, however, because the circuitry is predominantly of the digital type.

Analog systems are again of two general types — those that transmit tones whose frequency describes the desired control position (see "Ulti", American Modeler, May 1959) are of one class. Those that transmit pulses whose frequency and symmetry describe control positions form the other (WAG). These two classes have been effectively combined in some analog systems.

Digital systems are nearly always variations on the same theme. Strings of pulses are transmitted. Each pulse controls one function. The first, elevator; the second, rudder, etc. The control variable is the pulse width. Various schemes are used to decode or separate the pulses and transform pulse width information into servo position.

One feature common to both digital and many analog systems is the feedback servo. Early WAG systems were open ended. That is, the servo was told to go to a particular setting but there was no assurance that it really did. In present designs, the servo receives the desired command position. The actual servo position is defined by the position of a potentiometer which is driven by the servo shaft. The desired position is compared with the actual position. If these are not the same, an error signal is created which moves the servo until they **are** the same.

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Which system is better? Actually, there is nothing inherently "better" about one system or the other. Each has its own features and characteristics. The advantage of analog is its simplicity. This system **tends** to have less parts and be more straightforward. A big advantage of digital control is its expandability. An eight function receiver is little more complex than a four function unit.

Proponents of analog systems claim greater immunity to interference. This is possibly true, although from a practical standpoint it may be impossible to tell the difference. In analog systems, the devices used to discriminate the tones offer considerable rejection to disturbances. A digital system tends to be wide open unless the pulses are transmitted as bursts of tone. Noise or interference tends to appear as good information and can confuse the digital set. Steps are taken in the design considerations to prevent this, however, and there appears to be no observable difference. An on-frequency signal will clobber either system.

It appears that tighter control, more repeatable neutral, and smaller dead band is more practical with digital than analog. This statement will enrage analog proponents, and rightly so, as I would be hard pressed to prove it analytically. In my opinion, the single most important criteria to look for in a proportional system is deadband. In other words, how far can one slowly move the stick in either direction before the surface will move. A second important point is the speed of response. The sum of these two characteristics account for the stick action you have observed from some very good proportional pilots. Stick action in this case is not the smooth movement one might expect. When a change of control is desired, the stick is moved beyond the final point and returned to the proper position. The stick also is constantly being moved. This overtravel is necessary from either or both of two conditions. First with excessive deadband, and in order to get small changes, it is necessary to exceed the dead zone error in order to get the servo going at all. Therefore, the stick is moved beyond the point desired to start the servo moving and then returned to the proper spot to stop it. This overtravel control is also used to speed up the servo by applying maximum error voltage with exaggerated control movement. This starts the motor at maximum speed. The stick is then returned to stop the servo at the proper spot. A skilled flyer can fly this type of system wonderfully well. An unskilled flier will encounter difficulty — especially when using a sensitive, high-performance aircraft.

The crux of this whole problem is the nature of the proportional information from the receiver and the nature of the feedback signal from the servo. The tendency is to transform the information quantity (tone, pulse rate, etc.) into a D.C. voltage and compare this to a D.C. voltage divided down from a battery with a position potentiometer. As the information voltage tends to be in pulsating form, it is necessary to smooth it out. This is generally done with resistance-capacitance filters. It is desirable to smooth this voltage as much as possible. Filtering, however, slows the ability of the voltage to change level, thereby slowing down the response. Lack of filter will cause a ripple on the information voltage. When this is compared against the positional D.C. voltage, an error signal would be generated whenever the voltages were different — that is, at each ripple peak. This will cause the servo motor to continually "buzz" and draw current. The alternative is to build-in a dead zone to ignore the ripple and act only on larger changes. This tends to result in a control dead zone. The digital system would suffer the same disadvantage if it were mechanized in the same way. The saving grace here is the ability to generate feeback signals from the servo that have the same form as the information pulses. It is, therefore, useful not to transform into D.C. at all. The comparison in this case leads to an **error** pulse that is filtered and used to move the servo. This presents an entirely different picture. Hence, response can be very rapid and the error signal easily amplified to achieve excellent definition and minimum dead zone. The same principles could be applied to an analog system but not quite so easily.

We all live by comparison, and one popular comparison for proportional radio seems to be "is it smooth or jerky?" This is a valid comparison if one carefully observes what "jerky" really means. This goes back to our definition of dead-band. If, as the stick is moved, the servo follows by galloping, this means that the deadband is wide only if the increments of gallop are large. The thing to be careful of here is the ability of the servo to define the stick position. A jerk of a tenth degree is much to be preferred to a smooth gulp of several degrees. This is hard for many modelers to grasp. It is particularly important to have the servo loaded during these observations. If you have a chance to try this in a ship, pick a control with drag such as rudder with steerable nosewheel, or aileron with a sticky linkage.

Some people take to proportional flying like a fish to water — some don't. Most difficulties arise from habit and habitual reaction. For the flier converting from reeds, there will be a training period. The unfamiliar location of controls, coupled with the hard-learned automatic reaction to panic situations, create problems that have nothing to do with proportional control. Arguments will go on and on as to the relative merits of two stick versus one stick control. This really relates, not to the number of sticks, but the separation of aileron and elevator. At least one manufacturer offers this separation as an option. It is a real fact that almost no flier is able to simultaneously use two thumbs unless one is held still. When making a turn in a reed ship, aileron and elevator are beeped alternately, not simultaneously. It is this author's opinion that the single stick in one form or another will become the standard. Separate sticks will offer the easiest transition from reeds.

Most proportional sets install just like reeds. The notable exception is relative immunity from vibration. Some manufacturers are recommending no metal-to-metal joints anywhere if there is a possibility of rubbing contact such as pushrod connections, etc. It has been stated by these manufacturers that the noise generated at such points will cause malfunction under certain conditions of extreme range, etc.

The overall weight of proportional

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installations is usually a little less, simply because one less servo is required (no elevator trim).

Reliability should be nearly as good as reeds, but not quite. These systems are more complex and have many more parts to potentially fail than do reeds.

Ability to function over wide temperatures should be every bit as good as reeds and perhaps better. Most sets should function from freezing to 140 degrees with little change in characteristics.

The cost of proportional sets will be quite high for some time. Analog sets will tend to cost less than digital. The price tag startles one upon first glance but if time is taken to add up equivalent equipment to operate a reed set, the difference is not as great as was assumed at first glance. The prospective buyer is just not conditioned to see the cost of servos, battery packs, plugs, etc., all in one lump package.

We seem to have turned the corner on the age of proportional control, and I for one have joined the rush to my friendly hobby dealer.