

F & M ELECTRONICS, INC.

DIGITAL-5

**PROPORTIONAL
CONTROL SYSTEM**

INSTRUCTION MANUAL

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Congratulations on your purchase of the F & M Digital-5 Proportional Control System. This equipment is the most proved digital system available today. Over two years of engineering research and development brought about this equipment, and its reliability and control capabilities are truly unsurpassed. With proper care and competent installation, you will enjoy hundreds of hours of proportional flying with a minimum of trouble. Due to the complexity of this equipment, it is extremely important that you thoroughly read and understand the entire contents of this manual before attempting to use this equipment. Time and again, we have found that sets have required factory maintenance strictly because this precaution was not followed.

WARRANTY

The Digital-5 is warranted against defective materials and workmanship for a period of 90 days from date of purchase. F & M assumes no liability for damage to equipment or to property resulting from crash of your model. Equipment showing crash damage will not be covered by warranty. IN ORDER FOR YOUR EQUIPMENT TO BE COVERED BY WARRANTY, THE ENCLOSED CARD MUST BE FILLED OUT AND MAILED. Due to the complexity of the equipment, a \$12.00 service charge will apply to sets covered by warranty. ANY abuse or tampering with the set will void the warranty.

SPECIFICATIONS

Transmitter:

Case: Blue anodized aluminum
Size: 6-1/4" x 2-3/4" x 8"
Weight: 2 lbs. 12 oz. with battery-pack
Antenna: Base loaded, 56" telescoping chrome,

Battery Pack: 7.2 Volt rechargeable nicad with 1.2 ampere hour rating.
Current Drain: 240 Milliampere
Power Output: 0.8 Watts
Circuitry: RF; all silicon, MOPA circuit using pulse modulation.
Digital: All silicon, fully saturating capacitively coupled circuitry.

Receiver:

Case: Blue anodized aluminum
Size: 2" x 1-5/8" x 3"
Weight: 6 oz.
Antenna: 40" insulated wire
Battery Pack: 8.4 Volt rechargeable Nicad battery pack rated at 600 MAH at 5 hr.
Current Drain: Receiver 45 milliamps typically. Receiver with four servos approximately 85 milliamps.
Sensitivity: Better than 3 microvolts
Selectivity: 6 db down at 2 Kc off carrier frequency, 30 db at 10 Kc, 70 db at 50 Kc.
Temperature Range: 0° F to 160° F.
Circuit: RF; all silicon superhetrodyne with AGC rf amplifier stage and 3 IF stages.
Digital: All silicon, using fully saturating flipflops with silicon diode decoding.

THEORY OF OPERATION

The F & M Digital-5 Radio Control System makes use of the digital technique known as Pulse Duration Modulation, commonly referred to as PDM. This technique is widely used today in the transmission of information to and from missiles and satellites.

To understand how PDM actually works, consider the control of a single servo, say the aileron servo, in your system. Thirtytimes each second, the transmitter sends out a pulse which is routed (by the receiver) to the aileron servo. When the aileron control stick is in the center position, this pulse is 0.0017 seconds long (1.7 milliseconds). Inside the servo, a pulse is generated whose length is dependent upon the position of the servo arm. When the servo arm is in the center position, the pulse is 0.0017 seconds long.

Assume now that the servo is in the center position and that the corresponding control stick is also in the center position. When the pulse from the transmitter is received, its length is compared to the length of the pulse generated inside the servo. In this case, both pulses would be 0.0017 seconds long and the servo would thus sense that it is in the correct position and the servo arm would not move.

Assume now that the servo is in the center position and that the corresponding control stick is as far to the left as it can be moved. With the stick in this position, the transmitter will send out a pulse which is 0.0011 seconds long. When the servo receives this pulse, it will compare it to its own 0.0017 second pulse (remember it is this length because the servo is in the center position). Because it finds that the pulse from the transmitter is shorter than its own pulse, the servo will generate a signal telling the motor to run in the direction which will move the servo arm to the left.

Now, as the servo moves farther and farther to the left, the pulse generated by the servo will become shorter and shorter. In one-thirtieth of a second, the transmitter will again send out its 0.0017 second pulse. When the servo receives this pulse it will have moved a short distance to the left so that its

own pulse is about 0.0016 seconds long. Because the transmitter's pulse is still shorter, the motor will continue to drive the servo arm to the left. In about 1/2 second, the servo will have moved toward the left until its own pulse is 0.0011 seconds long. Then, the next pulse it receives from the transmitter will be the same length as its own pulse (0.0011 seconds) and the servo motor will stop.

This should illustrate the advantage of the feedback servo. Because the servo is continually "feeding-back" information indicating the position of the servo arm, it can always position the arm as directed by the control stick. If the stick is moved $X\%$ of the way toward the left, the servo will move exactly $X\%$ of its travel toward the left and will remain there until the stick is again moved. Let us now consider how the Digital-5 is able to control up to five servos. Figure 1a shows the RF signal out of the transmitter with all controls set in the center position. Note that the carrier, or RF signal is on almost all of the time. It is turned off for about 0.0004 seconds to signal the end of the pulse from each of the five controls. The time between the 2nd and 3rd OFF period is the duration of the signal generated by the engine control stick. Following that are the pulses for Aileron, Elevator, Rudder and Auxiliary. The two extra OFF periods are used by the receiver to make sure that each pulse is routed to the proper servo. The pulses shown in Figure 1b show what happens if the aileron stick (only) is moved to the far left. Note that the aileron pulse duration is shortened while all others remain the same. Figure 1c shows the carrier if the Aileron and Rudder controls are moved to the left and the Elevator, Engine and Auxiliary are moved all the way down. Figure 1d shows the carrier if the Aileron and Rudder controls are moved to the right and the Elevator, Engine

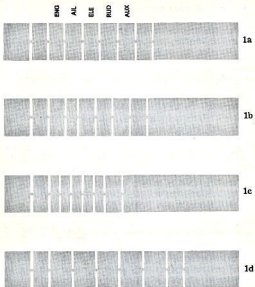


Fig. 1

and Auxiliary are moved all the way up.

In the receiver, a Digital Decoder sorts out all these pulses and routes them to the proper servos. In each servo, the pulses are operated upon as previously described.

FAIL SAFE

The Digital-5 receiver is equipped with a special F & M Fail Safe feature. The Fail Safe is provided to protect you against interference from other flyers who may have accidentally turned on a transmitter to your frequency, interference from CB or commercial transmitters, and it also protects you against loss of signal. Interference generally shows up as additional pulses on the carrier while loss of signal results in less than the normal 8 pulses. The Digital-5 receiver is constantly checking to see that there are 8 pulses on the carrier. Anytime there are more than 8 or less than 8 pulses, the receiver will automatically reject the bad carrier and go into Lock Out or lock all controls in their last position. The controls will remain locked for 1-1/2 seconds. At the end of this time, if the RF signal is still in error, the system will go into Fail Safe. This means that the engine servo will go to low throttle position and all other servos will go to their center position. If your plane is properly trimmed, it will go into a shallow glide at low throttle and should land without too much damage.

What if the interference or loss of signal is only temporary? Anytime that the proper signal returns to the receiver, the pilot immediately regains control of the airplane. If the trouble lasts less than 1-1/2 seconds, control will be regained while the system is still in Lock Out and the plane will not go into Fail Safe.

There are people who are opposed to the Fail Safe

feature and there are proportional systems sold which have no Fail Safe. Since you now own the F & M Digital-5, you should be aware of the argument of those opposed to Fail Safe. Their argument is primarily as follows: "If you trim a plane so that it will glide properly when in Fail Safe, then you cannot fly it as a class III stunt plane. In fact it is like flying a radio-controlled free flight model." This statement shows a complete misunderstanding of the entire Fail Safe concept. Those who present this argument do not understand that THE FAIL SAFE TRIM OF AN AIRPLANE HAS ABSOLUTELY NO EFFECT ON THE FLYING TRIM. The trim settings at which an airplane is flown are in no way related to the trim settings established for good Fail Safe operation.

It has been demonstrated that 99% of the stunt planes flown can be trimmed so that they will recover from ANY maneuver or ANY attitude if they go into Fail Safe. The procedure for establishing Fail Safe trim is explained later and should be followed exactly if you are to receive all the benefits of the feature.

ASSEMBLY INSTRUCTIONS

In order to bench test your complete Digital-5 system, follow the directions in this section. Remove the transmitter from the shipping container and slip the back off the case. Next, insert the crystal into the crystal socket on the transmitter circuit board. The crystal is in the lower left hand corner of the shipping container and is marked with your frequency. Make a note of this frequency and place the proper colored flag on your antenna.

<u>Frequency</u>	<u>Flag Color</u>
26,995	Brown

<u>Frequency</u>	<u>Flag Color</u>
27.045	Red
27.095	Orange
27.145	Yellow
27.195	Green
6 Meter (50mc)	White

With the transmitter standing upright, facing you, the crystal socket is found on the extreme upper left hand corner of the circuit board. Now, check to see that the nuts are securely tightened on the battery posts to insure that they did not loosen during shipping. Now, slip the back on to the transmitter and install the 4 self-tapping sheet metal screws along each edge. NOTE: Failure to install these screws may cause electrical noise which is detrimental to the proper operation of the transmitter. Next, insert the antenna into the red grommet and screw up tight. You may now bench test your rig as follows: Plug the battery pack into the switch harness and the switch harness into the proper receiver plug.

Plug the 4 servos into the yellow, white, orange and black servo connectors. Unwind the receiver antenna. You should now have control of all 4 servos with the transmitter switched on and the receiver harness switch in the proper position. NOTE: Be sure to save both the cardboard carton and the foam shipping container for use in mailing your equipment in the event that repairs are necessary.

EXPLANATION AND DESCRIPTION OF EQUIPMENT

The control sticks on the transmitter are arranged as follows: The right hand stick gives primary flight control, left-right movement controls aileron and up-down controls elevator. On the left stick, left-right controls rudder and up-down controls engine

speed. Because of the mechanical characteristics of the control sticks it is impossible to change their functions. In other words, the throttle control, for example, cannot be moved to the right stick. The panel located in the left center has two controls, the left being the auxiliary channel and the right is wired for throttle trim. If an additional channel is desired, this lever can be wired for the sixth channel. The controls will function as described when the servos are connected according to the following servo plug color code.

<u>Servo</u>	<u>Color</u>
Engine	Yellow
Aileron	White
Elevator	Orange
Rudder	Black
Auxiliary	Green

BATTERY CHARGING

The transmitter must be charged with the power switch off. While on charge, the transmitter meter indicates that charging is taking place.

Top quality batteries are supplied with your equipment, but they do not have an infinite life. You should check your receiver battery pack every six months using the following procedure: Charge the pack for a full 16 hours. Using standard glow plugs, connect two plugs in series and touch the two between pins 1 and 2. The glow plugs should light up and remain lighted for 5 seconds. Next, repeat the same procedure between pins 1 and 3. Using three glow plugs in series, test between pins 3 and 4. If all glow plugs do not remain lighted for 5 seconds in all three steps, your battery should be replaced. This procedure is not necessary for the transmitter battery pack as its condition is verified by the meter indicating correct output power.

It is recommended that replacement battery packs be purchased from F & M. The transmitter pack costs \$29.95 and the receiver pack \$34.95. If you wish, you may also purchase additional chargers for the transmitter for \$4.95 and the receiver for \$5.95.

INSTALLATION

It is strongly recommended that the installation hints outlined below be followed as closely as possible. Many thousands of flights by F & M personnel plus innumerable reports from customers have pointed out the necessity for correct installation.

Servos

Servos may be either bolted through the servo board or screwed into the board with wood screws. The wood screws used for this purpose should be #4 at least 3/8th of an inch long. It is extremely important that the rubber grommet supplied with your equipment be used on all four mounting screws. It has been established beyond doubt that the servos are subjected to worse vibration than any other component in a control system. The vibration stress in an airplane can exceed 40g's. If the servos are not all isolated by the rubber grommets, this vibration can fatigue the wiring and the component leads in the servo and cause failure after only a few flights.

Be sure to install the servo marked EFS for your throttle control. Also make sure that the dot on the servo is at the end in which direction the servo arm must move to cause low throttle. One bad practice involving servos shows up quite often in the installation of strip ailerons. Some flyers make a very neat installation by attaching a bell crank directly to the servo case. This is not a safe practice and often interferes with proper operation or severely limits the life expectancy of the servo.

Equipment which has been used in this fashion will not be covered by warranty.

Pushrods

Pushrods should be made such that the piano wire portion is no longer than it absolutely need be. The one exception is that the throttle linkage may be entirely of piano wire. If entire pushrods are piano wire or long pieces of piano wire are used at the end of balsa or hardwood pushrods, when your plane is in certain attitudes, this metal will interfere with or shield the receiver antenna. A very adequate pushrod may be constructed using 1/4" square hard balsa with piano wire end pieces no longer than 4" tied to the balsa with nylon hinge thread and heavily glued. It is suggested that 1/16" piano wire be used for this.

It is very important that no metal to metal contact be used in your installation. This means that you should not use piano wire into a metal bell crank or control horn and that you must not permit the metal portion of pushrods to rub against each other. This is an extremely important precaution because metal-to-metal contact can easily create electrical noise which may interfere with proper operation of the receiver.

On the throttle servo, a very effective installation can be accomplished by attaching a piece of brass tubing to the fuselage and using this as a guide for the piano wire pushrod. It is permissible to use an all-wire pushrod here because of its distance from the antenna. The reason that the metal-to-metal contact is permitted is because the length of the pushrod assures that there is constant contact between the piano wire and the tubing and as a result, no harmful electrical noise is generated.

It is critical that you make sure that none of the servos is hitting a mechanical stop on the linkages

before the servo has reached its full travel. This problem generally comes up on the throttle linkage but can occur on the other controls as well.

Control Horn Length

In spite of the experience gained through flying reed equipment, most good proportional flyers recognize that the control surface movement required for proportional equipped airplanes is significantly less than that required for reed equipment. We suggest that you start your proportional flying with a control horn linkage further out than is normally used on reed equipment.

Switch Installation and Use

It is recommended that the switch and harness assembly provided with your equipment be used to make your flying more enjoyable. The switch should be mounted to the side of the fuselage away from the exhaust of the engine. It has become "standard" procedure to wire the switch such that the "on" position occurs with the switch slide pushed towards the nose. If this procedure is followed, it makes receiving and giving help to a fellow flyer a little simpler. The switch that F & M provides is a two pole switch. This means that only two of the four battery pack wires are cut off and is permissible because the current drain is so low on the remaining two wires (100 microamps). The additional reliability attained by using a two pole switch instead of four poles certainly outweighs this slight battery drain. This battery drain is not noticeable when the switch is turned off between flights even during an all day flying session.

Receiver and Battery Pack Installation

The receiver and battery pack should each be

wrapped (separately) in 1/4 or 1/2 inch foam rubber and taped or rubber banded in such a fashion that all sides and especially all corners are adequately padded. It is suggested that if partitions are used to form battery and/or receiver compartments in the fuselage, that the compartments be very roomy and not compress the foam rubber any more than is necessary.

The receiver antenna should be extended to the top of the fin and attached by tying the wire to a rubber band and hooking the rubber band over the fin. We cannot over-emphasize the importance of this very simple warning: DO NOT, in any manner or fashion TAMPER with the receiver antenna. Do not remove insulation and secure on a metal hook, do not attach any plugs, loading coils, or change the length. The antenna functions as an active portion of the RF coil of your receiver and, as such, effects the tuning of the receiver. Any change to the antenna therefore, will detune the receiver and thereby reduce your sensitivity and range.

Extensive experience and flight testing by F & M has established that the most effective antenna merely runs from the receiver compartment to the top of the fin. No other routing of the antenna should be used.

Trim and Fail Safe

With all of your equipment installed, now turn on the transmitter and receiver switch, verify that all controls work properly, and move in the correct direction.

Set the control tabs on all of the sticks in the center position and then turn off the transmitter. The transmitter's being off is interpreted by the receiver as "loss of signal" and, after a 1-1/2 second delay, the system will go into Fail Safe. Remembering now that in the Fail Safe conditions you want your airplane

to go into a shallow glide with low engine throttle, you must then adjust the servo linkages so as to achieve this.

It must be emphasized that in Fail Safe, there is no contact between the transmitter and the airplane and for this reason the trim adjustments on the transmitter in no way affect the Fail Safe condition. Please keep this in mind and establish the proper Fail Safe attitude only by adjustment of the servo linkages. In other words, after you have gotten your system to Fail Safe on the bench, forget the transmitter and don't turn it on again until you have finished with all of the linkage adjustments.

The Rudder and Aileron linkages should be adjusted so that these control surfaces are in their exact center or neutral positions. This establishes that your plane will not have roll or yaw tendencies in Fail Safe. The engine throttle linkage should be adjusted to give the slowest reliable engine idle speed. It is important that you do not set this speed so low that there is a chance of your engine quitting.

The Fail Safe elevator position is sometimes somewhat confusing to the flyer and for this reason will be treated in some detail. Because we want our airplane to go into a shallow glide and because the throttle is low in Fail Safe, it is necessary that the elevator be in a slight "up" position in Fail Safe.

Make your adjustment in the elevator linkage such that the trailing edge is about 1/16" above the neutral position. As explained later, this position is only a starting point and will be better adjusted on your early flights.

Having now completed all your linkage adjustments, turn on your transmitter and check that operation of all controls is proper. Now hold both sticks in an extreme corner of their travel and while in this position, turn off the transmitter. After the 1-1/2

second delay, the controls should all Fail Safe to the positions previously established. Again turn on the transmitter and by means of the trim tabs, set the Aileron, Elevator and Rudder in the neutral position and the Engine Throttle at low. In this condition, turn off the transmitter and notice that when the system goes into Fail Safe, the elevator kicks up slightly and the other controls move very little, if any. This is proper Fail Safe operation.

PROPORTIONAL FLYING

As you are well aware, it is impossible for you to become a contest flyer by reading a few words. However, if you have not before flown proportional it is hoped that the following information might make your transition a bit more enjoyable (and less expensive).

It is recommended that the transmitter be used with a neck strap. It has been found that a standard saxophone strap is very nice for this use and this can be purchased from your local music store very reasonably. The saxophone strap should be attached to the transmitter by installing a #4 self tapping eye screw into the hole provided in the center of the transmitter. Through the use of this strap, it is possible for you to, at all times, keep both hands on the control sticks.

It is advisable, particularly while learning, to get into the habit of "working the stick off neutral". In other words, at the completion of a maneuver, release pressure on the stick and let it return to its neutral position.

There are two main precautions which should be borne in mind while flying: 1. Do not touch the antenna, and 2. Try not to point the transmitter antenna at your airplane more than is necessary. The antenna's radiation pattern is weakest in the direct-

ion in which it is pointing. Normally, the field strength in this direction is adequate, but if interference does exist, it is advisable that the antenna be pointed in another direction to maximize your signal strength.

The following suggestion is an obvious one but should probably be made anyhow; if at all possible, ask an experienced proportional flyer to take your ship up on its maiden flight and get it trimmed out properly for you.

On your initial flight, or at least a very early flight, test your airplane trim in Fail Safe by doing the following: take your airplane to a safe altitude and while in straight and level flight, turn off your transmitter. After a 1-1/2 second delay, you will notice that the engine goes to low throttle. The equipment is now in Fail Safe condition. The plane should automatically go into a gently glide with no roll or turn tendency. Control is regained by turning on the transmitter. If you are not satisfied with the Fail Safe attitude of the airplane, you should immediately land it and make the appropriate corrections in the linkages. It must again be emphasized that correct Fail Safe flight can be achieved ONLY through adjustment of the control linkages—the trim adjustments on the transmitter have no effect on Fail Safe flight. You should repeatedly make flights to test your Fail Safe attitude and continue adjusting the linkages until the proper conditions are established.

REPAIR AND REPLACEMENT

In the event that it is necessary for you to return your equipment to the factory for repair or maintenance, you should do the following:

1. Keep the shipping container and cardboard container in which you received your equipment and

be sure to use them when shipping your equipment back to F & M. *Note: Remove crystal from transmitter & place in crystal compartment in container.*

2. Always send all components of your system when repair is required. Even though you feel that you have located the problem, it is often found that there are compound causes and in order for us to make sure that everything is operating properly, we must have all the components. It is also important that you include a note with your equipment carefully explaining all of the symptoms of your problem. Because your Digital-5 system is a complex and very specialized piece of gear, we strongly advise that you do not permit any one other than our trained personnel to attempt repair of your equipment.

It is F & M's policy to exchange new equipment for equipment which has been damaged beyond repair for 50% off retail price.

SIX METER OPERATION

If you so desire, F & M can modify your equipment at any time to operate on the 6 meter band. Many flyers prefer operating on this frequency because of the wide spread presence and voice communications and other interference on the 27 mc citizens band. The charge for this modification is \$12.00. Here again, if you wish to convert your system, you should send all of your equipment to our factory.

REPLACEMENT COSTS

In the event that you would wish to purchase replacement items or duplicate some of the equipment you have, the following prices would apply. All of this equipment can be purchased through your local

hobby dealer.

Transmitter including Battery Pack *	..\$199.50
Receiver\$169.50
Transmitter Battery Pack\$ 29.95
Transmitter Charger\$ 4.95
Comb. Trans. Battery Pack & Charger\$ 34.95
Receiver Battery Pack\$ 34.95
Receiver Battery Charger\$ 5.95
Comb. Receiver Battery Pack & Charger\$ 39.95
Switch Harness\$ 4.50
Servos\$ 39.95

*Transmitter may be purchased only with Battery Pack.