CHAPTER 7

BASIC AVIONICS TEST EQUIPMENT

Every shop requires various items such as test panels, interconnecting cables and power supplies. Some are required to evaluate avionics but do not perform any evaluation of their own. A test panel, for example, may not provide a test function but is required to operate avionics under test. This includes receiver/transmitters that require a frequency selection device, a loudspeaker and a microphone to operate.

POWER SUPPLIES

Power for an avionics system is typically 14 or 28 volts DC and, for large aircraft, 400 Hz AC. When the avionics are removed from the aircraft, the appropriate bench supply is required.

There are bench power supplies available for any type of service. Laboratory power supplies, however, may be too good for powering avionics equipment on the shop bench, and are used in engineering development.

Avionics are designed to operate with, essentially, terrible power sources. Voltage can fluctuate 10% or more, noise spikes and ripple voltage often ride on the power wiring. Compare this with 0.01% regulation, millivolt ripple and no glitches in the laboratory power supply, and it is easy to see why such supplies are more appropriately applied to design work.

One important area for the bench power supply is that of fail-safe. Most supplies have crow bar circuits to insure that output voltage will not rise to its full capability in the event of a failure. Applying twice the rated voltage to an avionics system could cause considerable damage.

A power supply of about 20 amperes at 14 volts and 10 amperes at 28 volts should cover most avionics systems. One power hungry system is the HF transceiver. Many transmitters operate at more than 100 watts output, which requires about twice that as input
power. The output rating is a peak envelope power figure but a single tone test for a short period could occur at the peak output power.

**AUTOPILOT**

Another power hungry system is the autopilot, particularly if servos are involved. Servo motors of a large autopilot can draw hundreds of watts, more or less intermittently. Even though intermittent periods are only a few seconds, the power supply must deliver this energy. Autopilots, however, are not generally tested as a complete system out of the aircraft. Servos are usually tested alone on a special test fixture.

A problem with autopilot servos (which affects all motors) is inductive transients. The DC motor appears as a large inductor, and applying or removing it generates large voltages. These surges are placed on the primary DC power, and avionics systems are designed to withstand such spikes. Not all laboratory supplies, however, are capable of withstanding high voltage spikes and may be damaged. There are simple, robust power supplies with voltage stability and purity suited for avionics systems that can withstand abuse without failure.

When selecting a power supply for the avionics shop, current capability should be greater than the highest load expected. Supplies cannot be connected in series or parallel safely and the highest current and voltage requirements must be met by one supply.

Be sure to read the fine print of power supply voltage and current specifications. Most linear supplies generate a DC voltage considerably higher than the maximum output voltage and drop the voltage through large transistors. They dissipate quite a bit of power. Load current passes through the transistors, which are also dropping higher voltage down to load voltage. This means that more power is dissipated within the supply when it provides lower output voltages. Because of this, some supplies produce lower output current at lower voltages. This restriction is the opposite of avionics equipment; 14 volt
avionics require more current than do 28 volt units. The caution is, read the current capability of the power supply carefully.

**CURRENT LIMITING**

A useful feature in a power supply is a current limiter. Laboratory power supplies have an adjustable current limiter that serves as a simple electronic circuit breaker or allows the supply to operate as a constant current source. Operating avionics from a constant current generator could be dangerous. When a supply is in the constant current mode, reduction of current could cause an increase in power supply voltage. As an example, if a 28 volt transceiver box and indicator are powered from the supply and the current limit set to the supply current, the voltage would nominally be 28 volts and the supply current nominal. If, however, the transceiver were removed from the test harness, the indicator current would be considerably less than the total of transceiver and indicator. The open circuit voltage of the supply could rise in an attempt to establish the set current. This open circuit voltage rises as high as the supply capability. In many supplies it could be two or three times the nominal voltage. In this example, an extremely high voltage could damage the indicator.

Current limiting of a power supply can be safe if set properly. First, remove the load from the supply and set the desired open circuit voltage. To set current, if the current limit control is calibrated, simply set the desired limit. If the control is not calibrated, and many are not, there are two methods to set the limit. First, short the output terminals of the supply and set the control while observing the current meter. Second, set the limit control to maximum current while the equipment is powered up. The current limit control is reduced until supply voltage just begins to drop, indicating that current is being limited by reducing the applied voltage.

The danger with this technique occurs when the unit being tested has an overcurrent problem, before current is limited. The full current capability of the power supply is applied to the unit under test before the control is set. When a unit under test is known to draw excessive current (because the unit trips circuit breakers in the aircraft) do not use this technique for setting the current limit.

A second type of current limiting removes the applied voltage if current exceeds a set point. This is more like an electronic circuit breaker and requires a reset switch to restore power. This type of current limiting requires a calibrated control.

Power supplies have not changed much in 20 years. High efficiency switching supplies are available but as far as operation and front panel controls, they do virtually the same thing. Older designs use mechanical D’Arsonval meter movements for voltage and current indications. To save cost, one meter might serve both functions. Power supplies with digital meters were once deluxe units but the cost of mechanical meters has risen, while digital meter prices have fallen. It is more cost-effective to provide digital voltage and current read-outs than mechanical meters. When purchasing a new power supply, buy a unit with digital voltage and current indicators; they are more accurate, easier to read and often less expensive.

**400 HZ**

In the repair shop, there may be requirements for 400 Hz AC to operate servos or power avionics of larger aircraft. Where no air transport avionics are expected, 400 Hz requirements can be met by a static inverter. These supplies are also used in aircraft where
no 400 Hz generator is available. There are a number of manufacturers of static inverters and a 50 watt unit is often enough for the avionics repair bench.

Power input to the inverter is typically 14 or 28 volts from a dedicated power source or the same power supply used for the equipment under test. A drawback of using the same power source is that if both 14 and 28 volt equipment are serviced, the static inverter input will have to be changed.

A small, fixed-output power supply could be dedicated to the static inverter for a continual supply of 400 Hz power. There are manufacturers of power supplies called, “bricks”, “blocks”, “open frames” or other names. These supplies have a line cord and output terminals, and come in voltage ranges that may be adjusted slightly. Twelve volts is common and some supplies have internal adjustments for raising the nominal voltage to 14. Another common voltage is 15, which can be lowered to 14. There are similar power supplies in the 28 volt region.

In a shop where there is considerable instrument repair, a source of 400 Hz power, where frequency and voltage may be varied, is a better choice than the fixed-output static inverter. There are 400 Hz power supplies for low power levels where voltage and current are adjustable.

When a source of more than 50 watts is needed for air transport equipment, a large 400 Hz power supply is required. These units are available in a variety of power ranges from about 100 watts to many kilowatts. They are available in single and three phase versions, and can have variable frequency and adjustable phase, in the case of a three-phase power source.

One common method of supplying 400 Hz power is a motor-generator (M-G) set. It is an AC motor which turns a 400 Hz generator. M-G sets are available in power levels from about a 100 watts to thousands of watts. Like the variable power supply described previously, single and three phase versions are available.

Some attributes of the M-G set are not attractive. They are large and usually generate audible noise. M-G sets are typically located in an equipment room so the noise will not disturb anyone. Most do not have adjustable frequency and, to make matters worse, frequency varies as a function of load. If a heavy load is applied, the driving motor slows down and reduces the 400 Hz frequency. Because the generator has brushes, the output may contain brush noise.

There is another way of viewing weaknesses of the M-G set. Its characteristics resemble actual conditions in an aircraft, where 400 Hz power is also supplied by a generator. On the other hand, its weaknesses have caused the static inverter to gain acceptance for instruments to provide cleaner, steadier 400 Hz.

**AUDIO GENERATORS**

The first and most widespread use for the audio generator is to modulate radio transmitters. Another application is troubleshooting and testing audio panels and intercoms. When an audio generator provides signals for transmitters and audio equipment, the test is called a single tone test and is not ideal for transmitter testing. This is particularly the case with SSB (single sideband), where a single tone test is virtually worthless. To
effectively measure an SSB transmitter, two audio frequency tones within the speech range of 300 to 3000 Hz are applied. The tones are typically equal in amplitude and not harmonically related. The single tone test, although not ideal, is acceptable for routine amplitude modulation testing.

Rigorous transmitter tests require two tones but single tones are easier to use for troubleshooting. The two tones, being not harmonically related, mean that when an oscilloscope is triggered on one of the tones the other appears to move on the oscilloscope screen. It is desirable to view the peak of the test signal to determine distortion, which is difficult on a two tone signal.

No unusual features are needed for an audio source for voice transmitter testing because the transmitters are not high-fidelity and operate over a narrow range of audio frequencies. The ideal source would be two inexpensive audio frequency sine generators. The two are combined with a simple resistive network and function as a two-tone source, or one generator as a single-tone source. Shops that never repair SSB transceivers can survive with only one audio generator.

**ADF ANTENNA BOX**

The Automatic Direction Finder uses a directional antenna as an integral part of the system. Without the antenna, the ADF cannot function. To operate the ADF in the shop, therefore, a signal simulator and ADF antenna are required. To simulate a received ADF signal, the antenna is placed in a known magnetic field, where the field is a signal in space with known magnitude and direction. The ADF signal is generated by creating a magnetic field within a large aluminum box. The carrier frequency is provided by a signal generator. An ADF antenna matching the receiver to be serviced is placed within the ADF simulator and connected to the receiver.

A repair shop may have several ADF antennas for placing within the ADF simulator so several models may be serviced. Most failures, however, occur within the receiver rather than the antenna. The antenna contains few components although it is vulnerable to environmental damage at its location. Unless the antenna is suspected of being faulty, most ADF problems involve removing only the receiver and leaving the antenna in place. If the receiver is operational, the antenna is removed from the aircraft and placed in the signal simulator.

ADF receivers have two antennas: loop and sense. Most modern receivers locate both loop and sense antennas inside a common assembly. ADF signal simulators require a mounting plate for the specific antenna and an adapter box to couple the signal generator to the sense antenna with the correct amplitude and phase relationship.

The signal generator that excites an ADF antenna box covers the band from 190 kHz to 500 kHz as well as the standard broadcast band from 550 kHz to 1750 kHz. Many receivers cover to 1.999 MHz but higher frequencies are of little value for ADF’ing.
The signal generator that excites the antenna box only needs to have 1 kHz amplitude modulation to test the receiver ident circuits. It is important, however, that the generator have a well-calibrated output and cover a wide range of levels. A large number of “function” generators can provide the frequency range, but they usually do not have amplitude modulation capability or a calibrated, attenuated output. Also, function generators usually do not have the frequency stability and residual FM requirement to operate narrow band ADF receivers.

Many signal generators for HF and VHF servicing cover down to 100 kHz and would provide the necessary driving signal. They also extend to hundreds of MHz and are suitable for other testing duties. For the smaller shop, there are high performance, low frequency signal generators and function generators that can drive the ADF antenna box, as well as an audio generator for testing transmitters and audio panels.

TEST PANELS AND HARNESSES

Once an avionics unit has been removed from an aircraft, it cannot operate unless connections are made to antennas, speakers, power supplies, indicators, microphones, etc. These items are provided by a test panel and test harness. The panel provides hardware such as speakers, volume control, frequency setting, etc., while a wire harness makes connection to the unit under test (UUT).

A test panel generally covers a number of products but not all. As an example, a panel will handle one or more brands of navigation receiver or communications transceivers. Another test panel may handle DMEs and transponders or just DMEs or only transponders. Each model has a unique harness for signal connections via a mating connector.