

DME TROUBLESHOOTING

By Brad Primm

DME systems were high tech when I started my career. In the Navy, the TACAN systems had distance to the station as well as TACAN bearing. In civilian life, the DME (distance measuring equipment) is the distance portion of TACAN, same frequencies and same timing scheme. In fact, a civilian DME set will work with TACAN as long as you know what TACAN channel equates with the paired NAV receiver frequencies used to tune civilian DME equipment.

When a VOR station is shown on an aeronautical chart as a VORTAC, that station is actually a collocated TACAN and VOR station. The DME is receiving a real TACAN signal in that case. TACAN has bearing information superimposed on the squitter pulses and the pulse amplitude is modulated by a 30 Hz signal. The ATC-1200Y-3 test set has a TACAN switch on the rear panel to simulate this modulation. When it is switched on, all pulses generated by the test set are modulated with a 30 Hz sine wave to simulate real-world conditions.

Back when I got out of the Navy, the civilian airplane that had a DME installed was considered well equipped. Although digital units were beginning to hit the street, such as the Narco DME-190, you still saw plenty of tube sets with sweeping needle displays such as King's KN-60 series (introduced in 1967). So why is DME important to the serious IFR pilot? Why not just rely on the fancy new GPS equipment?

The databases for GPS systems do not contain the lat/long of the localizer antennas, which is where the collocated DME antenna is positioned. Since this is typically 1,000 feet off the departure end of the runway, there will be several tenths of a mile difference between the airport reference point (which is in the GPS database) and the DME/Localizer antennas. This is not "close enough" for an IFR approach in the soup and therefore, GPS is not approved to take the place of DME when needed on a precision approach.

Of course, it is only a matter of time before LOC/DME waypoints are entered in the IFR GPS databases. Until that time, we must keep our customers safe with a properly operating DME.

Before getting into our troubleshooting scenario, a review of DME basics is in order. An airborne DME measures slant range from the aircraft to the ground station by measuring the time it takes for a pulse-pair interrogation from the DME to be answered by the pulse-pair reply from the ground station. Radio waves take 6.18 μ s to travel one nautical mile or 12.36 μ s to travel one nautical mile round trip.

The ground station waits 50 μ s after receiving a valid interrogation before replying. Without this delay, the DME could still be transmitting its second interrogation pulse when the first pulse of the reply is received at close range. So if the time interval from interrogation by the DME to valid reply was 173.6 μ s, the ground station would be 10 nm away ($10 \times 12.36 \mu\text{s} + 50 \mu\text{s delay} = 173.6 \mu\text{s}$).

Civilian DME systems are frequency paired with NAV frequencies to eliminate the need for the pilot to tune each system. The DME frequencies are divided up into two groups. The whole-tenth Nav channels (i.e. 108.10, 112.20) are X channels utilizing pulse pairs spaced 12 μ s apart. The 50 KHz Nav channels (i.e. 108.15, 112.25) are Y channels utilizing pulse pairs spaced 36 μ s apart. Each DME channel is actually two frequencies, with the transmitter and receiver separated by 63 Mhz.

The civilian DME frequency range is between 978 Mhz and 1213 Mhz. For 108.00 to 112.20 Mhz nav channels, the DME receives X channel replies 63 Mhz below its transmitted frequency and Y channel replies 63 Mhz above the transmitted frequency. From 112.30 to 117.95, the roles are reversed, i.e. X channel replies are received 63 Mhz above the DME transmitted frequency.

The DME ground station transmits a constant maximum pulse repetition frequency (PRF) of 2700 pulses per second. When no interrogations are received, the 2700 PPS consists of random single pulses called "squitter". Each time a valid interrogation is received, a pulse pair reply is transmitted in place of a squitter pulse. If so many interrogations are received that no squitter pulses are left to replace, the DME ground station reduces its sensitivity to keep the number of replies below the 2700 PRF limit.

When the airborne DME unit has picked out the replies to its own interrogations from the squitter pulses and replies to other DME's, it is considered to be "locked-on" or "tracking" the ground station. The DME will not lock-on to another DME's replies because they are not in sync with its own interrogations. Approximately every 45 seconds, the DME ground station will substitute all squitter pulses and replies with pulse pairs at the rate of 1350 PPS. These pulses are detected as a 1350 Hz Morse-code identifier, for use by the pilot to properly identify the station. During the identifier transmission, no valid replies are received by the DME but tracking and memory circuitry prevent the loss of "lock-on".

In keeping with the recent troubleshooting issues, we will repair a hypothetical problem with a KN-64 DME. The KN-64 is a popular, panel mounted DME unit that first hit the street in 1982. It is based upon the design of the KN-62/A, which was introduced in 1978. The original KN-62 was 100 watts peak pulsed power nominal and not TSO approved. The KN-62A was also 100 watts peak pulsed power nominal and TSO approved which allowed its use as an approved DME above 24,000 feet. The KN-64 is not TSO approved and has only 50 watts peak pulsed power nominal, which is fine for the lower altitudes.

The customer walked into the shop with one hand protecting his wallet and sheepishly said, "My DME frequency display intermittently changes to other frequencies and I am having trouble changing channels." I ask, "How does it work when it is on frequency?" and "How does it work in remote mode?"

He replied, "It seems to work OK when the display frequency doesn't change and as far as remote operation goes, I don't think it was ever hooked up."

"Does the DME Ident sound good when the DME distance display is dashed?" I ask.

"I don't know, what is DME Ident?" he answers.

"Get out of my shop you idiot!" I thought, as I said, "Well, I can see you need the Pilots Avionics Troubleshooting Guide, downloadable for the Aircraft Electronics Association's website at www.aea.net. Anyway, I have a pretty good idea of what your problem is and you can't afford to fix it, just kidding." With that dry bit of humor behind us, he signs the work order and out to the aircraft I go with the ATC-600A ramp tester in tow.

After setting up the ramp tester, we fire the DME up in the aircraft and it is quickly apparent to me that the frequency selection switches themselves are causing the problem. When I switch modes to RMT from FREQ, or to GS/T, the DME stays locked on. The GS/T and the RMT (Remote channeling) modes electronically disconnect the front-panel channeling switches. In the GS/T mode, the frequency readout is removed from the display so the ground speed and time-to-station information can be shown. In the FREQ mode, wiggling or turning the frequency selection knobs creates erratic frequency changes.

This is a common problem on the older, digital King Silver Crown radio line as the switches wear out or get dirty. Similar frequency selection switches are used on the KR-87 ADF, KN-53 Nav, KX-155/165 Nav/Coms etc. Continuing the tests, I listen to the DME ident and it is hooked up. I was concerned that it might not be since the installing shop had failed to put in the remote channeling wires to the Collins Micro-line Navs. The Micro-line Navs have the necessary DME channeling outputs to allow remote operation of this customer's KN-64.

I also notice the sun-bleached, orange tinted display lens and make a mental note to tell the customer. This may generate another service job to replace the lens if he is in the mood to keep his stack looking spiffy. I also notice that the display lenses in his Collins Micro-line Nav and Com units are sun-bleached clear, not even orange looking anymore. This aircraft has obviously spent some time on tie-down in the south.

With my Xcelite, screwdriver style, King Allen (3/32), I remove the unit from the rack and immediately notice another shortcut that the installing shop has taken. Only two of the four screws needed to secure the front of the rack are installed. As one would expect, no support strap was installed in the rear of the rack and the whole tray was drooping just like my mother-in-law's... hey wait a minute, lets not even go there.

With the unit out of the rack, I proceed back to the bench for testing and troubleshooting. A quick check of the KN-64 on the pulse bench confirms that it has a definite case of switchosis. Getting the up-to-date maintenance manual off the shelf, I begin the disassembly process on the piece-work bench. I carefully separate the screws by size since the top and bottom covers employ several different lengths.

When proper access is gained, I start the switch disassembly, which starts with the removal of the "C" washer (retaining ring) on the end of the Khz knob shaft. As expected, I watch the little @\$%^ zing away into the twilight zone despite my best efforts to contain it as I pop it off the shaft. Anticipating this, I keep several in stock. It's a lot cheaper than getting down on my hands and knees and searching the floor for a \$2.00 part.

With the switch disassembled, I inspect the switch parts and the circuit board. This switch design uses the Switch Board Circuit card as the non-moving part of the switch. It looks like all this unit will need is a good cleaning. Using my FAA approved pencil eraser, I remove the grit from the printed circuit board traces and I clean and retention the finger tabs on the rotating switch halves. I was expecting to find a broken finger or tab on one of the rotating switch halves but this unit is just dirty.

Afterwards, I rinse the printed circuit board and other switch parts with isopropyl alcohol to remove any eraser residue. Reassembly begins and after the switch parts are assembled, I apply the high vacuum grease called out in the maintenance manual to the switch detents and a small amount of epoxy to the retaining ring. While the DME unit is apart, it is a good idea to check for peeling of the insulation on the flex cables. When this deterioration is spotted, the only proper repair is the replacement of the cables. In this case, no peeling was noted. The unit is ready for reassembly and final test.

Having already started warming up the IFR 1200Y3 bench test set, I move the KN-64 from the piece-work bench to the pulse bench and begin the checkout process. Of course the first thing I perform are checks involving the switches and everything appears fine. Next we begin the final test procedures spelled out in the KN-64 maintenance manual. These test procedures are very thorough and have spaces available for the entry of test results. This allows the technician to make copies, record his test results and file them with the work order. No further problems were encountered during the bench testing.

There are some special cautions to be aware of during the repair of these units. The VCO and transmitter circuits are constructed of laminated Teflon microstrip boards, which are easily damaged by heat. Use only a low-wattage soldering iron.

The large scale integrated circuits (LSI's) are mounted in sockets for easy replacement. An insertion/extraction tool (p/n 050-01671-0000) is sold by Honeywell to prevent damage to the LSI's during maintenance. It will also cut troubleshooting time way down to keep a known-good set of these LSI's in stock.

After the final checks are complete and all systems go, I take the KN-64 back to the aircraft. Before I can insert the DME back into its tray, I need to properly secure the tray to the aircraft, details, details... The rails in the radio rack do not have holes drilled for two of the four screws needed to secure the front of the rack. The rack gets removed, the holes drilled, the rear support installed and all of the proper hardware is used when the rack is reassembled.

A simple frequency knob repair has turned into a major production. My joke about the customer not being able to afford to fix it is closer to the truth than I had imagined. He authorized the repair only after I told him that if he didn't allow me to properly secure the rack, I could not return his aircraft to service.

Finally, I reinstall the KN-64 into its tray. During the final test of the DME, I make sure that the power output from the antenna is good because this 50-watt DME cannot afford to lose power in a poor antenna system. The DME ground stations will reduce their receiver sensitivity as the number of interrogating aircraft increase in order to avoid over-working the ground station transmitter. So, low power DME units can lose lock even when within their theoretical range limit.

I also check both X and Y channel operation using the ATC-600A ramp tester. The ATC-600A checks these channels using the paired frequency of 108.00 and 108.05 Mhz. Since the ATC-600A can only check two channels, I tune in the field DME just to get another valid test of the system on a different frequency. The local DME ground station is collocated with the field localizer and always reads .9 miles when interrogated from our hangar or ramp area.

A quick check of the DME ident is in order since most audio panels do not give the pilot any way to adjust the volume. In addition, the nominal bench setting of 3.0 volts \pm .5 V p-p does not guarantee that a comfortable listening level will be achieved in the cockpit. I have tested plenty of DME's in the aircraft that were so loud you wanted to rip the headphones off your head when the DME ident was selected. In this case, the DME ident is at an acceptable level. If the ident had been too low or high, the KN-64 could have been loosened from its rack and R305 adjusted through a hole in the top cover until a comfortable listening level is achieved.

Luckily, no further problems are encountered with the final checkout. I mention the bleached out displays to the customer and he declines the repair at this time since he had to spend extra money on the mounting rack repair. So, I send him on his merry way, sans a few bucks and with ugly looking displays. At least his DME is not ready to fall behind the panel during a hard landing.