Shure Model UT2
T-series UHF Handheld Transmitter
Project #16996

Outline

General Product Description

The Shure UT2 is a low cost wireless handheld transmitter designed for the Music industry (MI) market. The UT2 is a single frequency, crystal controlled transmitter with a 9 volt battery for power supply. The frequency range for the UT2 is 596 to 608, 614 to 626, 740 to 752 and 770 to 862MHz.

I Special Features

1. Power on/off LED to indicate the operating status of the transmitter.
2. Low profile on/off power switch prevents accidental turn-off.
3. Low battery indicator to inform the user when to change the battery.
4. Mute Switch to provide audio on /off function without turning the transmitter off.
5. A variety microphone heads may be used with the transmitter.
6. Adjustable gain provided for various source levels.
7. May be used with dynamic or condenser type microphones.
8. Electronic circuitry prevents damage to the unit if the user installs the battery reversed.
9. Compatible with SHURE UT4 receiver.

II Circuit Description

Audio Section

Signals

Audio signals enter the UT2 through gold sliding contacts from the Microphone head to the headboard. Contact GND is a ground, Contact AUD.IN is the audio input, contact +9V supplies regulated +9 Vdc bias

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for electret condenser microphone.

Preamplifier Stage

Next, the audio signal enters a preamplifier stage consisting of one section of op amp (U102B). The voltage gain of this stage may be adjusted over a 26 dB range by means of an externally-accessible potentiometer (R125). This enables the user to compensate for level difference at the source. The output of this stage is then divided down to match the input range of the next stage via R149 and R150.

Preemphasis

The preamplified audio signal is then passed through a passive pre-emphasis network consisting of R142, C110, C111, R112, and R115.

Audio Signal Compression

The signal next enters the NE571D integrated circuit compander (U101B), providing a 2:1 logarithmic compression of the audio signal. A lower noise floor is achieved with the assistance of U102C. An internal potentiometer (R130) is provided for nulling system audio distortion. Op amp U102B operates as a 2-pole active low pass filter to restrict the bandwidth of the system to audio frequencies. The NE571D also contains and identical second channel (U101A) that is used to supply regulated, low-noise 5 Vdc bias to various audio and RF circuit points.

RF section

Processed Audio enters R258, an internal potentiometer adjusted for 45 kHz deviation (100 % modulation) with a 0.3 dBV (2.5 dBu), 1 kHz tone at the output of the audio section. The audio is then fed to varactor diode D201, which is part of the modulated oscillator-tripler/quadrupler stage (Q201).

The base-emitter circuit of Q201 operates as a crystal-controlled Colpitts oscillator in the 20 MHz region. Fundamental-mode crystal Y201 is tuned to 10 kHz below series resonance by the series combination of frequency-netting coil L201, diode D201, capacitor C205, and capacitor divider C206 and C209.

Frequency Stability

To ensure frequency stability with changes in battery voltage, regulated +5 Vdc bias is applied to the varactor diode and to the base of Q201. Temperature compensation is provided by C206 and C209. The collector circuit of Q201 is tuned to the third/fourth harmonic of the oscillator frequency (approximately 67/90 MHz) by means of L202, C208, and C212. C220 couples RF energy to a second tuned circuit consisting of L203, C214/213, and C215 (coupling band-pass filter), which also forms a capacitively-tapped voltage divider for matching into the base of Q202, operating as a buffer amplifier.

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Frequency Tripler and Buffer

The third stage (Q203) is operated as a frequency tripler with the collector circuit tuned to the intermediate frequency (approximately 200/270 MHz) (frequency output of Q202 times three). At the collector there is a double tuned circuit that perform tuning and impedance matching into the base of Q204. Q204 operates at the same frequency as Q203. The circuit looks similar to Q203 but it is a buffer stage for additional filtering of the harmonics.

The fifth stage (Q205) is the last tripler in the RF circuit tuned to the output frequency. Once again, there is a double tuned circuit providing impedance matching to the amplifier stage.

Amplifier and Battery/Antenna matching

The amplifier brings the signal to the desired RF power. Behind the amplifier is a Collins filter, which works as a low-pass filter and a down converter from high to low impedance. After that is an additional band-pass filter, to meet the international regulations. Then a capacitor and a coil matches the network to the battery which works as an antenna. C266 couples the (+) and the (-) pole of the Battery for this purpose.

III Test Equipment

1. RF Signal Generator (Hewlett Packard HP8657B)
2. Frequency Counter (Hewlett Packard HP5386A)
3. Spectrum Analyzer (Hewlett Packard HP8591A)
4. Harmonic Distortion Analyzer (Hewlett Packard HP 339A)
5. Digital Multimeter(Fluke 77)
6. IF Receiver (Modified Shure SC4, tuned for 45 kHz deviation) (Ref. *Wireless Service Equipment* Manual), ***or a UT4 of the same frequency.***
7. RF Mixer (ZAD-1)
8. 9 volt Power Supply (Hewlett Packard HP6218A)
9. 50 Ω Cable (RG-174/u), BNC connector to bare ends
10. Non-metallic slot-type screwdriver (Toray yellow adjuster #A-1810)
11. Non-metallic slot-type screwdriver (Toray red adjuster # A-0910)

IV Alignment procedure

Alignment Setup

The model UT2 transmitter should be aligned as an interconnected board assembly. The 50 Ω output cable must be connected to TP217 (antenna output) and ground TP216. It may be tack soldered or connected by contact pins in a fixture.

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1. Be certain S101 (power) is in the "PWR" position (to the right side).
2. Verify that S102 (mute) is in the "on" position (up position).
3. Connect the positive lead of 9 volt supply to I140 (positive battery terminal). Connect the (-) terminal to I145 (ground). The green power LED should now be illuminated . If not, there is a circuit malfunction.
4. Temporarily reverse the polarity of the 9 Vdc supply. The green power LED should be extinguished and the current should be zero. Otherwise, there is a problem with the reverse polarity protection circuit. Return the polarity of the 9 volt supply to normal.
5. Reduce power supply voltage to 6.6 ± 0.1Vdc. The red LED should be illuminated. Return power supply voltage to 9 Vdc.
6. Connect positive lead of audio meter to I109 (Audio to RF). Connect the negative lead to I145 (ground).
7. Ensure that 9.0 ± 0.35 Vdc is present at I+9 using a digital multimeter (DMM). If not, see service evaluation section.
8. Preset R125 (Gain) to midrange.
9. Set the Audio Generator to 1 kHz with amplitude equal to -6.5 dBV (-4.3 dBu or 473 mV)

Audio Alignment

1. Adjust R125 (gain) for 0.3 ± 0.2 dBV (2.5±0.2 dBU or 1.035 V) at I109 using the audio meter. If this level cannot be obtained, see service evaluation section.
2. Reduce the audio generator output to -13 dBV (-10.8 dBu or 223 mV) and measure the level at I109. This is done to avoid the limiter which activates at 1.8 dBV (4.0 dBu).
3. Change frequency of audio generator to 100 Hz. Remove 400 Hz high pass filter from THD analyzer. Verify that the audio level is equal to -1.2 ± 1.0 dB relative to the level measured in (2) at I109.
4. Change frequency of audio generator to 10 kHz. Verify that the Audio level is equal to +4.5 ± 1.0 dB relative to the level in (2) at I109.
5. Return the Audio Generator frequency to 1kHz and amplitude to 0 mV.

RF Alignment

1. Connect the 50 Ω output cable from the spectrum analyzer to TP217. Peak C245 and C249 for maximum output power on spectrum analyzer.

   Output power should be 11 ± 3 dBm accounting cable losses.

2. Connect 50 Ω output cable to frequency counter. Adjust L201 to set the carrier frequency to F_C ±2.0 kHz.
3. Reconnect output cable to spectrum analyzer. Confirm output power

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remained within specification. If not, repeat step 1. Then check the level of spurious emission up to 1.8 GHz. All must be at least 50 dB below the carrier level.

4. Measure current drain of the transmitter using digital multimeter (DMM). Current drain should be less then 50 mA.
5. Return the Audio Generator frequency to 1kHz and amplitude to -6.5 dBV (-4.3 dBu or 473 mV)
6. Adjust signal generator to produce an unmodulated output signal at F_C -10.7 MHz with an amplitude of +7 dBm into one input port of ZAD -1 mixer. Connect the 50 Ω output cable through 40 dB attenuator to the second input port of mixer. With 0.3 ± 0.2 dBV (2.5 dBu, 1.035 V) at I109, adjust R258 to obtain 45 kHz deviation with a 1 kHz modulating tone at the IF receiver. (45 kHz deviation is equal to -8.2 ± 1 dBV out of the IF receiver when loaded with 3.3 kΩ.)
7. Adjust R130 for minimum distortion of IF receiver.

V Test for Product Acceptance

1) Insert battery and turn MUTE and POWER switches ON.

2) Verify LED's are visible through case and are lit.

3) Select appropriate frequency on Communications Receiver.

4) A tone which fluctuates in volume when the volume pot is adjusted should be audible.

5) Tap the unit to check for microphonics.

6) Turn POWER and MUTE switches off and verify that the LED's go off.

7) Set volume pot to midrange.

Output power	11 ± 3 dBm
Spurious	from 0.01 to 1.8 GHz at least -50 dBc
Frequency tolerance	F_C ± 2.0 kHz
System audio response	30 Hz to 15 kHz (+1 ,-3 dB)
System distortion	less than 1.0%

VI Agency Approval

1.0 IC *<616231160>*
2.0 FCC *<DD4UT2>*
3.0 ETS 300 422 Type approval for Europe

SS	Record of Changes Made
1.	Production Release
2	ECO 81418: Changes to audio limits pages 2 & 4

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4.0 ETS 300 445 EMC approval for Europe (CE mark)

VII Mechanical Specification

1. Overall Dimensions
   UT2/58: 241.3 mm (9-1/2 inches)
   UT2/31: 225.4 mm (8-7/8 inches)

2. Weight
   UT2/58: 296 grams (10.4 ounces), without battery
   UT2/31: 218 grams (7.7 ounces), without battery

3. Housing
   Handle and cup: black ABS plastic, black paint
   Bezel: polycarbonte, black paint

4. Battery
   9 Volt (Duracell MN1604), Alkaline type recommended

5. Switches
   A. OFF/PWR: low profile, two position slide type; located on microphone side
   B. MUTE/ON: low profile, two position slide type; located on microphone side

6. Controls
   Microphone Gain: Potentiometer, inside battery cup, screwdriver adjustable

7. Indicators
   Power: LED (green); located on microphone side
   Low battery: LED (red); located on microphone side

VIII Environmental Specifications

Moisture Resistance
7 days at 90% RH with the temperature cycled from +14°F (-10° C) to +150°F (+65° C) and back. Allow the units to recover for 24 hours. Product must meet the -7 specifications.

Steady State Humidity
Ten days at 90% RH and room temperature. Evaluate units for visual and mechanical defects after 1, 3, 5, 7, and 10 days. At the end of the 10 day period allow the units to recover for 24 hours. Units must pass the -7 print specifications.

Operational High Humidity
Units must operate per -7 print specifications at 90+% RH and room temperature.

Hot Temperature Storage
Seven days at +140/165°F (Packaged)/(Unpackaged). Allow 24 hours for recovery. Units must pass the -7 specifications.

Cold Temperature Storage
Seven days at -20°F (-7° C) (Packaged). After 24 hours, units must pass -7 print specifications.

Temperature Shock
Five cycles, 30 minutes each temperature, from -20°F (-7° C) to +165°F (+74°) (Unpackaged). Allow 24 hours for stabilization before testing. Units must operate per the -7 specifications.

Operational Temperature
Operate the unit at 20°F (-7° C) and 120°F (+49° C) after a three hour stabilization at each temperature. Units must operate per the -7 specifications.

Mechanical Shock (Drop Test)
The Body Pack Transmitter will be dropped from a height of 40" onto a hardwood floor. Two units onto each corner, two units on each edge, and two units on each face. Acceptable damage will be determined by the C.Q.E. Manager and the team. Defects should be minor such as: Minor nicks, dents, cracks, chips, etc.. Product must be fully functional.

Electrostatic Discharge (ESD)
Units will be subjected to ± 15 kV air discharge and ± 4 kV contact discharge. The product must pass -7 specifications.

IX Service Evaluation

<Trouble-Shooting Guide>

1. DC Power. Verify 9.0 ± 0.35 Vdc is present at I+9. If voltage is low, beginning tracing at the power supply to see where it drops. Check power switch, bias on Q105 and L102. Make shure circuit board ground is actually 0 V. If there is a short to ground from 9V, try to isolate different parts of the circuitry. Narrow it down to the RF or Audio section. Look for foil shorts, solder bridges, and capacitors that have been installed backward. Also check for 5 ± 0.25 Vdc at I+5 (U101 pin 7). If not, check U101 pin 13 for 9V, and the value of R133.
2. Audio. Determine where the audio signal disappears. Verify Audio at pin 7 of U102. If not found check DC bias at pins 5,6,7 of U102.

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They should be about half of the supply voltage, or around 4.5 Vdc. This bias comes from the 9V line trough divider R103/R105, then through R106 to Pin 5. Look for open vias, foil shorts, incorrect parts, and bad connections. If there is audio at Pin 7 of U102, but not at pin 14, check for DC bias; pins 12 and 13 should read approximately 1.8 Vdc, while pin 14 should read about 3.7 Vdc. DC bias comes from pin 9 of U101 through R107 to pin 12 of U102. Next check parts in feedback path from pin 14 of U102 to the next stage and to the limiter (Q103), and pin 14 of U101. Verify that the DC level at U101 pin 16 fluctuates as the input signal is changed; a low or constant DC voltage may be caused by Q103 or U101. The last stage to check is pins 8, 9 and 10 of U102. DC Bias should be about 4 Vdc for all three pins of U102D. Check values in feedback path from pin 8 to pin 9, and path to Q104 and pin 16 of U101.

3. Frequency problems. Make sure the RF carrier is at least 10 dB higher than the spurs to allow the frequency counter to lock on. Make sure the crystal is the correct frequency and fits with the board group (Group Indicators). Make sure L201's core is not cracked. Check DC bias for Q201. D201 needs to be the right varactor as well as have 5 Vdc on its cathode. Check parts and values of the oscillator stage. And as always, look for shorts and opens.

4. Low output power. The output of the transmitter should be terminated in a 50 Ohm load from TP217 to ground during testing. If the unit is being tested as a two board assembly with the RF and audio boards soldered together temporarily remove C265 to disconnect the Battery antenna. Probe output after the oscillator stage behind C210. If there is none, refer to section 3, check the oscillator stage. All six stages can probed in this way.

Stage 1	probe behind C210
Stage 2	probe behind C220
Stage 3	probe behind C229
Stage 4	probe behind C238
Stage 5	probe behind C247
Stage 6	probe TP217 remove C265

Check also the bias voltage on all six stages.

5. Excessive Current Drain. Try readjusting C245 and C249 for lower current drain while maintaining output power to specifications. If the current drain is still excessive, there may be a short somewhere, wrong resistor values, or a defective capacitor.

6. Deviation. If R258 cannot be adjusted to obtain 45 kHz deviation, try to isolate the problem to the audio or RF section. If the level at I109 is not 0.3 dBV, refer to section 2 audio. If the level at

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I109 is correct, check C203, R203, R204, D201, L201, and C205. The cathode of D201 should be Getting 5 Vdc bias from the 5V line through R202 and R203. The Value of C205 is very critical to the deviation sensitivity. As a last resort, try replacing D201 and Y201.

7. Distortion. First make sure the analyzer's 400 Hz high pass and 30 kHz low pass filters are "in". Pin 9 of U101 should read about 1.9 Vdc. The DC level on the wiper of R130 should change from about 1.5V to 3.5V when R130 is turned. If not, check R129, C125, R130, R141, R140, R126 and the parts tied to pin 9 of U101. Make sure the audio level is okay. Finally, try replacing D201 and Y201.

SS	Record of Changes Made
1.	Production Release
2	ECO 81418: Changes to audio limits pages 2 & 4

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