Description:UT1 Bodypack Transmitter	DRWG. UT1-7
Refer To Drawing NOS. 90-8786-11	Page 1 of 11

Shure Model UT1
T-series UHF Bodypack Transmitter
Project #16996

Outline

General Product Description

The Shure UT1 is a low cost wireless bodypack transmitter designed for the Music industry (MI) market. The UT1 is a single frequency, crystal controlled transmitter with a 9 volt battery for power supply. The frequency range for the UT1 is 596 to 608, 614 to 626, 740 to 752 and 800 to 862 MHz.

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. Input attenuation switch
4. Low battery indicator to inform the user when to change the battery.
5. Mute Switch to provide audio on /off function.
6. Tini QG microphone connector allows the users to choose a variety of headset or lavalier microphones offered by Shure.
7. Adjustable gain allows use with high or low impedance microphones.
8. May be used with dynamic or condenser type microphones.
9. Electronic circuitry prevents damage to the unit if the user installs the battery reversed.

II Circuit Description

Audio Section

Signals

Audio signals enter the UT1 through a 4 pin Tini QG jack. Pin 1 is a ground, pin 2 supplies regulated 5 Vdc bias for electret condenser

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Used in:

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Typed: Anny Liao

Checked:

Approved: Kevin Mikes

Approved:

microphone, pin 3 is the audio input, and pin 4 is a 20 kΩ load resistor connected to pin 3 for electret microphones.

The audio signals then pass through a switch (SW103) which engages and disengages a 20 dB pad. The pad is engaged when very large signals are expected at the input. An example would be those produced by an instrument with very sensitive or active pickups.

Next, the audio signal enters a preamplifier stage consisting of one section of op amp (U102D). The voltage gain of this stage may be adjusted over a 32 dB range by means of an externally-accessible potentiometer (R105). This enables the user to compensate for level difference at the source. The output signal is then attenuated via a voltage divider (R150 and R151) to match the input range of the compandor.

Pre-emphasis Stage

The preamplified audio signal is then passed through a passive pre-emphasis network consisting of R100, C105, C106, R110, and R111.

Audio Signal Compression

The signal next enters the NE571D integrated circuit compandor (U101B), providing a 2:1 logarithmic compression of the audio signal. A lower noise floor is achieved with the assistance of U102A. An internal potentiometer (R139) 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 an 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 R207, 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 stage (Q201)(see note).

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 L211, diode D201, capacitor C225, and feedback capacitors C220 and C229.

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. C220 and C229 provide temperature compensation. The collector circuit of Q201 is tuned to the third harmonic of the oscillator frequency (approximately 67 MHz) by means of L205, C214, and C239. C217 couples RF energy to a second tuned circuit consisting of L212, C235, C240 and C227, which also forms a capacitively-tapped voltage divider for matching into the base of Q202, operating as a buffer amplifier.

Note: For UT1's operating in the 800 MHz range, the tank circuitry of Q201 is tuned to the fourth harmonic of the oscillator (Approximately 90 MHz).

Frequency Tripler and Buffer

The third stage (Q203) is operated as a frequency tripler with the collector circuit tuned to the intermediate frequency (frequency output of Q202 times three). At the collector there is a double tuned circuit that performs 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 unwanted spurious 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.

The RF signal is then amplified by Q206 and filtered with a MuRata bandpass filter.

III Test Equipment

1. RF Signal Generator (Hewlett Packard HP8657B)
2. Frequency Counter (Hewlett Packard HP5386A)
3. Spectrum Analyzer (Hewlett Packard HP8591A)
4. 10x FET Probe (Philips PM8943A) with DC block (Tektronix 015-0221-00)
5. Harmonic Distortion Analyzer (Hewlett Packard HP 339A)
6. Digital Multimeter (Fluke 77)
7. IF Receiver (Modified Shure SC4)
8. RF Mixer (ZAD-1)
9. 9 volt Power Supply (Hewlett Packard HP6218A)
10. 50 Ω Cable (RG-174/u), BNC connector to bare ends
11. Non-metallic slot-type screwdriver (Toray yellow adjuster #A-1810)
12. Non-metallic slot-type screwdriver (Toray red adjuster # A-0910)

IV Alignment procedure

Alignment Setup

The model UT1 transmitter should be aligned as an interconnected board assembly. The 50 Ω output cable must be connected to TP235 (Antenna output) and ground. It may be tack soldered or connected by contact pins in a fixture.

1. Be certain SW101 (power) is in the "PWR" position (Away from green LED).
2. Verify that SW102 (mute) is in the "ON" position (up position).
3. Verify that SW103 (attenuation) is in the "0" position (Towards the green LED).
4. Connect the positive lead of 9 volt supply to I108 (positive battery terminal). Connect the negative lead to I109 (ground). The green power LED should now be illuminated. If not, there is a circuit malfunction.
5. 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.
6. Reduce power supply voltage to 6.8 ± 0.25 Vdc. The red LED should be illuminated. Return power supply voltage to 9 Vdc.
7. Connect the positive lead of the audio meter to TP104 (Audio to RF). Connect the negative lead to I109 (ground).
8. Ensure that 9.0 ± 0.35 Vdc is present at I106 using a digital multimeter (DMM). If not, see service evaluation section.
9. Preset R105 (Gain) to midrange.
10. Set the Audio Generator to 1 kHz with amplitude equal to -8 dBV (-5.8 dBu or 400 mV)

Audio Alignment

1. Adjust R105 (gain) for 0.3 ± 0.2 dBV (2.5 ± 0.2 dBu or 1.035 V) at TP104 using the audio meter. If this level cannot be obtained, see service evaluation section.
2. Reduce the audio generator output to -13 dBV (223 mV) and measure the level at TP104. 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 -0.7 ± 1.0 dB relative to the level measured in (2) at TP104.
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 TP104.
5. Set the Audio Generator to 1 kHz with amplitude equal to -8 dBV (-5.8

dBu or 400 mV)

RF Alignment

1. Connect the 50 Ω output cable from the spectrum analyzer to TP235. Following the table below peak out the appropriate trimmer capacitor and potentiometer.

   Output power should account for cable losses.

Frequency Group	Trimmer capacitor	Power output
A	C218, C246	11 ± 3 dBm
B	C218, C246, C251	11 ± 3 dBm
D	C218, C246, R13	8.8 ± 1dBm
E	C218, C246	10 +1, -2 dBm
H	C218, C234, C246	10 +1, -2 dBm

2. Connect 50 Ω output cable to frequency counter. Adjust L211 to set the carrier frequency to F_C ± 2.0 kHz.
3. Reconnect output cable to the spectrum analyzer. Confirm output power remained within specification. If not, repeat steps 1 through 2. 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 an ammeter. Current drain should be 40 mA ± 5 mA.
5. Adjust the signal generator to produce an unmodulated output signal at F_C -10.7 MHz with amplitude of +7 dBm into one input port of ZAD -1 mixer. Connect the 50 Ω output cable through 20 dB attenuator to the second input port of mixer. Verify the level at TP104 to be 0.3 ± 0.2 dBV (2.5 ± 0.2 dBu or 1.035 V). Adjust R207 to obtain 45 kHz 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.)
6. Adjust R139 for minimum distortion of the IF receiver.

V Test for Product Acceptance

1) Verify battery terminals are captured behind case wall.

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

3) Verify LED’s are visible through case and are lit.

4) Insert Tini QG connector from audio oscillator into unit.

5) Select appropriate frequency on communications receiver.

6) A tone, which fluctuates in volume when the volume pot is adjusted, should be audible. Return volume pot to midrange.

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

8) Tap the unit and check for microphonics.

Output power	11 ± 3 dBm
Output power	8.8 ± 1 dBm
Spurious	from 0.01 to 1.8 GHz at least -50 dBc
Frequency tolerance	F_C ±2.0 kHz
System audio response	20 Hz to 16 kHz (+1, -3 dB)
System distortion	less than 0.5%

9) Occupied Bandwidth Test **(JB models only)**
- Set transmitter gain to maximum.
- Set up the HP-8591E spectrum analyzer to measure *Occupied Bandwidth* with the following settings:
  Percentage Power = 99.5%
  Channel Spacing = 250kHz
  Bandwidth = 110kHz
- Connect the audio generator to the mic input with a 1kHz tone and a level which gives -23.47dBu (52mV) at TPA4.
- Increase the audio level by 36dB.
- Measure *Occupied Bandwidth* to be less than 110kHz.

10) Adjacent Channel Power Test **(JB models only)**
- Set the transmitter gain, HP-8591E spectrum analyzer, and audio input level to the same settings as stated in 8.0.
- Measure *Extended Adjacent Channel Power* to be less than 60dBc.

VI Agency Approval

1.0 FCC *<DD4UT1>*
2.0 IC *<616231164>*
3.0 ETS 300 422 Type approval for Europe
4.0 ETS 300 445 EMC approval for Europe (CE mark)

VII Mechanical Specification

1. Overall Dimensions

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3-1/4 inches (82.6 mm) long x 2-1/2 inches (63.5 mm) Wide x 1-1/32 Inches (26.2 mm) Thick. Excluding antenna and belt clip.

2. Weight
4.4 ounces (125 grams), including battery

3. Housing
Body: Black ABS plastic
Front panel: Aluminum

4. Belt Clip
Shure part number 90A4392
Removable/Rotatable

5. Antenna
1/4 wavelength, flexible insulated lead wire: 4.6 inches (120 mm) ± 0.25 inches (6.4 mm) long for 600 MHz (70B8015); 3.84 inches (100 mm) ± 0.25 inches (6.4 mm) for 800 MHz (70A8015). Conductor construction consists of 6 strand, double served (same direction), silver plated cadmium copper alloy over polyester. Insulation consists of 0.030 inches nominal wall flexible polyvinyl chloride.

6. Battery
9V (Duracell MN1604), Alkaline type recommended

7. Switches
A. OFF/PWR; right angle 2 position slide type, located on the front panel
B. INPUT ATTEN 0/-20: right angle 2 position slide type, located on the front panel
C. MUTE/ON: right angle 2 position toggle type, located on front panel

8. Controls
Microphone gain: potentiometer, exterior side of unit, screwdriver adjustable

9. Indicator
Power: LED (green); located on front panel
Low battery LED (red): located on front panel

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.

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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 minute 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

1. DC Power. Verify 9.0 ± 0.35 Vdc is present at I106. If the voltage is low, trace back to the power supply to see where power is lost. Check power switch, bias on Q105 and L101. Make sure circuit board

ground is at 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 I152(U101 pin 7). If not, check U101 pin 13 for 9V, and values of R128, R129, and R130.

2 Audio. Verify the supply voltage. If the audio is clipped, half-rectified, or missing altogether, Check biasing on U102. Verify audio is present at I104. Next, verify audio at pin 7 of U102. If there is no audio, verify that DC bias at pins 5, 6, and 7 of U102 is at 4.5 ±0.5 Vdc. This bias comes from the 9V line through voltage divider R107/R108, then through R146 to pin 5. Look for open vias, foil shorts, incorrect parts, and bad connections. If audio is present at pin 7 of U102 but not at Pin 14, verify that DC voltages at Pins 12 and 13 is approximately 1.8 Vdc, while pin 14 should read approximately 3.7 Vdc. DC bias comes from Pin 8 of U101 through R113 to pin 12 of U102. Next check parts in feedback path from pin 14 of U102 to the next stage and to the limiter (Q101), and pin 15 of U101. Next, verify DC bias at Pins 8, 9 and 10 of U102. DC Bias should be 4.0 ±0.5 Vdc for all three pins. Check values in feedback path from pin 8 to Pin 9 and path to Q102 and pin 1 of U101.

3. Frequency problems. Verify that 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 TP235 to ground during testing. Probe output of after the oscillator at pin 1 of Q202. If there is none, refer to section 3. In this way all six stages can be probed.

Stage 1	probe pin 1 of Q202.
Stage 2	probe pin 1 of Q203.
Stage 3	probe pin 1 of Q204.
Stage 4	probe pin 1 of Q205.
Stage 5	probe pin 1 of Q206.
Stage 6	probe TP234.

Make sure that the terminals of F201 are not shorted to each other. Also check the bias voltage on all six stages.

5. Deviation. If R207 cannot be adjusted to obtain 45 kHz deviation, try to isolate the problem to the audio or RF section. Make sure that TP104 reads +0.3 dBv. If not, refer to section 2 audio. With the correct level at TP104, check R207, C212, C223, R206, R209, D201, L211, and C225. The cathode of D201 should measure 5 Vdc. The value of C225 is very critical to the deviation sensitivity. As a last resort, try replacing D201 and Y201.

6. 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 1.9 Vdc. The DC level on the wiper of R130 should change when R130 is rotated, from about 1.5V to 3.5V. If not, check R129, C125, R130, R141, R140, R126 and the parts tied to pin 9 of U101. Make sure audio level is not too high. Finally, try replacing D201 and Y201.

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