BLX1 Circuit Description:

Audio

Audio enters the transmitter through pin 3 of the TQG connector (CON90) on the mic-jack board. Pin 2 of the connector provides 5V bias for lavalier mics. Pin 1 supplies the ground connection. Active bias (load) is provided on Pin 4 to permit compatibility with older (low current) and newer (higher current) electret microphones. The front-end gain stage (IC120-3) is powered from a voltage-doubler +10V supply to prevent clipping with high signal inputs (electric guitar with hot pickups). A user adjustable gain pot provides 26dB range, from 0dB for instruments to +26dB for low-sensitivity lavalier mics. Capacitor C140 couples the signal into a pre-emphasis network formed by R140, R141, and C141.

After the audio preamp, the audio signal is ready for processing by the audio level-dependent processing section, using Shure's patented ARC™ technique. The main elements in this section are the VCA (IC100-1) and the RMS Detector (IC100-2). The VCA, or Voltage Controlled Amplifier, is a DC-controlled amplifier. Following the VCA, the signal enters a 2-pole 17 kHz low-pass filter stage (IC120-2) that protects the RMS detector from energy above the audio band. Next, the signal is coupled to the RMS detector, which converts the decibel-level of the RMS value to a proportional DC voltage. A 1dB increase at the input to the detector produces a 6mV increase at its output. The detector output is fed to the compression threshold stage (IC150-4). This stage provides the transition from uncompressed to compressed signal. At low levels, the audio is uncompressed because diode D190 is turned off. As the AC level increases, the output of IC150-4 decreases enough to turn the diode on. As D190 conducts, the compression ratio changes from 1:1 to approximately 5:1. Once D190 is turned fully on, the audio compression ratio remains fixed at 5:1. An additional diode in the bias network (D162) provides temperature compensation for changes in the Vγ, or "cut-in" voltage of D190. After the compression threshold stage, the DC control signal is then sent to the VCA control voltage input (EC-) through buffer amp IC150-1. The VCA uses the difference between EC- & EC+ (connected to VREF) to determine the gain. Fixed gain, applied below the compression threshold, is set by the DC gain of IC150-1.

The audio muting function was disabled for UI simplicity, and it was later discovered that this circuitry (C205, Q205, etc.) adds additional distortion, so the components were DNP'ed. After this section, audio is then combined with tone key in the summing amp (IC120-4), which uses trim pot TR200 for tuning of audio deviation. The combined audio & tone key signal is then passed to the RF section for transmission. The tone key signal is used in the receiver to provide audio output only when the tone key signal is present with the transmitted signal; therefore, if the tone key or the transmitter is turned off, the receiver will be muted. Tone key squelch helps eliminate receiver noise associated with loss of the carrier, which usually sounds like a "pop". A local crystal oscillator made up of crystal Y347, transistors Q186-1, Q186-2, Q185-1, Q185-2 and surrounding passive biasing components generates the tone key signal. Q185-2 serves as a tone key mute controlled by the microcontroller. During low battery condition, tone key level is increased (TK_LO_BAT signal to R192) for indication on the ½-rack receiver (BLX4R). To improve tuning yield, a tone key trimpot (TR201) was added for 190-21280.

The complete signal is then coupled into the RF section through R504 and a minimum pulse distortion attenuation pad made up of R510, R511, R513, R514, C514, C515, C516, C531, C532, C533.

Power Section

Two AA batteries supply power to the transmitter through FET Q410, which provides electrical reverse battery protection. Next, power enters switching regulator IC400, which supplies regulated 5V power. To turn on the transmitter, SW400 shorts the base of Q480 to ground, enabling the regulator and powering up the unit. The microcontroller keeps Q480 disabled until shutdown.

Power is controlled by SW400 and a "shutdown" signal from the microcontroller, which can be initiated manually by the user (by flipping SW400 to the off position) or automatically by the system (after MCU shut-down procedure, or when the battery is too weak for proper operation). At this time, the MCU enables Q480 and shuts down the converter. In the case of the bodypack, which has a toggle switch (instead of a push-button), the TX is muted during dead-battery condition but doesn't actually stop drawing current until the user flips the switch or the battery is completely exhausted. When SW400 is in the off position, Q480 and its bias circuitry draws less than 30 μA, so the effect on battery life is negligible. In this condition, the regulator and MCU are disabled.

RF Section

The BLX1 uses a phased locked loop (PLL) system with direct carrier frequency modulation. Processed audio enters the voltage-controlled oscillator (VCO) through a passive "reflection" network before being applied to the varactor diode (D500) through RF choke L503. The VCO and PLL circuitry is shielded to prevent external RF fields from affecting its operation, and to help control radiated emissions of its harmonic frequencies. Power for the VCO and PLL circuitry is supplied by the main 5 volt boost converter and 3.3V regulator. The power and signal lines in the VCO area are heavily decoupled and bypassed to remove noise.

The VCO has a maximum tuning bandwidth of 24 MHz (band dependent), with a tuning voltage range of approximately 1 to 4 volts. The VCO employs separate stages for the oscillator (Q502) and buffer (Q501) to minimize phase noise and load pulling. The VCO output is isolated by capacitive and resistive dividers, before being applied to the frequency control pin of the PLL synthesizer (IC501) through C538. The synthesizer's internal circuitry divides the RF signal down as necessary to achieve tuning resolution steps of 25 kHz. The synthesizer circuit contains a quartz-controlled reference oscillator operating from a 16 MHz reference crystal (Y500) that is adjusted by a variable capacitor CV501. New board group 190-23742 uses a 30.4MHz TCXO as the reference to the new PLL synthesizer, and does not have a variable capacitor. The TCXO does not need adjusting. The transmitter output frequency is user selectable in groups of up to 12 compatible channels (band dependent) within each of the 18 available bands. Frequency selection is made via MCU (microcontroller) IC300. The output of the synthesizer is a series of pulses that are integrated by a passive loop filter consisting of C532, R514, C533, R513, and C531 to produce the control voltage signal.

The VCO output is coupled to the RF buffer stage (Q600) by a resistive isolation network consisting of R503, R505, R520, and R602 through a pi network resistive pad. The isolation network provides additional isolation between the RF buffer stage, the VCO and the PLL feedback loop to lessen the effect of VCO impedance pulling. R600 and R603 provide base bias for Q600, while R605 sets its operating current. RF choke L600 provides power and decoupling for the stage, in conjunction with C600, C601, C606, and C652. The collector of Q600 feeds the power amplifier stage via an impedance matching network consisting of L602, C611, and C618 through a second pi network resistive pad.

The bias voltage for the RF power amplifier (Q601) is supplied by R601 and R604. Its operating current is controlled via emitter resistor R606. RF choke L601 provides power and decoupling for the stage, in conjunction with C603, C607, C608, and C651. L603, C612, and L604 provide the output impedance matching into the low pass filter, which consists of L605, L606, C615, C616, and C617. The low pass filter output couples to the whip antenna via L607.

The transmitter is capable of delivering up to +12.0 dBm to the antenna. During transmitter power-up and frequency selection, the RF output is muted by bringing the base of Q631 low, which removes bias from Q630 and shuts down power to the RF stages. The RF output is also muted during the transmitter power-down sequence. This is done so that the carrier signal will not interfere with other transmissions when the VCO becomes unlocked.

Digital Section

The heart of the digital section is the MC9S08GT16A 8-bit microcontroller (IC300) from Freescale. This MCU has 16KB of internal Flash memory for program storage, up to 39 general purpose I/O pins, and integrated ADCs for measuring voltage levels.