

Listen Technologies

Microfield

Theory of Operation

M. Simon 6-30-03

Scope

This document describes the operation of the Microfield product at a circuit and component level. This theory of operation is to be used as an aid to the engineer or technician in troubleshooting the Microfield product. One should refer to the Microfield block diagram and schematic while reading this document. The schematic is organized as functional blocks with a description in the title block.

General

Microfield is designed to transmit audio to Phonak in-ear and behind-the-ear hearing aids. These hearing aids utilize 216 MHz FM receivers. The Microfield unit transmits on Phonak 216 MHz channels in addition to Listen and other manufacturer's channels. Microfield derives audio from either a built-in 72 MHz, 216 MHz or IR (infrared) receiver. Audio may also come from an external microphone or auxiliary input. An external speaker produces the same audio that is transmitted to the hearing aid.

A microprocessor controls all internal functions including battery charging and monitoring. The user may program the Microfield unit with preset transmit and receive frequencies.

CPU Section

The CPU performs many functions during Microfield operation. These include battery charging and monitoring, driving the LCD, controlling the transmit and receive PLL frequency synthesizers, reading and writing to EEPROM, controlling RF squelch, detecting front panel switch actions and controlling DC power to various circuits as needed. U9 is the CPU and runs at 1 MHz (Y1) clock speed. U5 is an EEPROM which stores information such as self calibration data(battery and squelch) , channel presets and volume settings. Self calibration is initiated by shorting jumper J1 while turning unit on. This process establishes accurate analog-to-digital conversion for battery monitoring and determines squelch and RF meter baseline values.

Receiver Section

U16 is an FM receiver circuit that contains IF amplification, FM demodulation, RSSI generation and RF mixing. U16 functions as either a 72 MHz, 216 MHz or IR receiver.

IR frequencies range between 95 kHz to 3.8 MHz. U18 up-converts these frequencies to the 48.095 to 51.8 MHz range.

U13 is a programmable phase locked loop (PLL) synthesizer that stabilizes the VCO (Q11) to the appropriate local oscillator (L.O.) frequency. The 72 MHz receiver operates with the L.O. set to 10.7 MHz below the receive frequency. The 216 MHz receiver operates with the L.O. set to 10.7 MHz above the receive frequency. The IR receiver operates with the L.O. set 10.7 MHz above the receive frequency.

F1 and F3 are 110 kHz bandwidth 10.7 MHz ceramic IF filters that provide channel-to-channel selectivity. L9, C97, R101 and C99 form a phase shift network that is part of the internal FM demodulator. C97 fine tunes the circuit for lowest audio distortion and maximum audio amplitude.

The RSSI (receive signal strength indicator) signal at TP7 is used to mute the receiver audio when no signal is present. It is also used for searching for an active channel and setting the receive RF level meter on the LCD. The RSSI signal connects to a microprocessor input which is an internal analog-to-digital converter. The RSSI is a DC level ranging from 200mV to 2.5 V and is proportional to RF signal strength. The RSSI also functional during IR reception.

U15-B is primarily a receiver de-emphasis (low-pass) filter but also equalizes audio gain between 72 MHz, IR, and 216 MHz operation.

Q10, Q11, Q18 and U13 form a PLL frequency synthesizer circuit. Q11 is a VCO for 72 MHz and IR. Q8 is a VCO for 216 MHz. Q10 is an RF buffer amplifier. The output of Q10 is split to two paths. One is to U16 to provide a local oscillator signal. The other is to the input of the PLL synthesizer U13. D7 and D8 are varactor diodes which control the VCO frequency by varying the DC bias voltage across these diodes. Pin 2 of U13 is a phase error signal that precisely controls the VCO frequency so that it is locked to the programmed frequency and stabilized by the 4 MHz reference crystal oscillator. The CPU selects either the 72 MHz/IR VCO or the 216 MHz VCO. The CPU loads U13 via three serial interface lines(U13 pins 11,12,13).

Receiver Antennas

The receiver uses two small loop antennas. One is tuned to the 72 MHz band and the other is tuned to 216 MHz. Variable capacitors tune the Each loop antenna is followed by a low noise amplifier (U20 and U21). The CPU switches power to the low noise amplifiers so that they are active only when receiving a channel in that band.

IR Section

The IR receiver uses an external sensor to detect the optical IR signal. The sensor uses a PIN photodiode detector (D1) which is connected to a low noise amplifier (Q11). Operational amplifier U1 provides additional amplification. The signal at the output of the sensor will be between 95 kHz and 3.8 MHz depending on IR transmitter channel. The signal at this point is very small and can not be observed on an oscilloscope unless the sensor is extremely close to the IR transmitter.

The Microfield unit provides 3.3 volts to the sensor circuit via the ring contact of the IR connector. The signal is carried via the tip connection.

The IR signal is up-converted to the range of 48.095 – 51.8 MHz by the diode mixer U18. Q19 is a crystal oscillator that generates a 48 MHz local oscillator for the mixer. L14 and L12 form a band pass filter for the up-converter frequencies. U10 amplifies the signal while C131 and L15 match the signal to the receiver input. D12 is a PIN diode that acts as a switch to open the IR circuit when it is not used so that the 72 MHz signal can flow to the receiver input.

The receiver (U16) down-converts the signal to 10.7 MHz, amplifies and performs FM demodulation. U15-B amplifies and filters the IR audio signal.

Audio Section

Q20 is a audio mute switch(squelch) that is controlled by the CPU. The switch is on when either the IR, 72 MHz or 216 MHz RSSI level is low. When Q20 is on the audio signal is shorted to ground.

U7-A is an audio mixer that combines audio signals from the receiver and the MIC/AUX input. U14 is a microphone preamplifier and automatic gain control. Q15 switches the power on to U14 when either a microphone or auxiliary input is connected to J5.

R108, R106 and C106 provide microphone bias voltage. Q14 detects the presence of a microphone or auxiliary connection.

U11 is a digitally controlled audio level potentiometer. The CPU controls U11 via a serial data stream over a three line interface consisting of a clock, data and an enable signal. The wiper of U11 connects to U7-B which is an audio buffer amplifier.

U2 is a bridged audio power amplifier used to boost the audio signal to drive a headphone or speaker. The outputs of the audio amplifier are 180 degrees out of phase with respect to each other.

216 MHz Transmitter Section

Q2 is a voltage controlled oscillator (VCO) that operates in the 216 MHz range. D4 is a varactor diode that changes the VCO frequency as the voltage at TP6 varies. Q3 is an RF buffer amplifier. The output of Q3 splits to two paths. One path is to Q4 which is an RF power amplifier and the other path is to the input of U6 which is a PLL synthesizer. U8 is a 4 MHz reference oscillator for U6. U6 phase locks the frequency of Q2 to a 216 MHz channel that is programmed into U6 by the CPU.

Audio frequency modulation of the VCO is induced via R14. Q1 is a buffer amplifier for the phase error signal from the U6 PLL.

Q9 selects the RF power amplifier Q4 power output level. When a microphone or auxiliary input is connected, Q9 is turned on by the CPU and the RF output power is at maximum. The transmitter antenna is a wire loop that is tuned to resonance by C155.

Power Supply

Microfield is powered by 4 AA NiMH batteries. The battery voltage is regulated to 3.3 VDC by U1 which is a linear low dropout regulator. Pin 3 of U1 is a shutdown control to remove all battery power from the unit when turned off. Power turn on is accomplished by closing S1 which manually turns on U1. The CPU takes control of U1 through Q7.

All Microfield circuits except for U14 operate from the 3.3V regulated supply voltage.

Q17 momentarily turns on U1 when an AC adapter is connected. Q6 detects the presence of external DC power being applied and the CPU initiates the charging sequence. U22 is a voltage regulator which is part of the battery charging circuit. Q12 allows the CPU to turn the charger on and off. Battery charging current flows through R75 and D9. R118 provides a small trickle current to the battery after the charging cycle is complete.

The battery voltage is monitored by the CPU via R35 and R36 which reduces the battery voltage so that it can be accurately read by the internal analog-to-digital converter.