

Appendix 1.

Design and measurement of the wearable ultrasound device

The wearable ultrasound device, model Cloud-35LL (Stork, Chengdu, China), consists of a patch transducer and a main unit. The patch transducer is designed as a lightweight, slim, and elongated patch-style made of skin-friendly silicone material, with dimensions of 60mm in length, 15mm in width, and 6mm in thickness, and a center frequency of 7.1 MHz. It connects to the main unit via a soft, thin, and flexible white cable. The main unit, which is also portable, measures 171mm in length, 50mm in width, and 32mm in thickness, which real-time communicate with a tablet via Wi-Fi, enabling the tablet to receive control commands and upload image data for immediate display and analysis. Operators can view ultrasound images in real-time on the tablet screen. The ultrasound image interface allows adjustments to various parameters within the image post-processing module, enhancing image quality to meet specific clinical requirements. The ultrasound system supports multiple imaging modes, including two-dimensional imaging, color Doppler imaging, and pulsed wave (PW) Doppler imaging. Moreover, it offers measurement capabilities for distance, area, and angle, making it a versatile and valuable tool for clinicians managing acute and critical patients.

The main unit hardware consists of the Field-Programmable Gate Array (FPGA) chip, Analog Front-End (AFE) chip, High Voltage Switch Chip (HV SWITCH) chip, and the Wi-Fi module. The FPGA chip used is the Xilinx Kintex-7 XC7K325T Field-Programmable Gate Array, which is responsible for the control, computation, and communication of the entire system. It primarily handles tasks such as Wi-Fi communication with the tablet, scanning sequence generation, parameter calculation, transmit waveform control, ultrasound beamforming, Doppler frequency shift estimation, and image preprocessing. The AFE chip is the MAX2082 from Maxim, which is an integrated transceiver analog front-end. In the transmit section, it controls transmit timing and generates high-voltage excitation signals. In the receive section, it handles signal conditioning and digital-to-analog conversion. The HV SWITCH chip is the HDL6M06531B from ABLIC, a high-voltage transceiver analog switch. It connects to a 128-element ultrasound transducer and is mainly responsible for transmitting high-voltage signals and receiving low-voltage echo signals. The Wi-Fi module is the CC32335MOD from Texas Instruments, a dual-band 2.4G/5G wireless communication module. It is ultra-low power, compact, and integrates the Wi-Fi protocol stack. The FPGA uses this module to wirelessly communicate with the main unit, enabling functionalities such as downloading scanning commands and uploading image data.