

Introduction

It was shown in [1] that electrophysiology and other non-MR signals can be measured by MR equipment after modulation to frequencies close to those of the MR-signals. After wireless transmission to the scanner, these signals were recorded in perfect synchrony with the image acquisition. Surplus sampling and storage capacity of the scanner were thereby exploited for recording of electrophysiology while imaging-induced distortions were largely avoided [2]. Here we demonstrate that the method is well-suited for EEG-recording during EPI at 3T. Eyes-open/eyes-closed conditions result in measurable alpha EEG modulation.

Methods

The “Magstripe MRI” principle is illustrated in figures 1 and 2: Electrophysiological signals are transmitted inside the RF cabin and are encoded in MR raw data without affecting reconstructed images. An improved version of the modulator described in ref. [1] was used. It differs mostly with respect to noise-characteristics, frequency control and signal previewing capabilities[3]. ECG, EEGs and EOGs were recorded during fast ramp sampling EPI on a Siemens Trio 3T MR system. Matrix 64x64, 10 slices, TE/TR=41/607ms, 220 mm FOV, echo spacing 560 microseconds, gradient plateau 300 microseconds, line sampling time 512 microseconds. A healthy volunteer was instructed to open and close the eyes every thirty seconds during a 145 second scanning period. Six twisted carbon electrode pairs were used to record ECG, 2xEOG and 3xEEG (electrodes placed at forehead and behind ears. Ambu, DK). An additional channel was used to record a known 30 Hz calibration signal. The electrophysiological recordings were reconstructed to 1.7 kHz bandwidth after lowpass filtering to 1.5 kHz bandwidth in the modulator. Residual gradient artifacts were easily removed [4]. A further reduction to 60 Hz was performed after reconstruction and gridding. Pulse artifact subtraction was performed with the FMRIB EEGlab plugin [5].

Results and Conclusion

Magstripe encoding reduce EEG gradient distortions significantly. Alpha activity and modulation by opening the eyes were detected (figs. 3, 4), thus demonstrating that the method is suited for EEG recording during rapid EPI. The system is easy to use. Excluding computer and cables, it weighs 2 kg including batteries. The results support claims [1] that neither image nor signal qualities are sacrificed.

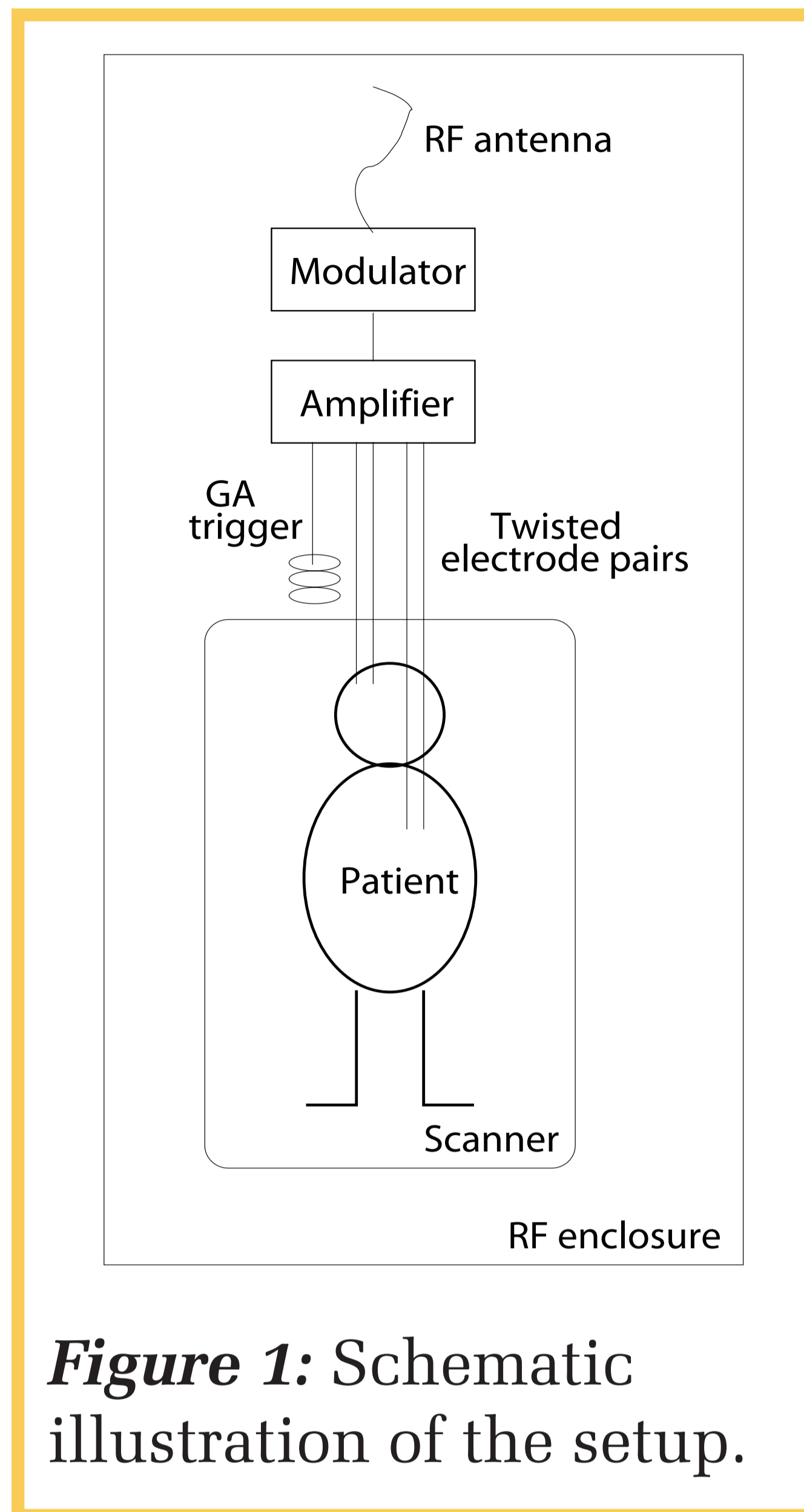


Figure 1: Schematic illustration of the setup.

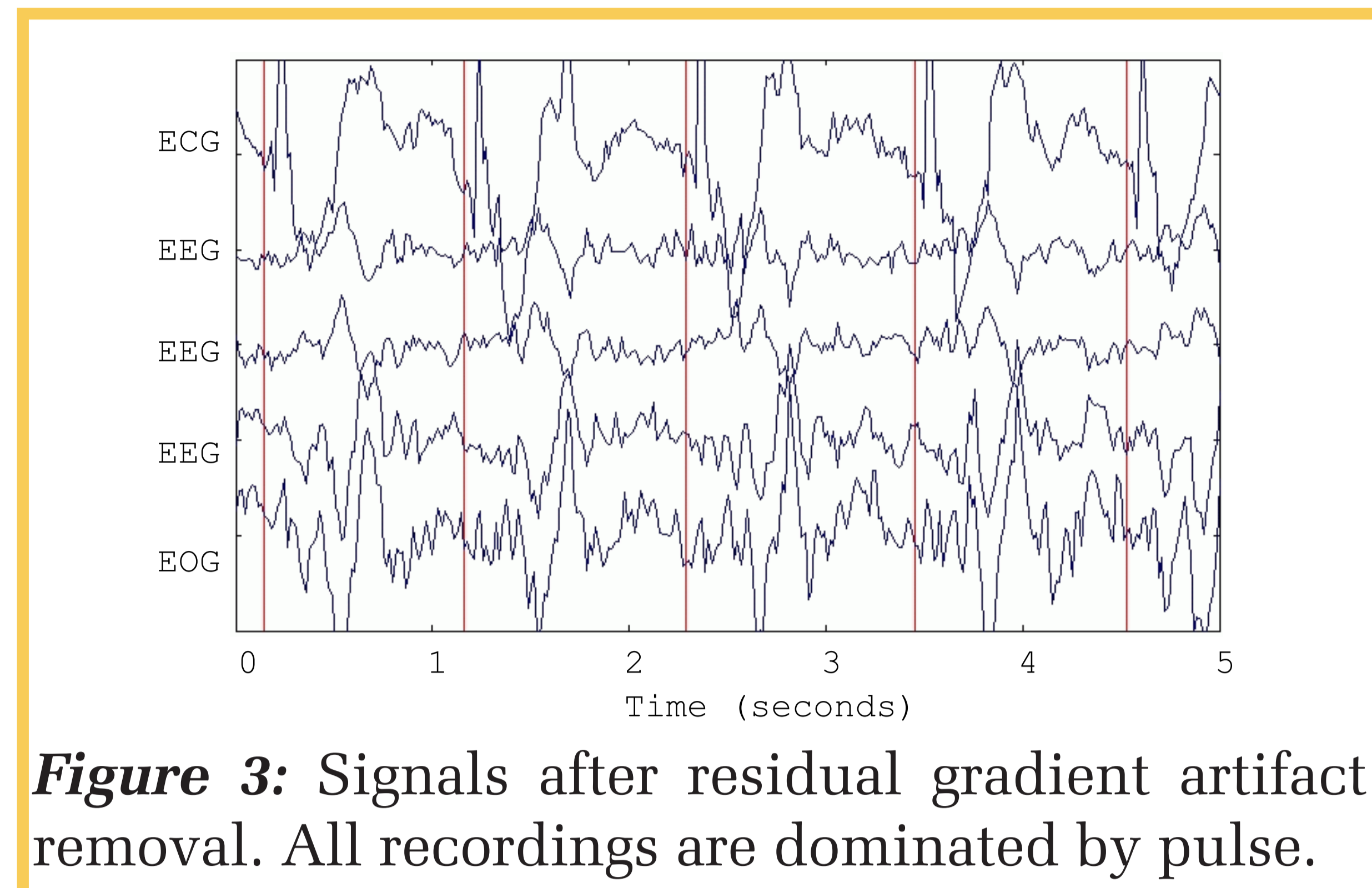
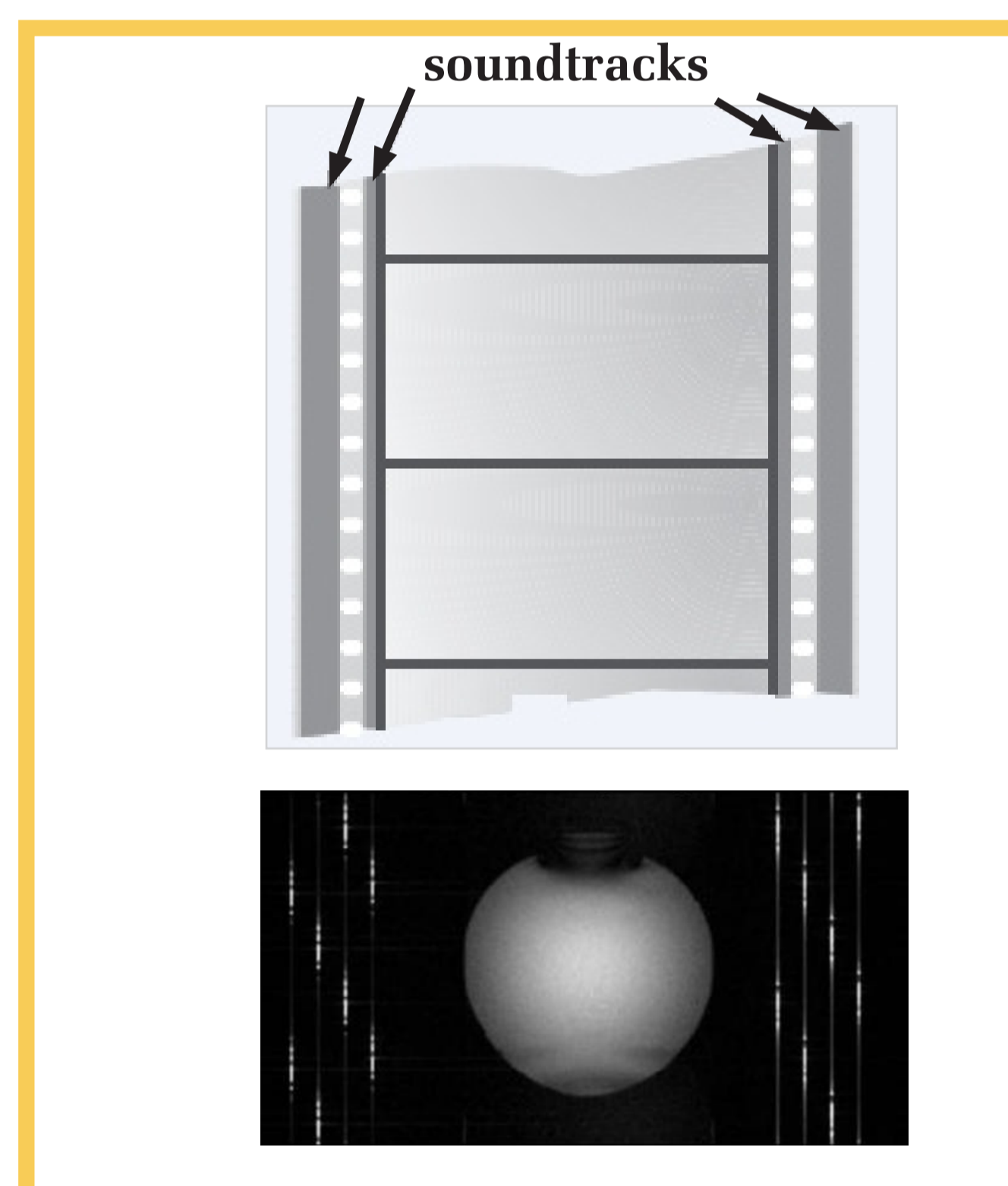


Figure 3: Signals after residual gradient artifact removal. All recordings are dominated by pulse.

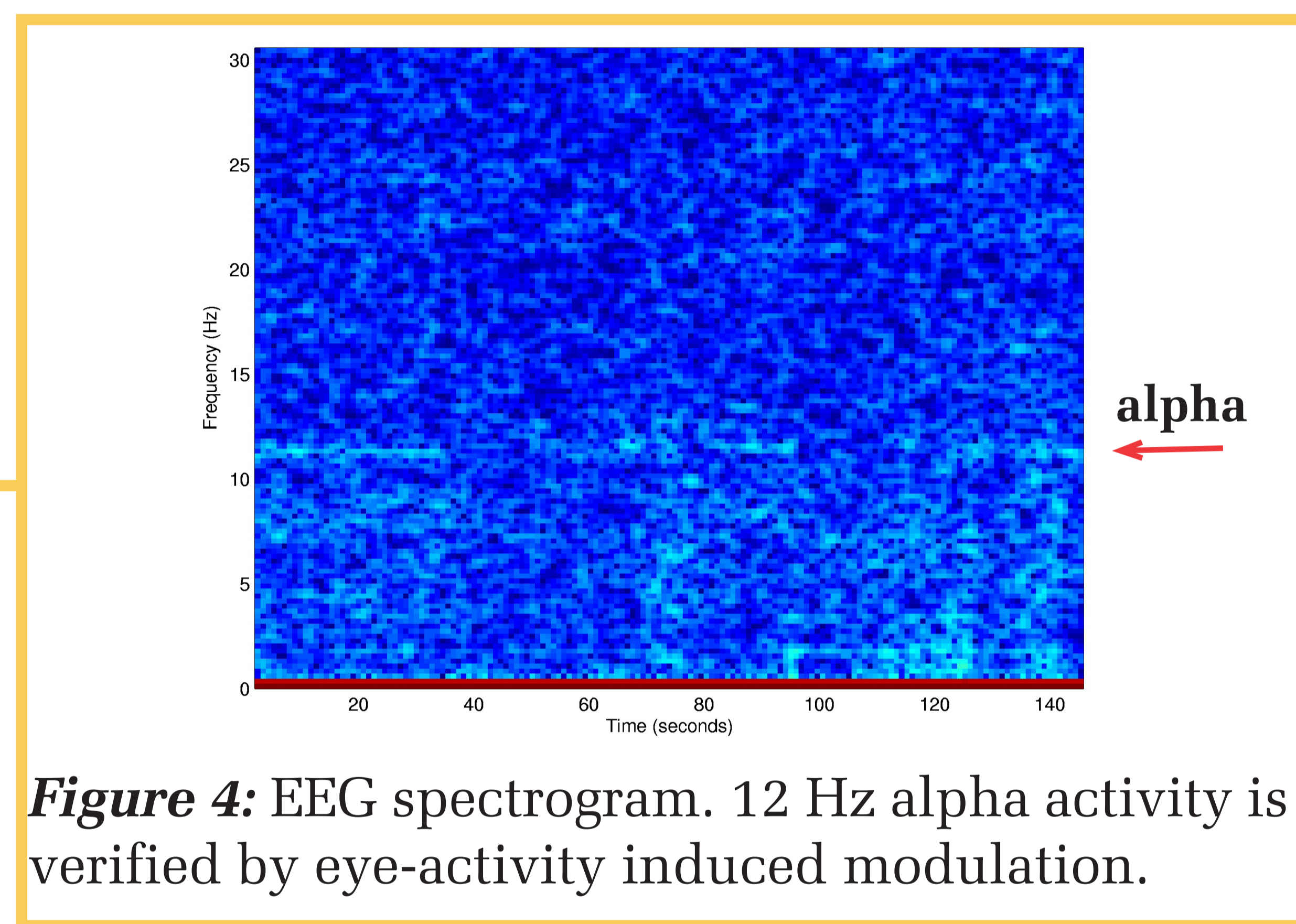


Figure 4: EEG spectrogram. 12 Hz alpha activity is verified by eye-activity induced modulation.

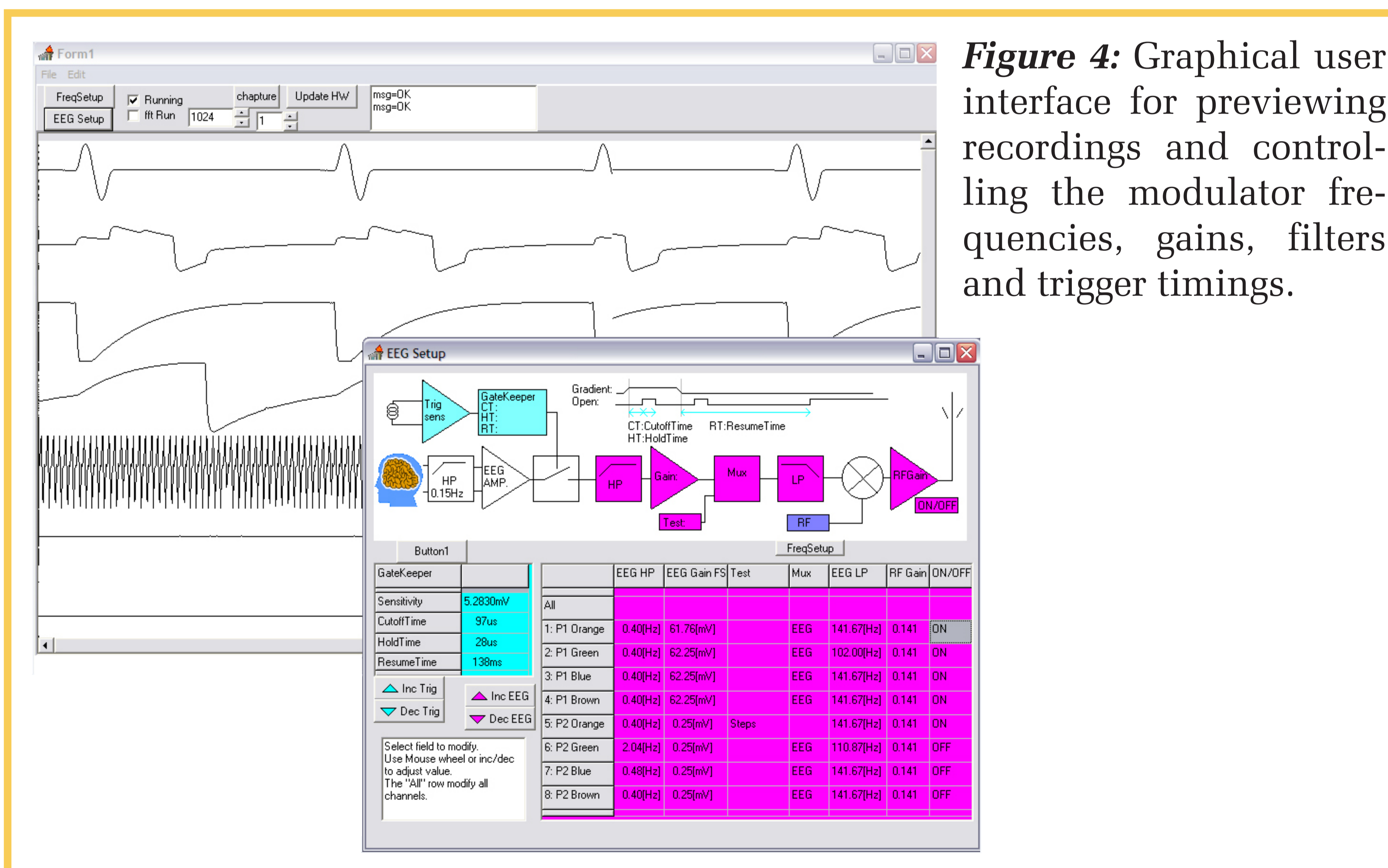


Figure 4: Graphical user interface for previewing recordings and controlling the modulator frequencies, gains, filters and trigger timings.

References

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