A new kind of monitor for ophthalmic operation

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A new kind of monitor for ophthalmic operation

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Abstract. The integrity of the vision channel is often checked using VEP in order to avoiding damaging important tissue during an ophthalmic operation. But the measurement of before operations has strong side effects, it may damage the eyeball. We will introduce a new kind for monitoring ophthalmic operations in this paper. It uses visual electrical evoked potential to check the integrity of the vision access and it can monitor ophthalmic operations and avoid damaging any tissue, so it ensures the safety of the operation.

1. VEP (Visual Evoked Potential)

Losing eyesight is possible after ophthalmic operation. In order to avoid this, the most effective method is to monitor the integrity of the vision channel during the operation. It can reduce the damage of the retina. The traditional measurement usually uses VEP to monitor the vision channel. VEP (Visual Evoked Potential) refers to stimulating the retina then recording the potential at the cortex [1]. It has two main methods: One is FVEP (Flash Visual Evoked Potential) and the other is PVEP (Pattern Visual Evoked Potential). FVEP refers to recording the potential at the cortex when the retina is stimulated by serial flash. PVEP refers to recording the potential at the cortex when the retina is stimulated by turned chessboard grid.

2. History of VEP for monitor the operation

In the 1870s VEP was discovered during animal experiments. But VEP is very weak and its variation is very strong, it is difficult to use VEP during clinical. Procedures FVEP and PVEP were not implemented during clinic until the computer technology development in the 1960s.

In 1973 Wright invented touched mirror stimulator based on the theory of FVEP and applied the technology in vision function monitoring of eye pit operations for the first time successfully [2]. But this kind of stimulation has some disadvantage: the stimulator is too big to be fixed and it is difficult to achieve reliable results. In addition, the stimulator can damage the cornea.

In 1976 Feinsod used red LED as a stimulator, and applied the technology in vision function monitoring of nerve surgery operations for the first time [2].

In 1978 Harding invented a new kind of touched mirror stimulator and it achieved good result as an operation monitor. But it may damage the eyeball or cornea [2].
It is valuable to use VEP as a vision nerve function monitor, but cornea mirror FVEP can make the cornea dry and can damage the cornea. In order to overcome the limitation which has been mentioned above, some scholar invented untouched stimulator by fixing red flash LED on goggles. But this kind of FVEP stimulator has two disadvantages: the normal value of wave and latent period change is strong, what’s worse, the FVEP is still normal when the vision channel is damaged.

During clinic the stimulator usually adopts changed tessellation on screen. Vision cortex is very sensitive if it is stimulated by vivid and changed figure. But this kind of VEP is much affected by anesthesia. The stimulation and record method is not suitable for use during operation.

3. VEEP (Visual Electrical Evoked Potential)

For the disadvantages which are mentioned above, a new kind of monitor for ophthalmic operation is presented in this paper. It uses visual electrical evoked potential to check the integrity of the vision channel. Visual electrical evoked potential (VEEP) refers to stimulating the retina by weak DC in pulse mode, and then recording electrical movement at the visual cortex. It is also named electrically evoked response of the visual system (EER) [3]. The frequency of VEEP is the same as the stimulus signal, this is named rhythm assimilation.

Many foreign scholars research VEEP [4], they usually record the visual evoked potential at the cortex but this method can damage tissue. The electrical movement of nerve cell can be detected by implanting a sensitive electrode at vision cortex. The method is complex and is not suitable for use during operation. The method introduced in this paper operates more easily and can not damage any tissue, so it ensures the safety of the operation.

3.1. Functional description

The electrical signal with some frequency and magnitude is loaded onto the bistoury during the operation, and the VEEP magnitude is a function of the distance between the bistoury and the retina, it can be detected and used to monitor the distance between the bistoury and the retina. When the distance is too close to damage the retina, the alarm will be given to the doctor to caution them to stop the operation.

The system uses a needle electrode, the recording electrode is implanted in the cortex 0.5cm above occipital, the reference electrode is placed above the nose root, and the ground electrode is placed at the papilla of one ear. VEEP signal is magnified and filtered then changed to digital signal, finally the signal is sent to note computer to be folded and showed.

3.2. The introduction of hardware circuit

The VEEP magnitude which can be detected at the cortex is very low. It is only in the magnitude of µV. So the signal must be detected by a higher precision system. ADuC847 (produced by ADI) is used as MCU in this system. It integrates high resolution Σ-Δ ADC with flexible, 12-bit DAC, up to 10-channel input multiplexing, a fast 8-bit MCU, 2304 bytes on-chip date RAM, and program/data Flash/EE memory on a single chip [5].

Figure 1 is the hardware circuit diagram. The frequency, intensity and stimulating duration of VEEP is not fixted so the state of the stimulating signal can be changed. The stimulating signal of the system is provided by DAC of ADuC847. DAC can be started after inputting the necessary frequency, intensity and stimulus duration. The stimulus signal is loaded onto the bistoury.

Figure 2 is the analog circuit diagram. The detected VEEP signal is sent to a parallel connection differential preamplifier. The parallel connection dual amplifier has many advantages. Its CMRR is infinite in theory and is not related to the matched degree of resistant around. The amplifier gain can not be too big because of the polarization voltage. Our design is 10. We used OP2177 (produced by ADI) to work the task. It is a precision low noise, low input bias current operational amplifier and the $V_{o.p}$ of noise is only 0.4µV. The coupling circuit lies between the two amplifier circuits. It offers condition to improve CMRR, what’s more, it avoids putting the heat noise to the main amplifier. According to the feature of stimulus signal and the rhythm assimilation, the bandpass of the filter is
from 0.5Hz to 100Hz. The offset voltage of the main amplifier is as small as possible because its gain is very large. AD620 (produced by ADI) can complete the task very well. Its most offset voltage is only 50µV and it gains 1000. The CMRR of the design is above 120dB and it can satisfy the requirement of the vision evoked potential.

![Diagram](image)

Figure 1. Hardware circuit diagram

4. Experiment
Some experiments have been done to prove the function of the detected system. Adult white rabbits (2-3kg) used in the study were initially anesthetized using urethane (1mg/kg). The stimulus signal was 15Hz and the pulse duration was constant at 10ms (figure 3). The stimulus electrode was placed 1mm before the retina with 5mA. One of the differential recording electrodes was placed at occipital and the other was placed at the forehead. The reference electrode was placed at papilla of one ear. The VEP signal will be shown at the screen after visual stimulation. The result was shown in figure 3. The positive pulse was a stimulus signal. The amplitude was about 336µV.

5. Conclusion
It is much more effective and reliable to use VEEP to monitor the ophthalmic operation than to use the traditional method. It can help a doctor know the integrity of the vision channel and reduce the risk of damaging the patient. In a word, it ensures the ophthalmic operations are more successful.
References


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