Capacitance Sensor for Finger Motion Sensing

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This contribution described a design of a capacitance sensor for finger motion sensing. A sensing of human body motion is very important for current neurology. There are several requirements that should be accomplished: non-contact sensing, very fast response and an analog output. A solution with a high-frequency capacitance sensor is described in this contribution. There is a brief description of each blocks and theirs function. Presented solution is purely analog and the designed sensor is very fast, but not totally precise.

1 Introduction

One of the most interesting tasks in current neurology is looking for a correlation between a human body motion and electro-encephalograph (EEG) signals. It is very important for comprehension of the human brain function.

The correlation between the body motion and EEG signals is very complicated. Therefore it is necessary to start with finding the response to basic motions of elementary parts of the human body. For example, one of the most elementary motions of the body is the 2-D motion of the index finger.

2 Specifications

There are several requirements measuring the motion of the index finger that the sensor has to accomplish:

- non-contact sensing
  The sensing of finger location does not have to be invasive, because the contact sensing could affect the measured EEG signals.
- very fast response of the sensor output on the motion of the finger
  There is the demand on speed of the response. It has to be very fast, because slow response could devalue the measuring.
- analog output adapted to the input of the EEG measuring device

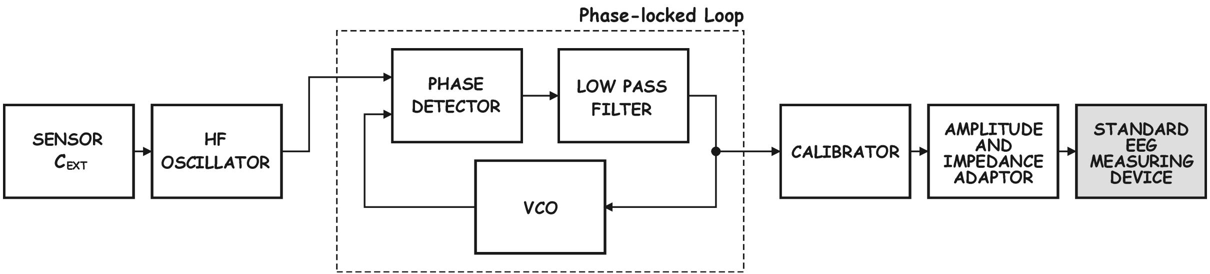

Fig. 1 General Diagram of Capacitance Sensor for Finger Motion Sensing

The output of the sensor will be linked to the input on the standard EEG measuring device. From this reason the amplitude and the impedance adaptation have to be provided.

3 Description

The sensor consists of several independent blocks (see Fig. 1).

The main block of the sensor is the phase-locked loop which consisting of a phase detector, a low pass filter and a voltage controlled oscillator. This block converts the frequency of the signal from a high-frequency oscillator to a DC voltage.

The high-frequency oscillator, the next block of the sensor, generates a sine signal, whose frequency depends on the finger location. The location of the index finger is sensed with the capacitance sensor C_{EXT}.

The output signal from the phase-locked loop is transmitted to the last two blocks, the calibrator and the amplitude and impedance adaptor. The signal is adapted to the input of the standard EEG measuring device there.

The output of the sensor is connected to the standard EEG measuring device.

4 Function

4.1 Sensor C_{EXT} and High-frequency oscillator

The high-frequency oscillator is the sine oscillator whose frequency depends on the location of the index finger. If the finger is in the sensor, the capacitance C_{EXT} is depended on the finger location (the construction of the sensor C_{EXT} is represented on Fig. 2), because the capacitor C_{EXT} comprises both the index finger and a copper board. The dielectric in this capacitor is air. Quiescent frequency (no finger frequency) of the high-frequency oscillator is set up to 10 MHz.

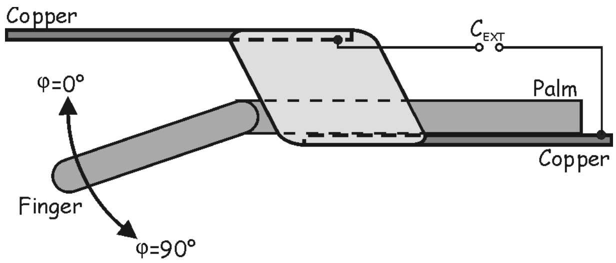

Fig. 2 Construction of Sensor C_{EXT}

The frequency of the output sine signal is being decreased with the decreasing of the finger angle (see Fig. 2).

4.2 Phase-locked Loop

The circuits of the phase-locked loop are based on the high-performance silicon-gate CMOS device MC74HC4046AN (HC4046) connected in common configuration (see Fig. 3).

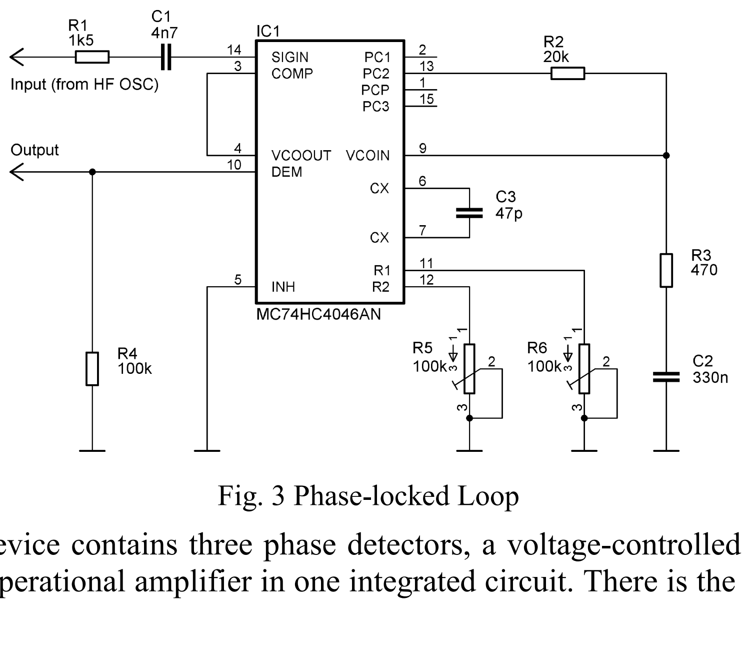

Fig. 3 Phase-locked Loop

The HC4046 device contains three phase detectors, a voltage-controlled oscillator (VCO) and a unity gain operational amplifier in one integrated circuit. There is the phase comparator

2 (PC2), which is appropriate for applications like this. This phase comparator is a digital memory network, which consists of some flip-flops and some gating logic.

The low pass filter is an external circuit, which consists of R2, R3 and C2 (see Fig. 3).

The voltage-controlled oscillator is used as well to make a fine conversion function between the finger location and the output voltage.

5 Results

Suggested solution is purely analog. The sensor is very fast, but not totally precise. It provides a non-linear conversion function (see Fig. 4), which can be used for real measuring in medical practice.

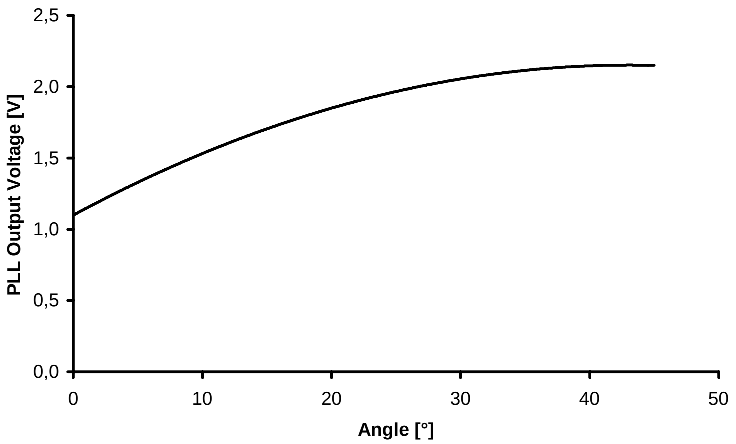

Fig. 4 Conversion Function

6 Conclusions

The presented capacitance sensor is sufficient for finger motion sensing, but it is not ideal. It has some minor problems to be solved, for example:

- non-linearity of conversion function,
- influence of parasite capacities.

7 References

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