# Detection of Back Magneto-cardiogram for Heart Disease Using Pico-Tesla Resolution Amorphous Wire Magneto-Impedance Sensor

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**Abstract**— We measured the magneto-cardiogram at the back of the human body (Back Magneto-cardiogram; Back-MCG) using the pico-Tesla resolution amorphous wire magneto-impedance sensor (PT-MI sensor) and found that the double-peak magnetic field waveform appeared in the healthy subject's Back-MCG only, while disappeared in the angina pectoris patient's Back-MCG. We also found that the double-peak waveform appeared for a while such as around 1 hour even in the Back-MCG of the angina pectoris patients after application of an ELF magnetic stimulus with stroking a magnetized crashed stone packed pipe on the body through 10 min.

## 1. INTRODUCTION

A non-invasive and sensitive detection method for heart diseases have been required on the prediction of the World Health Statistics 2012 by the WHO which predicted that the number of deaths from heart diseases per one year would increase to 25 million by 2030. We have developed a highly sensitive magnetic sensor having 1 pico-Tesla resolution using the amorphous wire CMOS IC magneto-impedance sensor named the PT-MI sensor [1, 2]. We detected the Back Magneto-cardiogram (Back-MCG) at the left shoulder blade bottom position of the subject slightly touching the amorphous wire head using the PT-MI sensor and found that the double-peak magnetic field waveform appeared in the Back-MCG of the healthy subjects, which disappeared in the Back-MCG of angina pectoris patients. The double-peak waveform does not appear in the Chest-MCG for both healthy and patients with heart diseases.

We also found that the double-peak waveform appeared for a while such as one hour in the Back-MCG of the angina pectoris patients after application of an ELF magnetic stimulus with stroking a magnetized stone packed pipe on their body surface through 10 min., resulting a probable improvement of the heart diseases. Similar probable improvement was obtained after application of an ELF magnetic stimulus with touching a magnetized sintered particle train belt [3] on their spine position through 30 min..

## 2. MEASUREMENTS

### 2.1. Chest Magneto-cardiogram

Figure 1 represents simultaneous measurement results of the electrocardiogram (ECG) and the chest magneto-cardiogram (MCG) for a healthy subject (51 year old male) using the PT-MI sensor without any magnetic shielding. We found a time lag of around 150 ms of the MCG peak waveform behind the ECG peak waveform ($0.4\pi$rad. phase lag) , which substantiates an assumption that the origin of the MCG peak pulse should be the $Ca^{2+}$ ion current magnetic field flowing into the muscle cells triggered with the action potential ECG peak pulse [4, 5].

### 2.2. Back Magneto-cardiogram

Figure 2 illustrates measured results of the back magneto-cardiogram (Back-MCG) for five subjects: (a) healthy 51 year-old male, (b) healthy 46 year-old male, (c) healthy 73 year-old female, (d) 71 year-old male with the angina pectoris, and (e) 73 year-old male with the angina pectoris. The Back-MCG was detected using the PT-MI sensor at the left shoulder blade bottom position of each subject sitting quietly on a wooden chair without any magnetic shielding. We newly found that a double-peak waveform (DP) appeared in the Back-MCG of all healthy subjects (a), (b), and (c), while no appearance for angina pectoris patients (d) and (e).

We found a conformity of the double peaks in the Back-MCG for the healthy subjects in Figure 2 to the open and close, respectively, of the aortic valve in the time phase. Thus, it would be possible

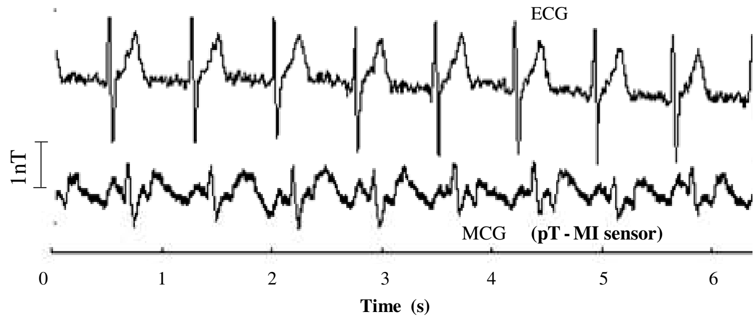


Figure 1: Simultaneous measurements of the electrocardiogram (ECG) and the chest magneto-cardiogram (MCG) for a healthy subject (51 year-old male) using the PT-MI sensor.

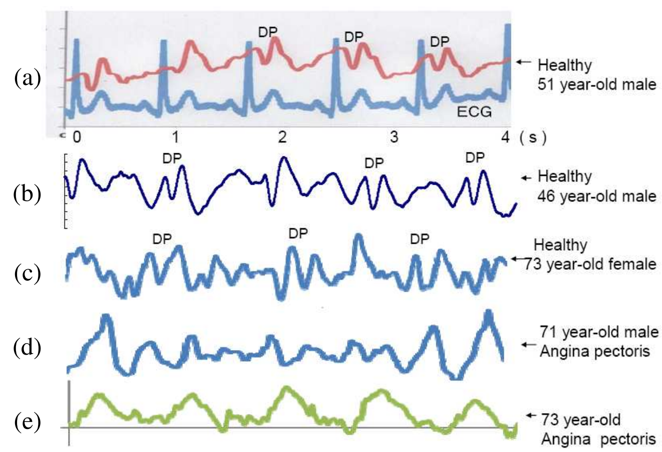


Figure 2: Back Magneto-cardiogram using the PT-MI sensor for (a) healthy 51 year-old male, (b) healthy 46 year-old male, (c) healthy 73 year-old female, (d) 71 year-old male with angina pectoris, and (e) 73 year-old male with angina pectoris.

to develop a new device for diagnosis of the arteriosclerosis measuring the time between the aortic valve open and the ascending of the pulse wave at the ankle.

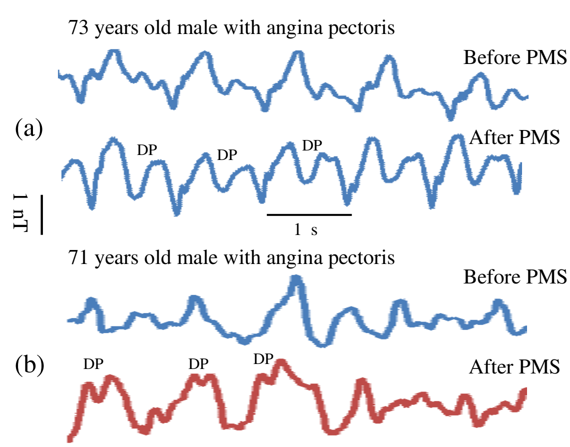


Figure 3: Change of the Back-MCG waveform for two patients with the angina pectoris after stroking a magnetized stone packed pipe on their body through 10 min.: (a) 73 year-old male, and (b) 71 yea-old male.

## 3. CHANGE OF BACK-MCG WITH ELF MAGNETIC STIMULUS

We found that the DP magnetic field waveform appeared in the Back-MCG of the two angina pectoris patients after stroking a magnetized stone packed pipe on their body through 10 min. (we say "Physiological Magnetic Stimulus; PMS") as represented in Figure 3. The probable improvement of the angina pectoris showing the Back-MCG DP wave with the pipe magnetic stimulus is considered due to the magneto-protonics principle, in which the free protons generated in the body water running through the periodical distributed alternating pulse magnetic field on the pipe surface activated the ATP production function of the mitochondria in the aorta muscle cells and the heart muscle cells [3, 6].

## 4. FFT FREQUENCY SPECTRUM OF BACK-MCG

Figure 4 shows the FFT frequency spectrum of the Back-MCG of the three subjects: (a) healthy 73 year-old female, (b) 71 year-old male with the angina pectoris, and (c) 73 year-old male with the angina pectoris.

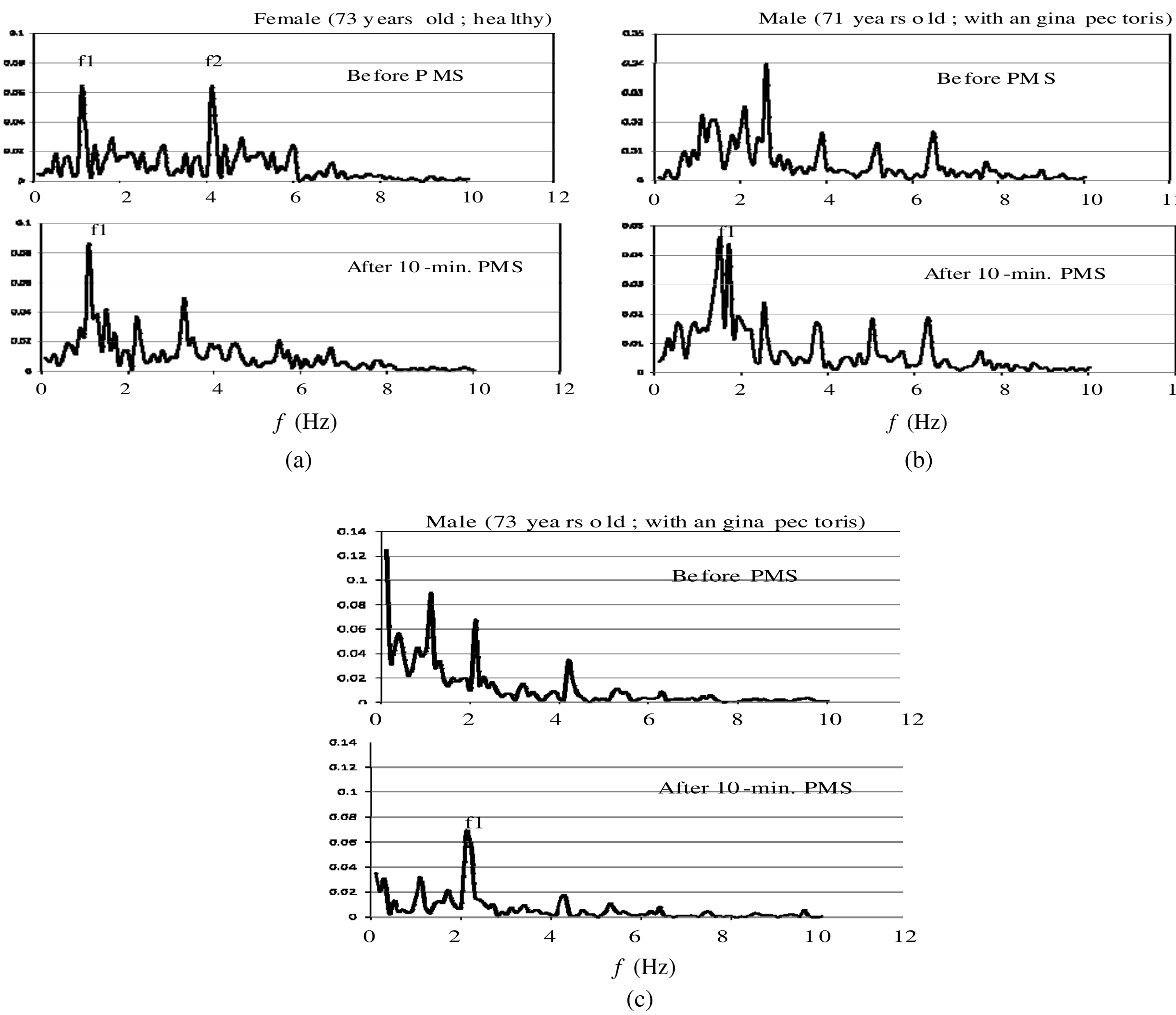


Figure 4: FFT frequency spectrum of the Back-MCG before and after the magnetic stimulus with stroking the magnetized stone packed pipe on the body through 10 min. for (a) healthy 73 year-old female, (b) 71 year-old male with the angina pectoris, and (c) 73 year-old male with the angina pectoris.

We found an energy concentration in the frequency spectra (a)–(c) to the basic stroking frequency $f_1$ of the heart-aorta blood circulation system with application of the ELF magnetic stimulus.

## 5. CONCLUSIONS

We newly found the existence of a double-peak magnetic field wave in the Back-MCG for healthy subjects whilst disappears for subjects with the angina pectoris. We may expect a new non-invasive and sensitive diagnosis method for heart diseases with measurement of the Back-MCG using the amorphous wire PT-MI sensor although we should increase the number of subjects. The ELF magnetic stimulus may effective for tentative recovery of the angina pectoris.

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