IMPLEMENTATION OF A PEDOBAROGRAPHIC SYSTEM THROUGH EFFECTIVE CROSSTALK SUPPRESSION WITH AN ALL PROGRAMMABLE SYSTEM ON CHIP

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Declaration

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The above candidate has carried out research for the MPhil Dissertation under my supervision.

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Dedication

There are a number of people without whom this thesis might not have been written, and to whom I am greatly indebted.

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Abstract

Diabetes Mellitus which is characterized by longstanding hyperglycemia, promote diabetic peripheral neuropathy (DPN) and peripheral artery diseases (PAD) which invoke ulcerations especially on the foot plantar ultimately leads to amputations related morbidity and mortality. Recent clinical studies have identified distinct associations between DPN and foot plantar pressure, and PAD and foot plantar temperature. Hence, development of technology to analyze foot plantar pressure (pedobarography) and foot plantar temperature (pedothermography) to infer DPN and PAD associated diseases at the onset have recently stirred a significant interest among the scientific community.

In the present study, we have primarily investigated the possibility of implementing a highly accurate large piezoresistive platform sensor array (a pedobrographic system) with an improved readout mechanism. We devised a readout circuit to mitigate inherent crosstalk interference with an improved scanning architecture implemented using a decoder-transistor based row driving electrodes and related electronics compatible with high frequency sensing. Then, the developed readout circuit was extensively validated and the proposed implementation was able to make measurements of significant accuracy with errors $< 1\%$ while not compromising the shape accuracy of the measured object. Initiatives were also taken to improve the data acquisition rate despite massive sensor data influx from 30,000 sensels. A Xilinx Zynq APSoC based data acquisition system was implemented to scan the entire array with 30,000 sensels and the analysis showed that the system demonstrated expected behavior. Overall, the proposed implementation entertained both static and dynamic pressure measurements of a foot plantar. A subsequent static calibration of the piezoresisitive sensor array was conducted using weight plates and the calibrated sensor array was validated against an existing commercial plantar pressure measurement system to determine its performance.

In addition, possibility of implementing a screening tool for pedothermographic assessment using near infrared (NIR) technology was investigated to provide an overall assessment of both foot planters in a single frame and record both regional and point temperatures of the foot plantar. The proposed thermal imaging system is anticipated to be used in routine clinical assessment of diabetic foot complications at diabetic clinics to provide improved diagnostics, thereby contributing to prevention of diabetic foot ulcerations, amputations and related morbidity.

List of Abbreviations

Abbreviation	Description
AA	Anti–Aliasing
ABI	Ankle-Brachial Index
ADC	Analog to Digital Converter
AGC	Automatic Gain Control
APSoC	All Programmable System on Chip
ASIC	Application Specific Integrated Circuit
AXI	Advanced eXtensible Interface
BRAM	Block Random Access Memory
CAN	Controller Area Network
CMOS	Complementary Metal-Oxide-Semiconductor
CPT	Current Perception Threshold
DAQ	Data Acquisition
DFU	Diabetic Foot Ulceration
DMA	Direct Memory Access
DPN	Diabetic Peripheral Neuropathy
DSP	Digital Signal Processing
EBT	Element Being Tested
EMG	Electromyography
ESR	Equivalent Series Resistance
FF	Flip-Flop
FPGA	Field Programmable Gate Array
Gbps	Giga-bits per second

GPIO	General Purpose Input Output
GRF	Ground Reaction Force
GUI	Graphical User Interface
HDL	Hardware Description Language
HDMI	High-Definition Multimedia Interface
IP	Intellectual Property
IWGDF	International Working Group on Diabetic Foot
LCT	Liquid Crystal Thermography
LDO	Linear Dropout Regulators
LOPS	Loss of Peripheral Sensation
LUT	Look Up Table
Mbps	Mega bits per second
Mux	Multiplexer
NCS	Nerve Conduction Studies
NCV	Nerve Conduction Velocity
NIR	Near Infrared
Op-amp	Operational Amplifier
PAD	Peripheral Artery Disease
PCB	Printed Circuit Board
PL	Programmable Logic
PS	Processing System
PSoC	Programmable System on Chip
QST	Quantitative sensory threshold
RTL	Register Transfer Level
RSA	Resistor Sensor Array
SBC	Single Board Computer
SDK	Software Development Kit
SMD	Surface Mount Devices
SMD	Surface-Mounted Device
SMPS	Switch Mode Power Supply

S-NSE-ZP	Setting Non-Scanned Electrode Zero Potential
S-NSDE-ZP	Setting Non-Scanned Driving Electrode Zero Potential
S-NSSE-ZP	Setting Non-Scanned Sampling Electrode Zero Potential
SPST	Single Pole Single Throw
SSH	Secure Shell
TBI	Toe-brachial Index
UART	Universal Asynchronous Receiver-Transmitter
USB	Universal Serial Bus
VFM	Voltage Feedback Method
VF-NSE	Voltage Feedback Non-Scanned Electrode
VF-NSDE	Voltage Feedback Non-Scanned Driving Electrode
VF-NSSE	Voltage Feedback Non-Scanned Sampling Electrode
VNC	Virtual Network Computing
WHO	World Health Organization
WHS	Worst Hold Slack
WNS	Worst Negative Slack
ZPM	Zero Potential Method

List of Appendices