

Posturographic platform based on RaspberryPi -prototype of mobile rehabilitation device

Professional posturographic platforms usually cost a couple of hundred euros. An alternative for such a device can be a platform based on Raspberry Pi microPC and MCP 3424 converter. Moreover because of HDMI output data can be presented without use of extra computer. It can also be retrieved easily through the built in WLAN card.

Posturography is a test that measures force of pressure, it can be performed as stable posturography or dynamic. Center of Foot Pressure is presented as statokinesiogram or stabilogram (fig.1). Statokinesiogram presents data as (x,y) plot where x is Left-Right axis and y is Anterior-Posterior axis. Stabilogram show pressure in time, movement in Left-Right axis and Anterior-Posterior axis are shown separately.

Exercises based on posturography are often performed with patients with neurological disorders (e.g. patients after strokes)[1,2] and with patients after orthopaedic surgeries (especially in knee joint - e.g. anterior cruciate ligament reconstruction).

(www.pro-wiss.de) [8] were made. All those projects are based on old Nintendo product - Wii BalanceBoard which is not supported and not produced anymore. Moreover in every one of those Project use of external computer is needed. Next step in posturography diagnostics and active rehabilitation or exergaming (from exercise+gaming) is creation of a platform with a built-in microPC. In this article keypoints and technical specification is being presented.

Prototype

In constructed prototype four tensile sensors were used and connected to the INA125 amplifier [9]. INA125 amplifier (fig.2) has low energy consumption and provides stable reference voltage. Signal amplification is possible from x4 till x10000 depending on the amplifier connected between pins eight and nine.

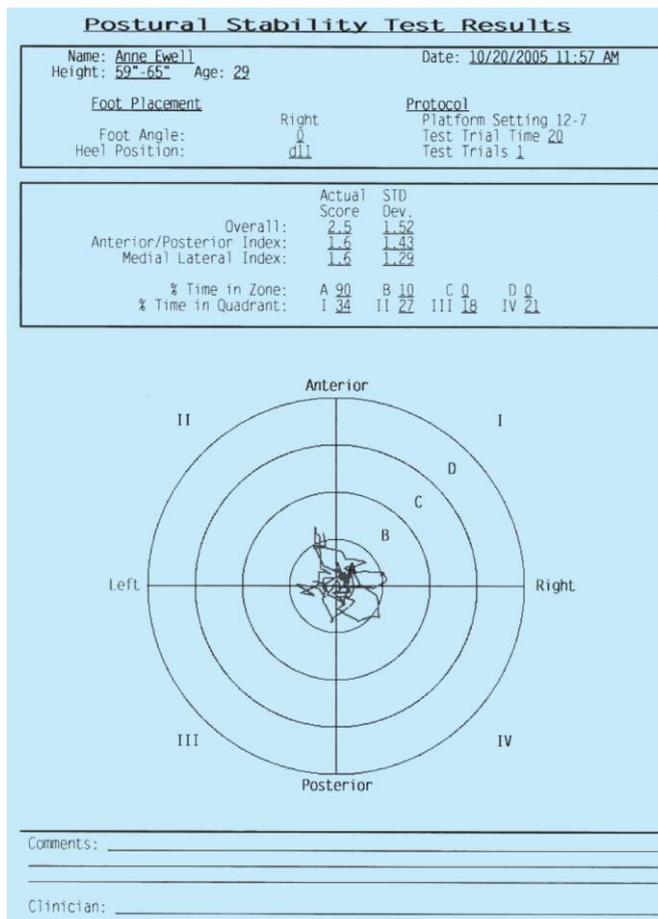


Fig.1 Example of stabilogram, source: Instruction Manual Balance System SD, Biodex Medical System Inc

Till now except standard commercially build platforms many teams and companies have tried to adapt Nintendo Wii Balance Board[3-5] Projects like HomeBalance in Czech Republic (www.homebalance.cz) [6], NeuroForma in Poland (www.neuroforma.pl), FysioMeter in Denmark (www.fysioMeter.com) [7], STABLE in Germany

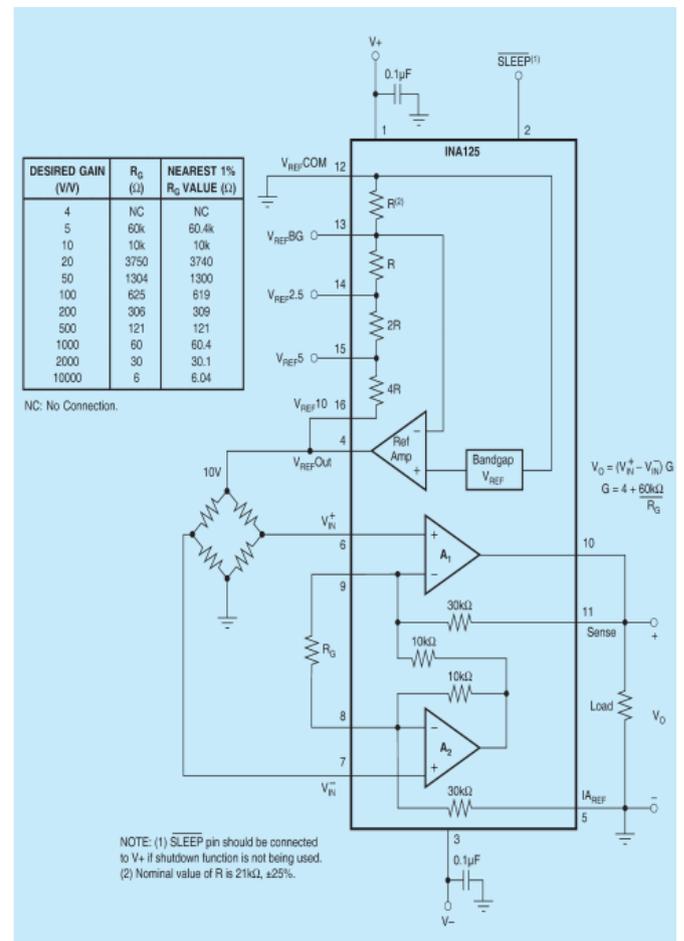


Fig.2 INA125 Amplifier

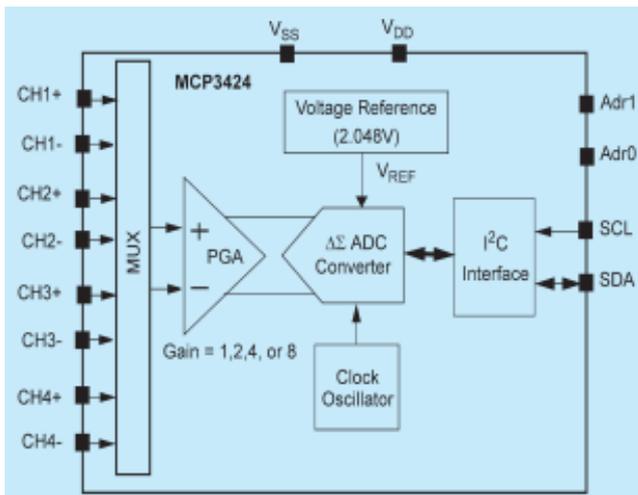


Fig.3 MCP3423 Converter

Signal from four INA125 amplifier is then converted by analog to digital MCP3424 chip (fig.3). It reads data 240 per second with 18 bit resolution [8]. Analog signal is converted to digital I2C standard and then transferred to input in RaspberryPi microPC. I2C standard was developed by Philips (currently NXP Semiconductors) in 80s. It uses two lines: SCL – Serial Clock Line and SDA – Serial Data Line. I2C is based on positive logic [9].

Software

Four different values of pressure can show current deviation of patient standing on platform. It is presented as point in the middle of screen. Data is read real-time. Range of motion is presented as statokinesiogram. Everyday patient progress can be measured. Examination is performed with patient standing on one and on both legs. It is very valuable that one can compare results from the operated leg with ones from the non-operated. The WLAN card in RaspberryPi is configured as Access Point, it enables any external device to connect with device without installation of software. One can connect with mobile posturographic rehabilitation device with any device equipped with WiFi (i.e. smartphone, laptop, tablet etc.). The application is web based and displayed in WWW browser.

Moreover RaspberryPi has two HDMI outputs that enable direct connection with TVset.

Exercises

Mobile rehabilitation device allows patients to train with use of exercises with biofeedback, for instance one can move a point on screen with movement of leg. All exercises are registered and stored. It enables the person in charge of rehabilitation to monitor the patient.

The patient does sets of exercises that were pre-programmed by the trainer. Level of difficulty is modified.

Next development step is of this project is creation of software that will allow remote control of patients progress through Internet. Exercise programme could be also modified remotely if WiFi Internet Access would be provided.

Discussion

There are many alternatives to the commercially built costly posturographs. Some of the alternatives use the Nintendo Wii Balance Board, but since it discontinued one needs to search for alternatives. The above described solution can be achieved in ca. 400 euro. It can be a good solution for small outpatient clinics. Since the device is small and mobile it can be lent to patients for use at home.

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REFERENCES

- [1] Hung J.W., Yu M.Y., Chang K.C., Lee H.C., Hsieh Y.W., Chen P.C. "Feasibility of using Tetrax biofeedback video games for balance training in patients with chronic hemiplegic stroke". *PM&R*, 10(2016):962970, <https://doi.org/10.1016/j.pmrj.2016.02.009>.
- [2] Siddiqi F.A., Masood T. "Training on Biodex balance system improves balance and mobility in the elderly". *Journal of the Pakistan Medical Association*. 68, 11 (2018): 1655–1659.
- [3] Clark R.A., Mentiplay B.F., Pua Y.H., Bower K.J. "Reliability and validity of the Wii Balance Board for assessment of standing balance: A systematic review". *Gait & Posture*. 61 (2018): 40–54, <https://doi.org/10.1016/j.gaitpost.2017.12.022>.
- [4] Merchant-Borna K., Jones C.M., Janigro M., Wasserman E.B., Clark R.A., Bazarian J.J. "Evaluation of Nintendo Wii Balance Board as a tool for measuring postural stability after sport-related concussion". *Journal of Athletic Training*. 52, 3 (2017): 245–255, <https://doi.org/10.4085/1062-6050-52.1.13>.
- [5] Audiffren J., Contal E. "Preprocessing the Nintendo Wii Board signal to derive more accurate descriptors of statokinesiograms". *Sensors*. 16, 8 (2016): 1208, <https://doi.org/10.3390/s16081208>.
- [6] Tichá M., Janatová M., Bohunčák A., Svozilková P., Sladková P., Hána K., Jeřábek J., Angerová Y., Švestková O. "Use of force platform and visual feedback in the therapy of stability disorders". *Turkish Society for Medicine and Rehabilitation. Abstract Proceedings of 12th Congress of EU Forum for Research in Rehabilitation 2013*. Istanbul – Turkey, 2013, 111, ISSN 1302-0234.
- [7] Wilkinson T.J., Nixon D.G.D., Smith A.C. "Postural stability during standing and its association with physical and cognitive functions in non-dialysis chronic kidney disease patients". *International Urology and Nephrology*. 51, 8 (2019): 1407–1414, <https://doi.org/10.1007/s11255-019-02192-4>.
- [8] Völker I., Kirchner C., Bock O.L., Wascher E. "Body Sway as a Possible Indicator of Fatigue in Clerical Workers". *Safety and Health at Work*. 6, 3 (2015): 206–210, ISSN 2093-7911, <https://doi.org/10.1016/j.shaw.2015.04.003>.
- [9] <http://www.ti.com/lit/ds/symlink/ina125.pdf>.
- [10] <http://www.microchip.com/downloads/en/device-doc/22088b.pdf>.
- [11] Mielczarek W. „Szeregowe interfejsy cyfrowe”. Gliwice: Helion, 1993, ISBN 83-85701-23-0. ■