HYCON TECHNOLOGY

HY11P13
Application Note
Glucose Meter

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1. Brief Introduction

There is a widespread application of measuring current signal according to fixed-bias method, such as CO meter, glucose meter…etc. The article only focuses on illustrating the glucose meter application.

2. Theory

2.1 What is “Diabetes Mellitus”?

Normally, the body decomposes starch and transforms it to glucose as the body energy. The insulin is one of the hormones that made by the pancreas, this kind of hormone helps the glucose penetrate into cells to provide the body heat energy. Diabetes is a chronic disease, which occurs when the pancreas produce insufficient insulin, or when the body cannot effectively use the insulin it produces. This leads to an increased concentration of hyperglycemia. Serious chronic complications include retinopathy, chronic renal failure, nephropathy (ex: possibility of amputation), heart and cardiovascular diseases (ex: apoplexy), hypertension, sex ability weakening, even death. The main factor of having diabetes is genetic susceptibility and obesity, emotional stress, pregnancy, medicine, dystrophy are related reasons as well.

Diabetes mellitus has become the major chronic disease and has earned the world’s attention. "Early diagnosis, adequate treatment" and " self control by diabetic” are the right treatment. Except for the serious chronic diabetics have to inject insulin, it is important to have well-controlled blood sugar level, and suitable medication. The attention to diet and continuous monitoring are in needed to prevent the risk of diabetes complications, of course, patient with the diabetes can own healthy life. [1]

Using test strips to capture glucose signals. Then adopt fixed-bias method to stimulate the strip and blood’s electrochemical reaction as to form current output signals. HY11P13, designed by HYCON Technology, can measure current signals, operate and display digitally (as shown in Figure 1). This is the solution to measure current value according to fixed-bias method with the minimum components.

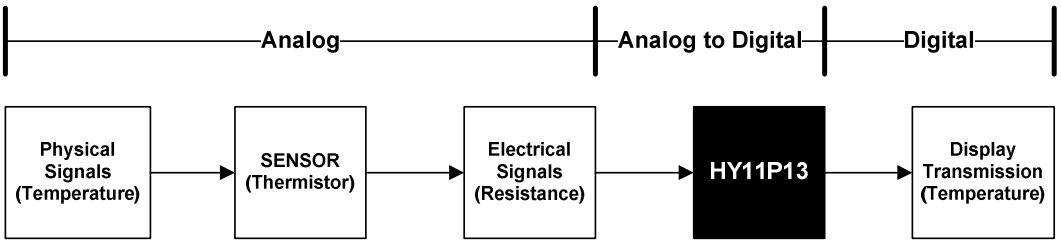


Figure 1 Analog and Digital Signal Conversion

2.1 Brief Introduction of Glucose Strip

Due to the diversity of strips, the discussion of this article is based on Equivalent Circuit. Before kicking off new project, it is necessary to understand Equivalent Circuit (as shown in Figure 1), electrochemistry reaction time (Figure 2) and current

conversion equation of strips.

- **Equivalent Circuit**

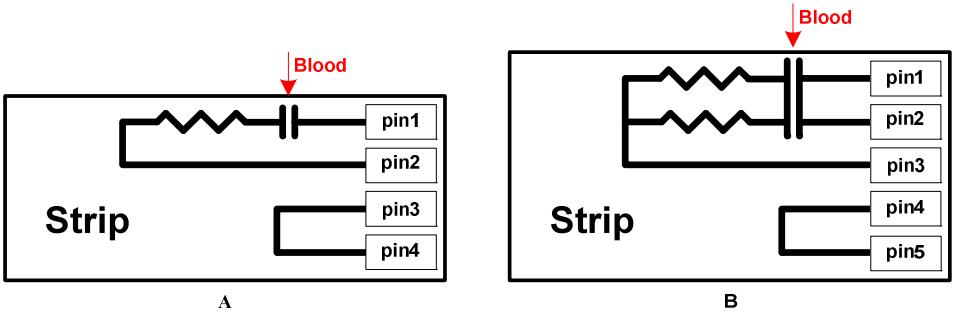


Figure 2 Equivalent Circuit of Strips. A：Single-trace resistance B：Dual-trace resistance

- **Electrochemistry Reaction Time**

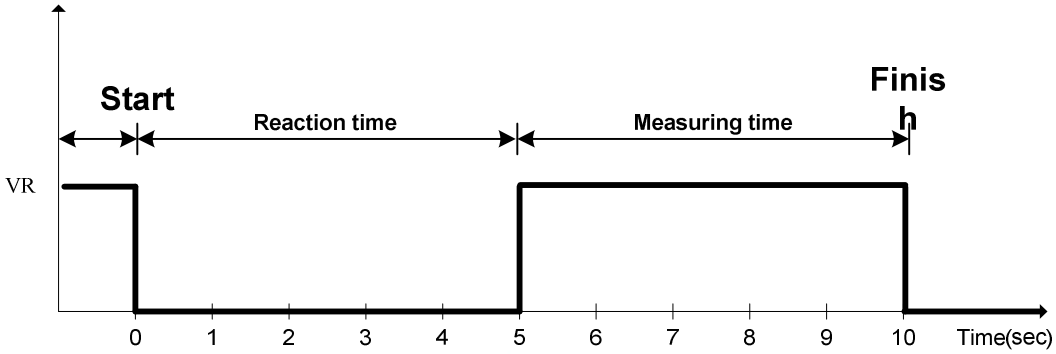


Figure 3 Electrochemistry Reaction Time

VR：Fixed -Bias

Reaction time：Strip reaction time

Measuring time：Strip measurement time

- **Current Conversion Equation**

Example：

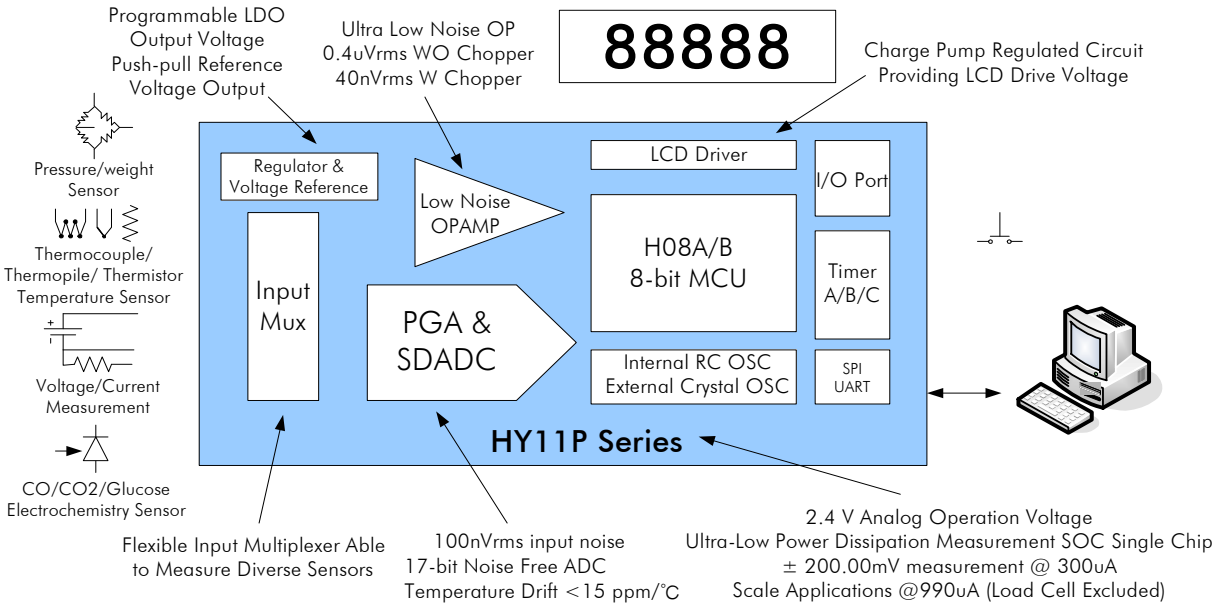
$$\text{Glucose} = I \times F(\text{code}) \times T(t)$$

I：Current (μA)

F(code)：Different strip has diverse value.

T(t)：Temperature parameter

2.2 Control IC



- 8 bit enhanced RISC. 68 instructions including Hardware Multiplier Instruction and Look-up Table Instruction
- Operating voltage range: 2.0V to 3.6V, Operating temperature range: -40℃~85℃
- External Crystal Oscillator, 6 CPU clock rate enable users to have the most power-saving plan
  - Run Mode 300uA@2MHz
  - Standby Mode 3uA@32KHz
  - Sleep Mode 1uA
- 4K Word OTP (One Time Programmable) Type program memory, 256 Byte data memory
- Brownout Detector and Watch dog Timer prevents CPU from crash
- 18-Bit fully differential input Sigma-Delta Analog-to-Digital Converter(A/D)
  - Build-in PGA (Programmable Gain Amplifier). 1/4x, 1/2x, 1x…128x, 10 input signal gain selection
  - Build-in Input zero point adjustment can increase measurement range according to different application
  - Build-in high impedance input buffer(Not suitable for 32x or upwards input gain)
  - Build-in absolute temperature sensor
- Ultra-Low Input Noise(<1uVpp) OP provides High Output Impedance, small signal amplification and low current voltage transformation
- 1.2 low temperatures drift parameter internal analog circuit common ground that equips with Push-Pull drive ability to provide sensor driving voltage
- LVD low voltage detection function has 14 steps of voltage detection configuration and external input voltage detectable function

- 10mA Low dropout Regulator and low temperatures drift parameter has 4 different output voltage selections.
- 4x20 LCD driver
  - Static, 1/2, 1/3, 1/4 Duty and 1/2, 1/3 Bias Programmable Option
  - Embedded Charge Pump Regulated Circuit with 4 LCD Bias Voltage
- 8-bit Timer A
- 16-bit Timer B With Capture/Compare Function
- 8-bit Timer C Module Generates PWN/FD waveform
- Serial Communication SPI Module

3. Design Scheme

3.1 Hardware Illustration

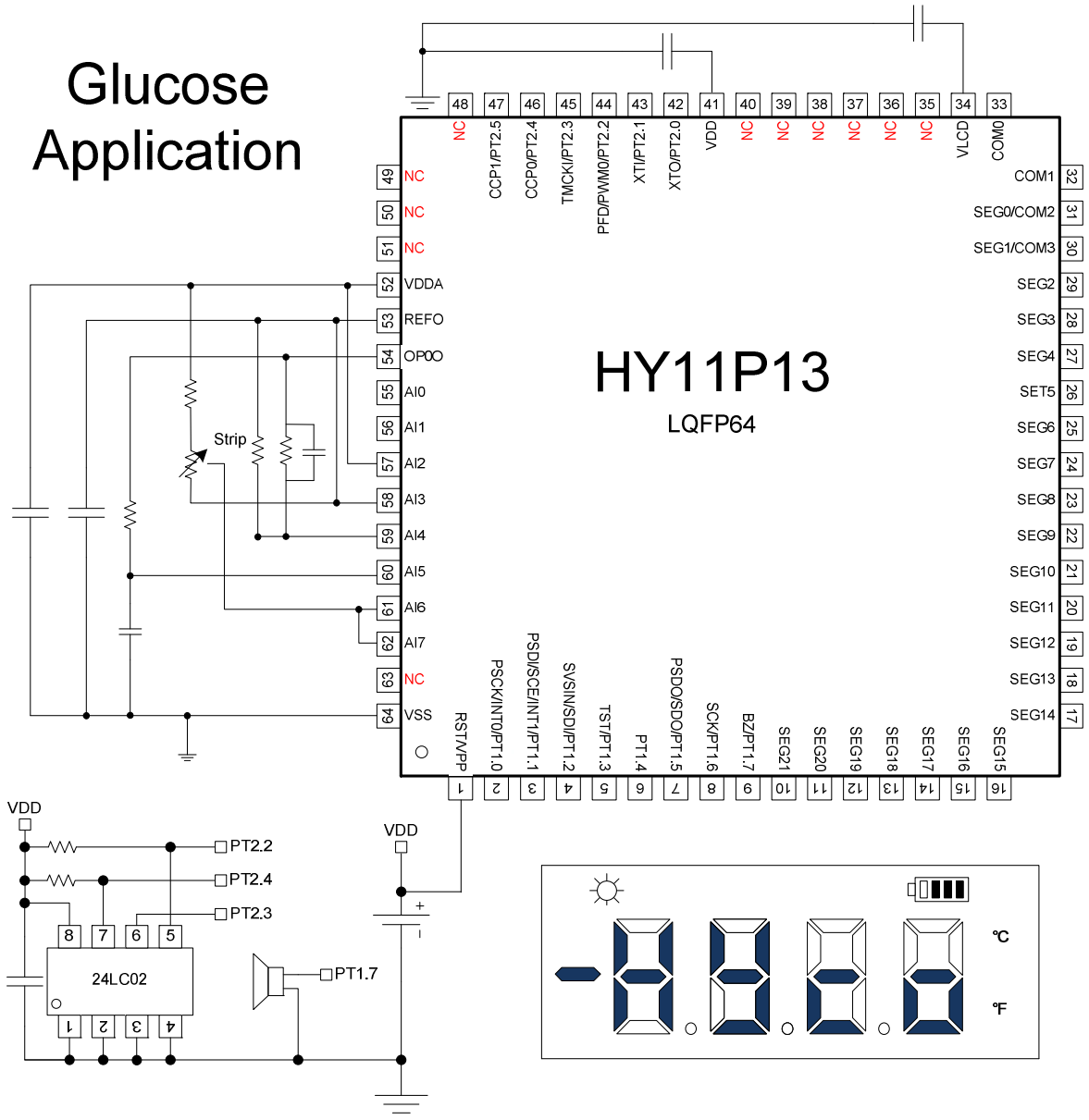


Figure 4 Application Circuit of Fixed-Bias Current Measurement

Main Components Introduction

MCU：HY11P13, the function is to measure electrical signal, control, operate, and display.

EEPROM：24LC02, the function is to save calibration parameters.

Strip：Resistance is utilized to replace strip in this application, to emulate strip electrochemistry signal.

3.2 Software Illustration

3.2.1 Program Flow

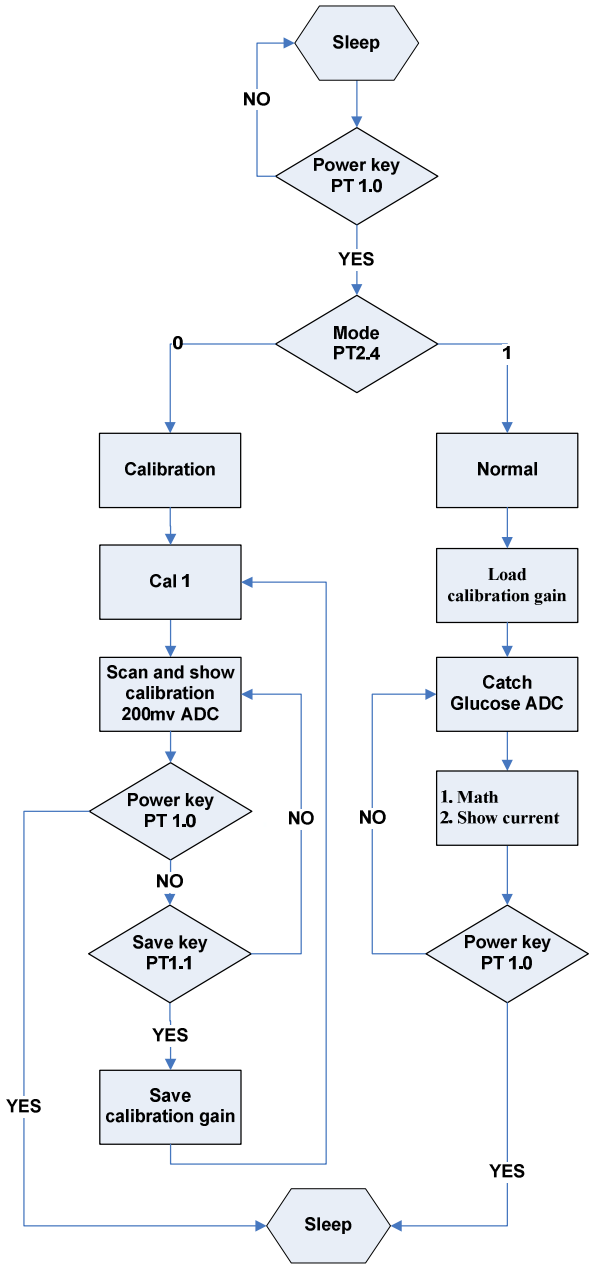


Figure 5 Program Flow

3.2.2 Calibration Flow

- Connect PT2.4 to VSS, enter the calibration mode.
- Power on (PT1.0)
- Cal 1 mode：

  Push down PT1.1 to save 200mv Gain in EEPROM

4. Technical Specification

- Operating voltage：2.4~3.6V
- Sleep mode current：0.63uA(Typical)
- Operation mode current: 0.75mA
- Glucose current range: ≦80.0uA()

5. References

[1] BIONIME Corporation http://www.bionime.com/ch-t/5.htm
[2] HYCON Technology Corporation http://www.hycontek.com/