A Method to Simulate Treatment of Thyroid Problems in the Human Body

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ABSTRACT

This is an effort to simulate the concept of treatment of different types of Thyroidism after determining the TSH, T3 and T4 levels in the human body. The target is to determine the effective dose of Thyroxine to be provided to the patient so that normal level of the same can be maintained in the human body. It interacts with every organ system and plays a crucial role in metabolism [1], but there is no software technique to bypass the doctors for the treatment of Thyroid malfunctioning. The Analog devices like operational amplifiers have features identical to the arithmetic operations. Primarily, the voltages in the high-gain dc amplifiers can be reduced to an average to these three variables and the operational amplifiers can do the arithmetic operations on the voltages, the accuracy of measuring voltage may be circumscribed to limited point. A Digital circuit has been implemented to determine the dosage required by the patients using the best market products. The simulation has been done using CircuitMaker (Student version).

Keywords

TSH (Thyroid Stimulating Hormones), T4(Thyroxine), Neomercazole, Eltroxin and OPAMPs

1. INTRODUCTION

Thyroid hormone levels are maintained by a feedback system, which involves the hypothalamus, pituitary gland, thyroid gland, and receptors available in cells as shown in Figure.1[2].

The thyroid, a gland in the Human neck, generates two thyroid hormones, thyroxine (T4) and Tri-iodothyronine (T3). Thyroxine (T4) is not active and is converted by the tissues and organs that need it into tri-iodothyronine (T3) [3]. The role of thyroid hormones are needed for the regulation of metabolism of all the cells in one or another way in the body. When there is not sufficient thyroid hormone (hypothyroidism) the body's metabolism reduces and this is determined by variations in the various tissues [4]. Thyroxine is the major product of the thyroid gland and much of it is later deiodinated in extrathyroidal tissue to form T3. The liver, thyroid, and kidneys have the highest concentration of the type I deiodinase. Other form of this enzyme, type II deiodinase, is found in the brain, pituitary, and skin[5].

The free fraction of T4 and T3 in the blood remains more useful parameter of thyroid hormone levels measurement than the total amount of these hormones. This is what is meant by free T4 (FT4) and free tri-iodothyronine (FT3).
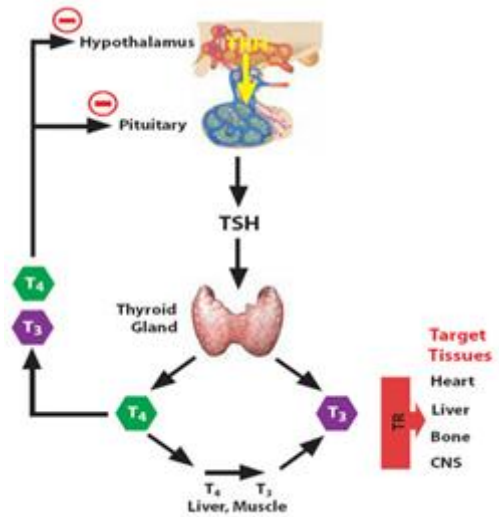

Figure.1:Thyroid hormones

Thus Thyroxine level confirms whether a Human Body is suffering Thyroid disorder or not. The normal ranges for these variables can be given as in Table I and different values of these variables make different types of thyroid disorders as given in Table II[6].

Each component of the hypothalamic-pituitary-thyroid axis can be computed. The concentration of serum TSH can be efficiently measured using an immunoradiometric assay and is often the initial point for an evaluation of thyroid function.

TABLE I NORMAL RANGES

VARIABLES	NORMAL RANGES
TSH	0.3-3.0(MIU/L)
TOTAL T4	4.5-12.5(NG/DL)
FREE T4	0.7-2.0
TOTAL T3	0.60-1.81(NG/ML)
FREE T3	2.3-4.2

TABLE II THYROID DYSFUNCTION

TSH	T3	T4	EXPECTED DYSFUNCTION
HIGH	HIGH	HIGH	MAY BE PITUITARY TUMOR OR HYPERTHYROIDISM
LOW	LOW	LOW	SECONDARY HYPOTHYROIDISM OR MAY BE PITUITARY FAILURE
HIGH	NORMAL	NORMAL	MILD SUBCLINICAL HYPOTHYROIDISM
HIGH	LOW	LOW	PRIMARY, FULL-BLOWN HYPOTHYROIDISM
VERY LOW	HIGH	HIGH	MAY BE ON REPLACEMENT THERAPY OR HYPERTHYROIDISM
LOW	NORMAL	NORMAL	MILD HYPERTHYROIDISM
HIGH	NORMAL	LOW	MAY BE SECONDARY HYPOTHYROIDISM

Over the last decade, this test has got sophistication.Now AACE advises doctors to observe treatment for patients who test outside the boundaries of a shorter gap based on a target TSH level of 0.3 to 3.0. AACE believes the new range will result in proper diagnosis for millions of Americans who suffer from a mild thyroid disorder, but have not undergone treatment till now. Thyroid hormones (T4 and T3) are produced by the follicular cells of the thyroidgland and are regulated by TSH made by the thyrotropes of the anterior pituitary gland [7].

Thyroxine is produced by attaching iodine atoms to the ring structures of tyrosine molecules. Thyroxine (T4) contains four iodine atoms. Triiodothyronine (T3) is identical to T4, but it has one less iodine atom per molecule [8].

If there is a deficiency of dietary iodine, the thyroid will not be able to make thyroid hormone [9]. The deficiency of thyroid hormone will result in diminished negative feedback on the pituitary, leading to increased production of thyroid-stimulating hormone, which causes the thyroid to increase in the size. This problem is called goitre.

2. COMMON TREATMENT
Thyroid dysfunction can be mainly classified as

    i)   Hypothyroidism

    ii)   Hyperthyroidism

Following steps [10] may be used, although the order of them and the number that may need further pursuit may vary from one patient to the next, based upon the individual patient's circumstances.

    i)   Confirm the diagnosis and laboratory results.
    ii)   Ask about compliance
    iii)   Check the patient's medication bottles and tablets.
    iv)   Review the thyroxine ingestion history.
    v)   Investigate for malabsorption.
    vi)   Consider increased turnover or excretion.
    vii)   Perform a thyroxine absorption test.
    viii)   Treat the patient.

After proper diagnosis of hypothyroidism, the next issue is with what substance to treat.. The traditional approach is to use Synthroid/ Levoxyl/Levothroid (levothyroxine) which is only T4. Natural medicine doctors tend to use Armour thyroid which is a mixture of mono and di-iodothryonine and T3 and T4, the entire range of thyroid hormones[11]. If Thyroid Antibodies are tested positive, it indicates that the Thyroid is in the process of Autoimmune failure [12].

3. THEORETICAL ASPECTS
To simulate the proposed circuit, we can use an analog method by the use of operational amplifiers. An analog method can be applied to find solutions of a number of differential equations, linear equations etc [13]. Then a digital circuit is used to determine the dosage of treatment requied by the patient making it a hybrid approach.

Refer [6] electronic circuit diagram for the proposed device. There were six Ideal OPAMPs[14] (U1A, U1B, U2, U3, U4, U5) which had been used for implementation of TSH level interpretation. The circuit was implemented using four multimeters[15] so that output of each OPAMP could be watched. The Vs1 represented the TSH level of Human Body. If the output of U3 and U4 were both high (9.984nV) then the TSH level (> 3.0 uIU/mL) was high [16]. If the outputs of both OPAmps were low (4.898V) then the TSH level (<0.3uIU/mL) was low. If the output of U3 was high and U4 was low then the human body was having TSH level in the normal range.

The instance of the circuit showed Vs1 = 0.72V that was the TSH level was between normal range. We were representing the single unit of TSH (1 uIU/mL) by 1V of the voltage supplies). In the given circuit, the ideal OPAMP U5 output was the negative of input Voltage. Thus, the output represented +TSH.

The ideal OPAMP U1A was a comparator[17]. The comparator compared the linear voltage applied on the negative terminal with the voltage applied on the positive voltage. If the voltage on positive terminal was greater than on the negative terminal, the output was high (9.984 nV), otherwise low(4.898V). It compared the reference lower limit of TSH that was 0.3 with
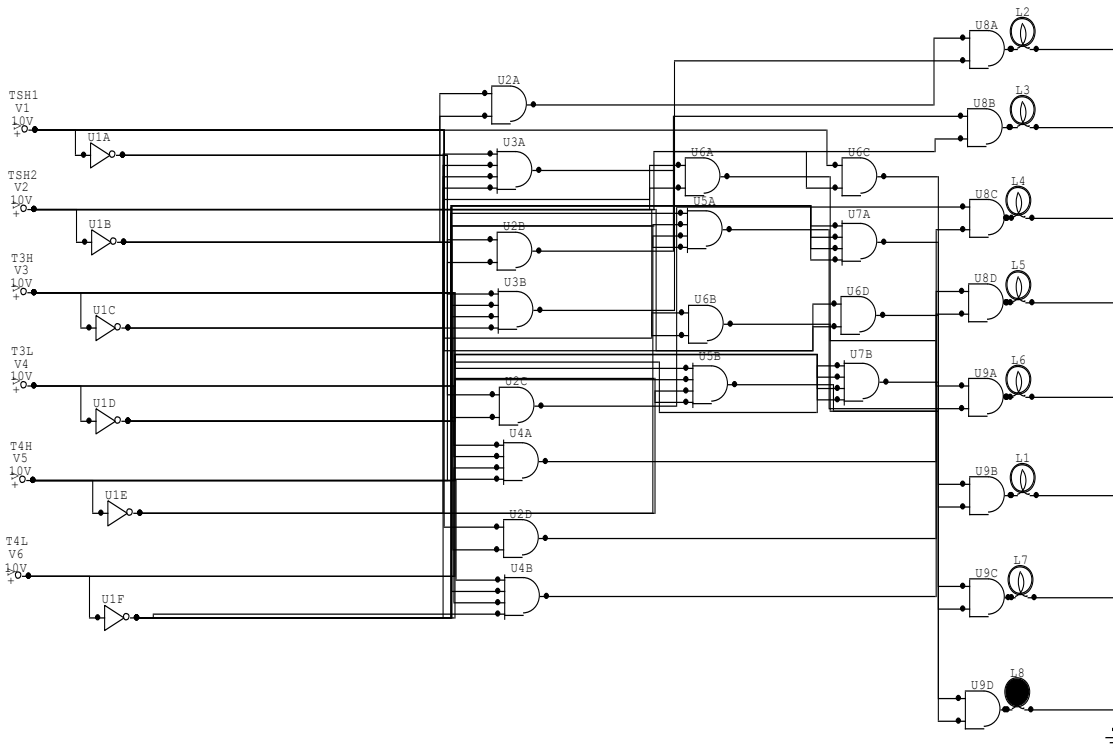
Figure. 2: Simulation for determination of Thyroid Dysfunction using Circuit Maker

TABLE III: BEST MARKET MEDICINES FOR DIFFERENT TYPES OF THYROIDISM

Thyroid Dysfunction	Treatments for the different Types of the Thyroid Disorders given in TABLE IV
MAY BE PITUITARY TUMOR OR HYPERTHYROIDISM	20 MG NEOMERCAZOLE
SECONDARY HYPOTHYROIDISM OR MAY BE PITUITARY FAILURE	25 MCG THYRO-3
MILD SUBCLINICAL HYPOTHYROIDISM	25MCG ELTROXIN
PRIMARY, FULL-BLOWN HYPOTHYROIDISM	100 MCG ELTROXIN
MAY BE ON REPLACEMENT THERAPY OR HYPERTHYROIDISM	10 MG NEOMERCAZOLE
MILD HYPERTHYROIDISM	5 MG NEOMERCAZOLE
MAY BE SECONDARY HYPOTHYROIDISM	50 MG NEOMERCAZOLE

recorded TSH level. It gave the high output (9.984 nV) because 0.72 > 0.3.

Similarly, the ideal OPAMP U1B was a comparator for comparing the higher limit that is 3.0 uIU/mL with the recorded TSH level. In the same way we could construct the circuits for Total T3 and Total T4 and find the possibility of type of Thyroid dysfunction. The truth table for circuit for interpretation of Thyroid dysfunction is given in Table IV.

As the digital circuit in Figure. 2 shows, the lamp which ignites gives the indication for the treatment of the Thyroid disorder as per TABLE III. If the first lamp at the top ignites, we can infer that the disorder is Hyrperthyroid or pituitary tumor and treatment is 20mg Neomercazole. Similarly, other inferences can be deducted.

TABLE IV
TRUTH TABLE FOR DISEASES IN TABLE II

TSH1	TSH2	T3H	T3L	T4H	T4L
0	0	0	0	0	0
0	0	1	0	1	0
0	0	1	1	1	1
1	0	1	0	1	0
1	1	0	0	0	0
1	1	1	0	0	0
1	1	1	0	1	0
1	1	1	1	1	1

4. CONCLUSION

In an analog computer simulation there are so much assumption in deriving the relationships for operational amplifiers. Accuracy of voltage is upto a certain limit. So we have an analog computer applied for a single problem. We have designed a hybrid representation of a thyroid system which is more natural in the meaning that it simplifies the implementation of simulation and comprehension of the results.

5. FUTURE WORK

As TSH, T3 and T4 levels are determined and type of dysfunction is confirmed, the accurate dosage can be calculated by applying interpolation methods in MATLAB and the corresponding best fitted equations can be implemented in the Circuit-maker. And the medicines available in the market can be produced in different varieties.

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