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# 安定限界 線形電流펄스辨別器 (A Stable Threshold Linear Current Pulse Discriminator)

金 炳 贊 *

(Kim, Byung Chan)


## 要 約

트란지스타 單一 安定 멀티바이부래타 (monostable multi-vibrator)와 시리콘턴넬 다이오드 (T.D)로써 構成된 電流波 波高辨別器를 設計하여 그 特性을 調査하였다. 被測定 電流波의 範圍는 $50\mu A$—5.23 mA 이며, 이 範圍에 있어서 測定된 最大非直線度는 ±0.75% 이었다. 이 辨別器의 電流波 分解能은 T.D를 通하여 흐르는 偏倚電流에 따라서 若干 달라지며 逆方向 偏倚電流가 3 mA 일때, 萬一 5%의 過剩波高를 許容한다면 그 分解時間은 2 $\mu$S 이다. 다음에 이 辨別器의 臨界值 安定度는 主로 T.D의 턴넬電流의 最大值 $I_p$의 安定度에 依하여 左右 되며 環境溫度의 變化範圍가 0°C~50°C 일때는 最大非直線度 即 ±0.75% 보다 더큰 臨界值 變化는 觀測 되지 않았다.

## ABSTRACT

A linear current-pulse discriminator consisting of a transistor monostable multivibrator and a Si tunnel diode is described. The input current pulse range is about $50\mu A \sim 5.23mA$. The measured maximum linearity deviation is ±0.75% in the input current pulse range mentioned above. The pulse resolving ability of the discriminator measured depends upon the bias current through the T.D. ;and, under the reverse bias current of 3mA, the resolving time is $2\mu s$ if allow the excess pulse amplitude of 5%.

The threshold stability of the discriminator depends mainly upon the stability of the peak current Ip of the T.D. ;and, under the ambient temperature variation from 0°C to 50°C, no bigger threshold variation than the maximum linearity deviation, i.e. ±0.75%, was observed.


## INTRODUCTION

A transistorized current pulse discriminator which was originated by Kandiah [1] has been reported by Goulding et al [2].

This current pulse discriminator is essentially a transistor free running oscillator clamped by a pn junction diode. As the V— I characteristics of a pn junction diode is not linear, the linearity of the discrinimator is very poor, and moreover, when the input pulse length

* 成均館理工大 電氣工學科

Dept of Electrical Engineering, Sung Kyun Kwan Univ

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is longer than the period of the free running oscillator, may be we will have two or more output pulses and this will lead to an incorrect result of the measurement.

The current pulse discriminator described here utilizes the V— I charaeteristics of a tunnel diode, and a transistor monostable multivibrator which is triggered when the sum of the input current and the bias current exceed the peak current of the T.D. used.

## DESCRIPTION OF THE DISCRIMINATOR

Fig 1 shows the schematic diagram of the discriminator. The essential part of the discriminator is the parallel connection of a Si tunnel diode (TD) and the emitter base junction of the transistor $T_1$.

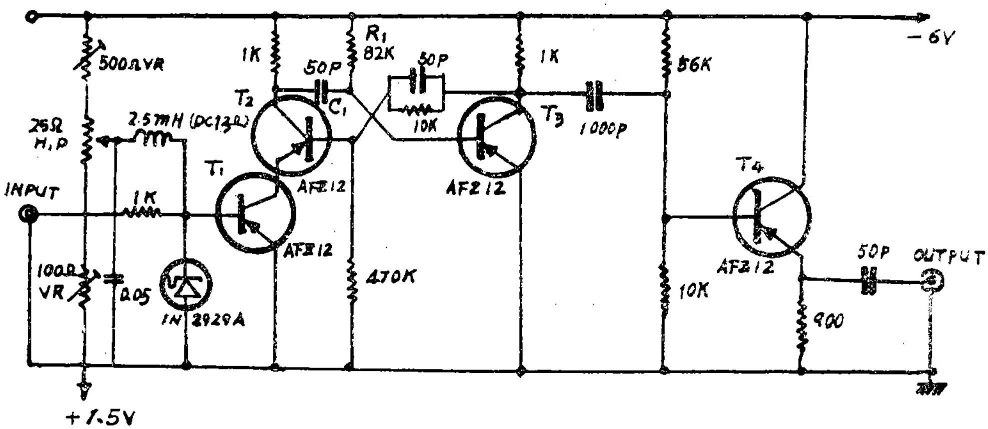


Fig 1. The schemetic diagram of discriminator.

Referring to Fig 1 and Fig 2, when the input current pulse height exceeds $I_p - I_b$, the current variation $I_e$ through the emitter base junction of the transistor $T_1$ is large enough to trigger the monostable multivibrator which is consisted of the transistors $T_2$ and $T_3$.

As the input pulse to the discriminator is a current pulse, and the dc operating point is adjustable by a helical potentiometer through an R.F, choke of 2.5mH whose dc resistance is 13 ohms, the ac loac line will be nearly horizontal. Therefore, referring to Fig 2, the threshold equation of the discriminator may be written as,

$$I_{in} = I_p - I_b$$

where $I_{in}$ : input current pulse

$I_p$ : Peak current of the T.D.

$I_b$ : dc bias current through the T.D.

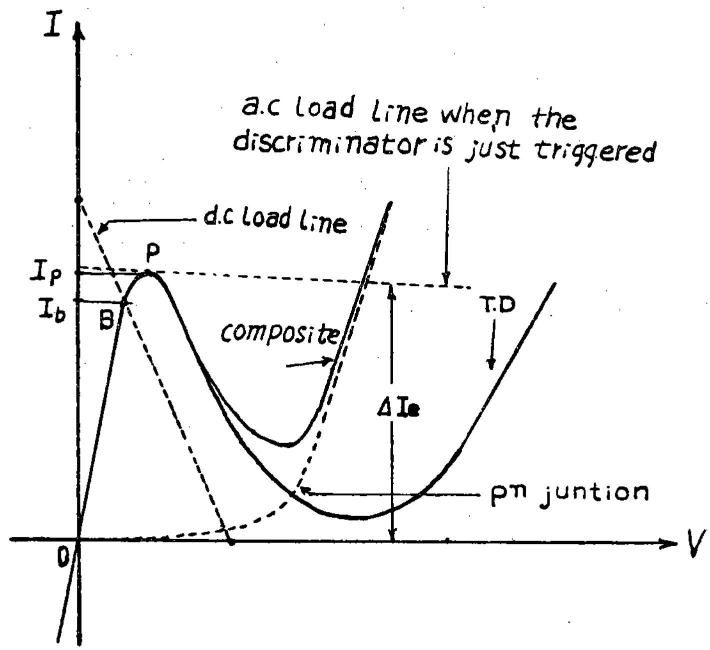


Fig 2. V I characteristic curve of a T.D, pn juntion and composite.

## SOME CHARACTERISTICS OF THE DISCRIMINATOR

(1) Fig 3 (a) shows the theoretical and the experimental relation between the input current pulse height and the dc bias current. The experimental relation is an excellently straight line if we allow the linearity deviation of $\pm 0.75\%$. And this is shown in Fig 3(b).

The discrepancy between the theoretical line and the measured straight line may be caused by the inaccurate knowledge about the peak current $I_p$ of the tunnel diode and also a small portion of the current which might flow through the choke coil.

As the bias current flows through the voltage dividing resistors via the R.F. choke coil, the helipot dial reading is not linearly proportional to the bias current. However, as Fig. 4 shows, if we can allow $\pm 5\%$ inaccuracy, may be the helipot dial reading could be used as a measure of the bias current.

(2) As the switching time of the T.D. will be shorter the higher the input current pulse is, and also it is proportional to the junction capacitance of the T.D. [3], the pulse resolving ability of the discriminator will be better when it is biased in the reverse direction than it is biased in the forward direction. This could explain the reason why we can

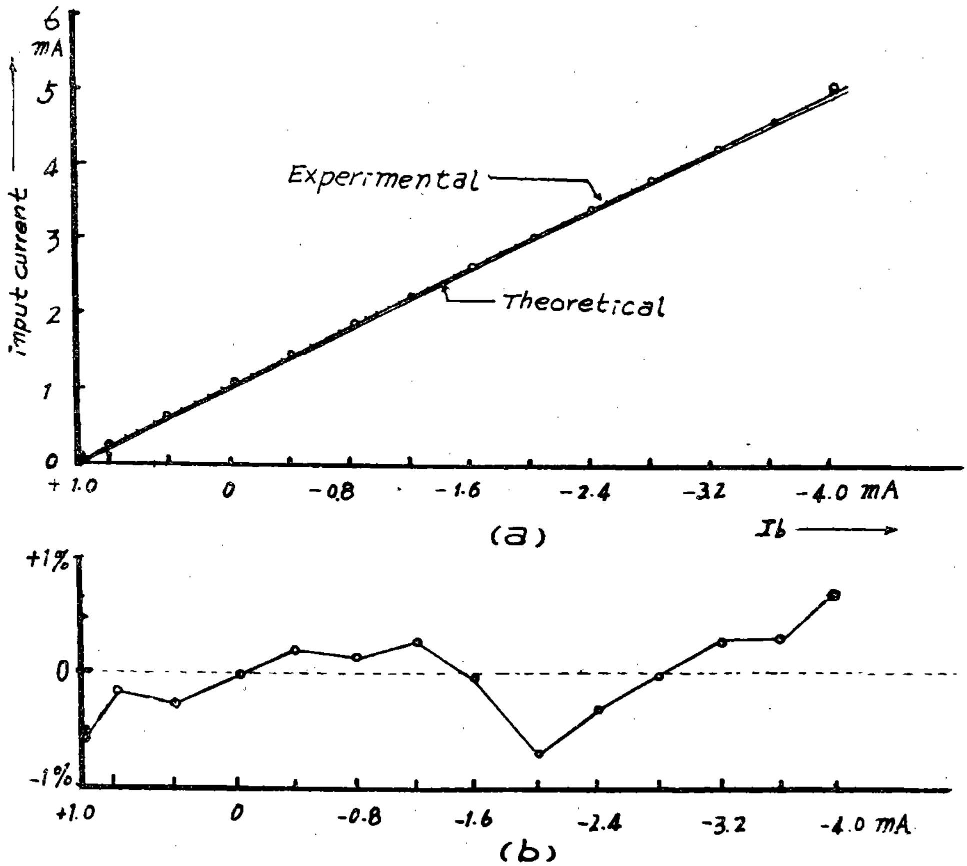


Fig 3. (a) Iin vs Ib. (b) Linearity deviation.

clearly notice that the resolving ability under the backward bias current of 3mA, the solid curve in Fig 5, is better than that for no bias current, the dotted curve in Fig 5.

Fig 6 shows the block diagram for the measurement of the pulse resolving ability of the discriminator.

For this measurement, the amplitude controlling potentiometer of the HP 212A pulse generator was replaced by a ganged 20kΩ helipot and the helipot dial reading is calibrated by the pulse generator NE 015A. And the output pulse of the waveform generator NE 015A was used as No. 1 pulse, and that of the pulse generator HP 212A was used as No. 2 pulse. These pulses were fed to the discriminator through a mixer network which is shown in Fig 6. The pulse spacing, Tps, was adjusted by the change of the position of No. 2 pulse.

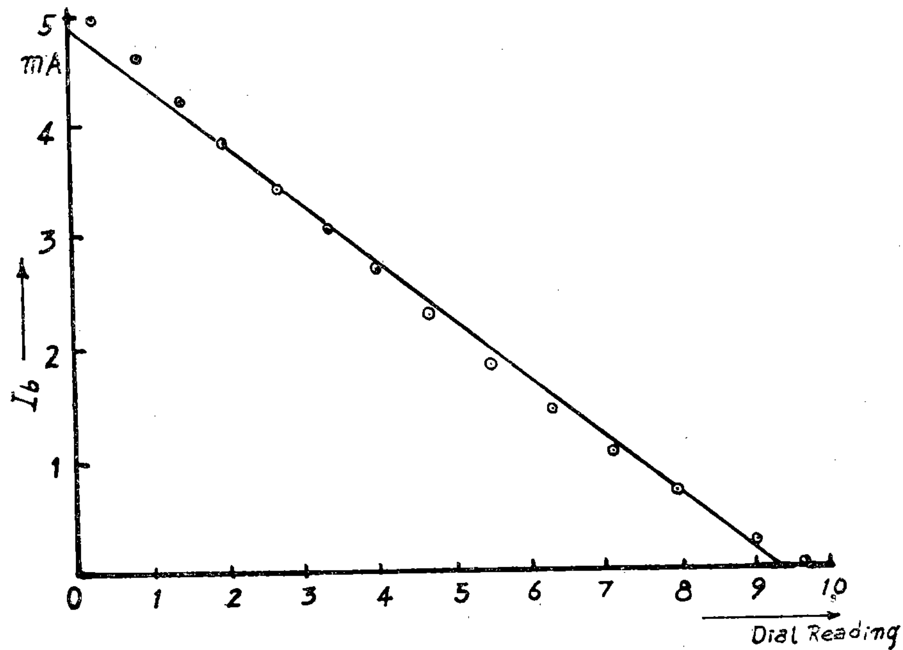


Fig 4. Helipot dial reading vs Ib

(3) Though the output pulse length of the discriminator is about 1$\mu$s, it is proportional to the time constant $C_1$ $R_1$ of Fig 1.

(4) The threshold variation according to the ambient temperature variation of the discriminator depends mainly upon the peak current variation of the T.D. used. And, when the junction area is kept constant, the peak current variation will be determined by the variation of the energy level difference ($E_f-E_c$) in the n-region and ($E_v-E_f$) in the p-region of the T.D..

where $E_f$ : Fermi level

$E_c$ : Bottom of the conduction band

$E_v$ : Top of the valence band

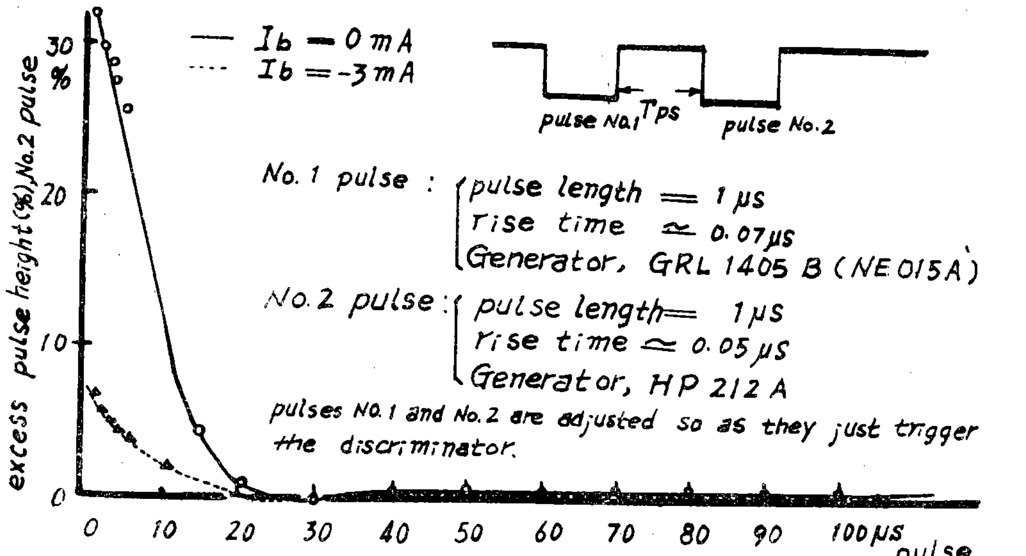


Fig 5. Excess pulse height (%) vs $T_{ps}$.

Generally, for a T. D., $E_f$ of the n-material is located above $E_c$ and $E_f$ of the p-material is located below $E_v$; and, $E_f - E_v > E_c - E_v \cong 1.12$ eV (the energy gap of Si) for n-material and $E_c - E_f > E_c - E_v \cong 1.12$ eV (the energy gap of Si) for p-material. Therefore, the variation of the total number of electrons, which could absorb enough thermal energy in order to jump from $E_v$ energy state to $E_f$ energy state in the n-material and from $E_f$ energy state to $E_c$ energy state in the p-material, will be very small even when the ambient temperature is changed from 0°C to 50°C. Actual measurement of the threshold variation of the discriminator according to the ambient temperature variation from 0°C to 50°C showed only a few tenth of a % of the threshold value.

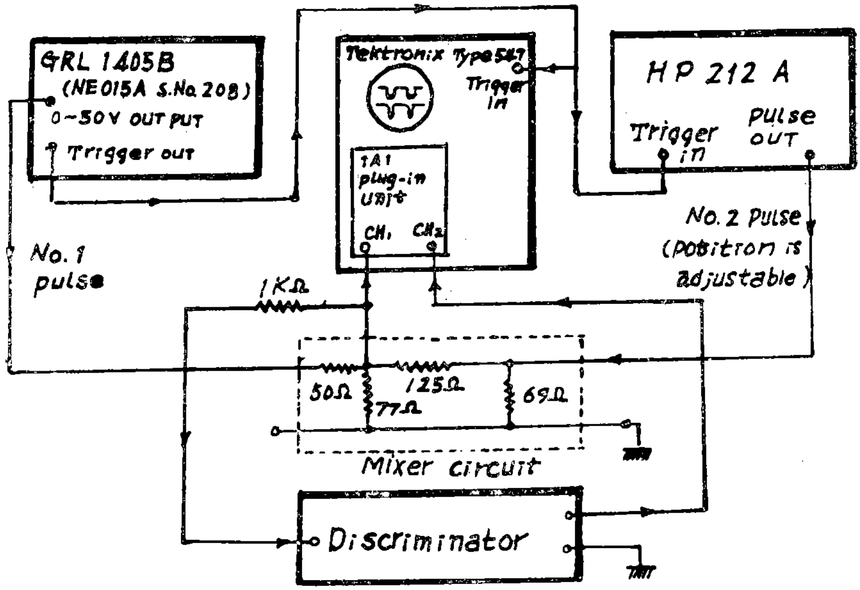


*Fig 6. Block diagram for the measurement of the pulse resolving ability of the discriminator.*

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