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Author	高橋, 恒介(Takahashi, Kosuke)
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Analysis of Tunnel Diode Oscillator

Kosuke TAKAHASHI*

In this paper, a nonlinear differential equation

$$\ddot{x} - \varepsilon (1 + \beta x - x^2) \dot{x} + x = 0, \qquad \varepsilon > 0,$$

was studied. This equation was introduced from an oscillator with a tunnel diode whose dharacteristic curve was not always symmetric with respect to a bias point. As this equation agrees with Van der Pol's equation in special case for $\beta = 0$, this equation is considered to be in a generalized form of Van der Pol's equation. As to this equation, some property of periodic solutions has been studied from a mathematical point of view. From an engineering point of view, however, the waveform of periodic solutions are not well known. In order to know the outline of the solutions, the author first sketched the trajectories by the method of isoclines. Next a new method of obtaining a limit cycle was devised, using a digital computer Tosbac 3400. This computation program based on the theorem of Bendixson-Poincarè is made by confining a region into a narrow one. Making use of this method, twelve limit cycles for $\beta = 0, -1, -2$, and $= 0.2, 0.5, 1.0, 2.0$, were obtained, which were not always symmetric with respect to the origin.

As to the waveform of periodic solutions which correspond to the limit cycles, the following properties were found; "When β (<0) is decreased from zero, the negative amplitude of waveform increases, while the positve amplitude varies scarcely. The interval when the waveform is positive increases, while the negative interval varies scarecely".

These periodic solutions were compared with experimental results, showing qualitatively good coincidence in waveform. The above results can be easily applied to the case for $\beta < 0$ if x is replaced by $-x$.

Lastly by the program used here consisting of 1232 words, one limit cycle was made for 8-minutes. And a numerical computation is based on Runge Kutter's method with the increment $t = 0.002$.

*高 橋 恒 介