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تدارست هيئة التحرير البحث المقدم من قبلكم والموسوم:-

Differential Equation For Higher Frequency Periodic Direction Function

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وسينشر في الأعداد القادمة للمجلة.

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Differential Equation For Higher Frequency Periodic Direction Function

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Abstract :

In this research, we will study an ordinary differential equation (n degree) for higher Frecuency periodic direction function (f_0, f_1).

Introduction :

In this research , f_0 *and* f_1 Vector Periodic in normal high order differential equations of order (n) with high frequency that a specific conditions are put in this research is differ from (Bateman H.1985 , Boyce W.E. , Di Prima R.C. 1977) . whom study a normal differential equation of order one for trigonometric function . While (Greenberg M.D.1994 and Struble R.A) deal with study of differential equation of order two for vector periodic function during which they put a specific conditions . While in this research we work studying a differential of order (n) for any two vector periodic function so by this work we consider this study is an important and expand study.

1- Basic Concept

Let m and p-natural number , and also n-even , $n = 2p$, and G_i , $i = 0,1,2,3,\ldots\ldots,p$ organic domain in space R^m .We have to study problem $2\pi\omega^{-1}$periodic solution for differential equations to be formal n .

$$\frac{d^n u}{dt^n} = f_0(u, \frac{du}{dt}, \ldots\ldots, \frac{d^p u}{dt^p}, \omega t) + \omega^p f_1(u, \omega t) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where ω-big parameter .We will be presupposed the following :

1.Vector functions $f_0(e,\tau)$ defined in the set $\Omega_0 = \{e, \tau, e \in G_0 \times G_1 \times \ldots\ldots \times G_p, \tau \in R\}$ u vector functions $f_1(u,\tau)$ defined in the set $\Omega_1 = \{u, \tau, u \in G_0, \tau \in R\}$, have meaning in R^m.

2. Vector functions $f_0(e,\tau)$ and $f_1(u,\tau)$ have continuously differentiable for any order with respect to e and u respectively .

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Asymptotic expansion solution equation (1) will be sought in the form

$$u_{\omega}(t)=\sum_{j=0}^{\infty}\omega^{-j}u_j+\sum_{j=p}^{\infty}\omega^{-j}v_j(\omega t)\qquad(2)$$

where $v_j(\tau)-2\pi$ periodic vector functions have meaning in R^m. u_j-vector in R^m and

$$<v_j>=\frac{1}{2\pi}\int_0^{2\pi}v(\tau)d\tau=0$$

We substitute equation (1) in place of $u,\frac{du}{dt},\ldots\ldots,\frac{d^p u}{dt^p}$ expression (2) and we develop nonlinear f_0 and f_1 in Taylor series , as a result we have the following equation :

$$\sum_{j=p}^{\infty}\omega^{-j+n}\frac{\partial^n v_j}{\partial\tau^n}=f_0(u_0,0,\ldots\ldots,0,\frac{\partial^p v_p}{\partial\tau^p},\tau)+\frac{\partial f_0(u_0,0,\ldots\ldots,0,\frac{\partial^p v_p}{\partial\tau^p},\tau)}{\partial e_0}\left[\sum_{j=1}^{\infty}\omega^{-j}u_j+\sum_{j=p}^{\infty}\omega^{-j}v_j\right]+$$

$$\frac{\partial f_0(u_0,0,\ldots\ldots,0,\frac{\partial^p v_p}{\partial\tau^p},\tau)}{\partial e_1}\sum_{j=p}^{\infty}\omega^{-j+1}\frac{\partial^n v_j}{\partial\tau}+\ldots+f_0(u_0,0,\ldots\ldots,0,\frac{\partial^p v_p}{\partial\tau^p},\tau)\sum_{j=p}^{\infty}\omega^{-j+p}\frac{\partial^p v_j}{\partial\tau^p}+\ldots+$$

$$\omega^p\{f_1(u_0,\tau)+$$

$$\frac{\partial f_1(u,\tau)}{\partial u}[\sum_{j=1}^{\infty}\omega^{-j}u_j+\sum_{j=1}^{\infty}\omega^{-j}v_j]+\frac{1}{2!}\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2}[\sum_{j=1}^{\infty}\omega^{-j}u_j+\sum_{j=p}^{\infty}\omega^{-j}v_j]^2+\ldots\}\qquad(3)$$

Where

$$\frac{1}{2!}\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2}[\sum_{j=1}^{\infty}\omega^{-j}u_j+\sum_{j=p}^{\infty}\omega^{-j}v_j]^2=$$

$$\frac{1}{2!}\sum_{k,s=1}^{n}[\frac{\partial^2 f_1(u_0,\tau)}{\partial u_k\partial u_s}[\sum_{j=1}^{\infty}\omega^{-j}u_{j_k}+\sum_{j=p}^{\infty}\omega^{-j}v_{j_k}][\sum_{j=1}^{\infty}\omega^{-j}u_{j_s}+\sum_{j=p}^{\infty}\omega^{-j}v_{j_s}]]$$

Equations coefficient with positive degree keep in mind:

$$\omega^p:\frac{\partial^n v_p}{\partial\tau^n}=f_1(u_0,\tau),\qquad(4)$$

$$\omega^{p-1}:\frac{\partial^n v_{p+1}}{\partial\tau^n}=f_1(u_0,\tau)u_1,\qquad(5)$$

$$\omega^{p-2}: \frac{\partial^n v_{p+2}}{\partial \tau^n} = \frac{\partial f_1(u_0,\tau)}{\partial u} u_2 + \frac{1}{2!}\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2} u_1^{\,2}, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\omega^1: \frac{\partial^n v_{n-1}}{\partial \tau^n} = \frac{\partial f_1(u_0,\tau)}{\partial u} u_{p-1} + \frac{1}{2!}\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2} \sum_{\substack{i+j=p-1 \\ i,j\geq 1}} (u_i u_j) + \ldots + \frac{1}{(p-1)!}\frac{\partial^{p-1} f_1(u_0,\tau)}{\partial u^{p-1}} u_1^{\,p-1}, \ldots$$

Where ...(7)

$$\frac{1}{2!}\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2} \sum_{\substack{i+j=p-1 \\ i,j\geq 1}} (u_i u_j) = \frac{1}{2!}\sum_{s,\ell=1}^{n} [\frac{\partial^2 f_1(u_0,\tau)}{\partial u_s \partial u_\ell} \sum_{\substack{i+j=p-1 \\ i,j\geq 1}} (u_{i_s} u_{j_\ell})]$$

And

$$\frac{1}{(p-1)!}\frac{\partial^{p-1} f_1(u_0,\tau)}{\partial u^{p-1}} u_1^{\,p-1} = \sum_{i_1,i_2,\ldots,i_{p-1}=1}^{n} \frac{\partial^{p-1} f_1(u_0,\tau)}{\partial u_{i_1} \partial u_{i_2} \ldots \partial u_{i_{p-1}}} (u_{1j_1} u_{1j_2} \ldots u_{1j_{p-1}}).$$

The equation (4) , where u_0 be considered parameter , it is well known have unique satisfying condition $< v_p(\tau) >= \frac{1}{2\pi}\int_0^{2\pi} v(s)ds = 0$. We produce this solution in the from

$$v_p(\tau) = \varphi_p(u_0,\tau) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Analogous we have the solution equations (5)- (7) with zero mean :

$$v_s(\tau) = \frac{\partial \varphi_p(u_0,\tau)}{\partial u} u_{s-p} + F_s \quad s=p+1, \ldots, n+1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where F_s-expression depending on $u_i, 1 \leq i \leq s-p-1$ .Now we equate in (3) coefficient expansion with ω^0 :

$$\frac{\partial^n v_j}{\partial \tau^n} = f_0(u_0, 0, \ldots, 0, \frac{\partial^p v_p}{\partial \tau^p}, \tau) + \frac{\partial f_1(u_0,\tau)}{\partial u}(u_p + v_p) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

If we substitute expression v_p in equation (10) and from average , we have the equation:

$$\Phi(u) = \left\langle f_0(u_0, 0, \ldots, 0, \frac{\partial^p \Psi_p(u,\tau)}{\partial \tau^p}, \tau) + \frac{\partial f_1(u,\tau)}{\partial u} \Psi_p(u,v) \right\rangle \ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

We will presuppose, the equation (11) has stationary solution $u = u_0$,that mean ,for vector function $\Phi(u)$ this equation is correct

$$\Phi(u_0) = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Where $\Phi(u_0)$-invertible matrix .Here

$$\Phi'(u_0)=\left\langle \frac{\partial f_0(u_0,0,\ldots\ldots,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0}+\frac{\partial f_0(u_0,0,\ldots\ldots,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_p}\frac{\partial^{p+1}\Psi_p(u_0,\tau)}{\partial\tau^p\partial u}+\right.$$

$$\left.\frac{\partial f_1(u_o,\tau)}{\partial u}\frac{\partial\Psi_p(u_o,\nu)}{\partial u}+\frac{1}{2!}\sum_{i,k=1}^{n}[\frac{\partial^2 f_1(u_0,\tau)}{\partial u_i\partial u_k}\psi(u_o,\tau)\right\rangle \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(13)$$

Equation coefficient at ω^{-1}, have to equation

$$\frac{\partial v_{n+1}}{\partial\tau^n}=\frac{\partial f_0(u_0,0,0,\ldots.,0,\frac{\partial^p\Psi'_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0}u_1+\frac{\partial f_0(u_0,0,0,\ldots.,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_{p-1}}\frac{\partial^{p-1}v_p}{\partial\tau^{p-1}}$$

$$+\frac{\partial f_0(u_0,0,0,\ldots.,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_p}\frac{\partial^p v_{p+1}}{\partial\tau^p}+\frac{\partial f_1(u_0,\tau)}{\partial u}(u_{p+1}+v_{p+1})+\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2}(u_1v_p)\equiv$$

$$\Lambda_{p+1}(u_0+\tau)+\frac{\partial f_p(u_0,\tau)}{\partial u}u_{p+1}\ , \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(14)$$

Here

$$\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2}(u_1v_p)=\sum_{s,k=1}^{n}\frac{\partial^2 f_1(u_0,\tau)}{\partial u_k\partial u_s}(u_{1_s}v_{p_k}).$$

If we apply the equation (14) operation average with regard (9) we obtain:

$$\left\langle\frac{\partial f_0(u_0,0,0,\ldots.,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0}\right\rangle u_1+\left\langle\frac{\partial f_0(u_0,0,0,\ldots.,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_{p-1}}\frac{\partial^{p-1}\Psi_p}{\partial\tau^{p-1}}\right\rangle+$$

$$\left\langle\frac{\partial f_0(u_0,0,0,\ldots.,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_p}\frac{\partial^{p+1}\psi_p(u_0,\tau)}{\partial\tau^p\partial u}\right\rangle u_1+\left\langle\frac{\partial f_1(u_0,\tau)}{\partial u}\frac{\partial\ \psi_p(u_0,\tau)}{\partial u}\right\rangle u_1$$

$$+\left\langle\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2}\psi_p(u_0,\tau)\right\rangle u_1=0$$

$$\Phi'(u_0)u_1 = -\left\langle \frac{\partial f_0(u_0,0,.....,0,\dfrac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_{p-1}} \frac{\partial^{p-1}\Psi_p}{\partial \tau^{p-1}} \right\rangle \text{..........................(15)}$$

By virtue equation (9) , the solution problem (14) have the meaning :

$$v_{n+1}(\tau) = \frac{\partial \psi_p(u_0,\tau)}{\partial u} u_{p+1} + \chi_{p+1}(u_0,\tau) \text{ ....(16)}$$

$< \chi_{p+1} >= 0$ and $\dfrac{d^n \chi_{p+1}}{d\tau^p} = \Lambda_{p+1}(u_0,\tau)$, where χ_{p+1}-expression , depending on u_{s_1} and v_{s_s} at $0 \le s_1 \le 1$ and $p \le s_2 \le p+1$. From (15) we have define u_1. From (9) we will find v_{p+1} :

$$v_{p+1}(\tau) = -\frac{\partial \psi_p(u_0,\tau)}{\partial u}\left[\Phi'(u_0)\right]^{-1} \left\langle \frac{\partial f_0(u_0,0,.....,0,\dfrac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_{p-1}} \frac{\partial^{p-1}\Psi_p}{\partial \tau^{p-1}} \right\rangle \text{......(17)}$$

The equations from coefficients v_j , $j \ge n$ bear in mind :

$$\omega^{-2} : \frac{\partial^n v_{n+2}}{\partial \tau^n} = \frac{\partial f_0(u_0,0,0,....,0,\dfrac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_0} u_2 + \frac{1}{2!} \frac{\partial^2 f_0(u_0,0,0,....,0,\dfrac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_0^2} u_1^2 +$$

$$\frac{\partial f_0(u_0,0,0,....,0,\dfrac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_{p-2}} \frac{\partial^{p-2} v_p}{\partial \tau^{p-2}} + \frac{\partial f_0(u_0,0,0,....,0,\dfrac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_{p-1}} \frac{\partial^{p-1} v_{p+1}}{\partial \tau^{p-1}} +$$

$$\frac{\partial f_0(u_0,0,0,....,0,\dfrac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_p} \frac{\partial^p v_{p+2}}{\partial \tau^p} + \frac{\partial f_1(u_0,\tau)}{\partial u}(u_{p+2} + v_{p+2}) + \frac{\partial^2 f_1(u_0,\tau)}{\partial u^2}(u_2 v_p) +$$

$$\frac{\partial^3 f_1(u_0,\tau)}{\partial u^3}(u_1^2 v_p)$$

$$\equiv \Lambda_{p+2}(u_0 + \tau) + \frac{\partial f_1(u_0,\tau)}{\partial u} u_{p+2} \ .$$

$$\omega^{-3}:\frac{\partial^n v_{n+3}}{\partial\tau^n}=\frac{\partial f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0}u_3+\frac{\partial^2 f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0^2}u_1u_2+\frac{1}{3!}$$

$$\frac{\partial^3 f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0^3}u_1^3+\frac{\partial f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_{p-3}}\frac{\partial^{p-3}v_p}{\partial\tau^{p-3}}+\frac{\partial f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_{p-2}}$$

$$\frac{\partial^{p-2}v_{p+1}}{\partial\tau^{p-2}}+\frac{\partial f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_{p-1}}\frac{\partial^{p-1}v_{p+2}}{\partial\tau^{p-1}}+\frac{\partial f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_p}\frac{\partial^p v_{p+3}}{\partial\tau^p}$$

$$\frac{\partial f_p(u_0,\tau)}{\partial u}(u_{p+3}+v_{P+3})+\frac{\partial^2 f_p(u_0,\tau)}{\partial u^2}(u_3v_P)+\frac{\partial^3 f_p(u_0,\tau)}{\partial u^3}(u_1u_2v_P)+\frac{\partial^4 f_0(u_0,\tau)}{\partial u^4}(u_1^3v_P)$$

$$\equiv\Lambda_{p+3}(u_0+\tau)+\frac{\partial f_p(u_0,\tau)}{\partial u}u_{p+3}\ .$$

We show that description it is possible find any coefficients expansion (2) . presuppose , that we know $v_p,v_{p+1},.......,v_{n+j-1}$ and $u_0,u_1,........,u_{j-1}$.

We cant find v_{n-j} and u_j . we have equation :

$$\omega^{-j}:\frac{\partial^n v_{n+j}}{\partial\tau^n}=\frac{\partial f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0}u_j+\frac{1}{2!}\frac{\partial^2 f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0^2}\sum_{m+n=j}u_m$$

$$+\ldots+$$

$$\frac{1}{j!}\frac{\partial^j f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0^j}u_1^j+\sum_{s=0}^{j}\frac{\partial f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_{p-s}}\frac{\partial^{p-s}v_{p+j-s}}{\partial\tau^{p-s}}+$$

$$\frac{\partial f_1(u_0,\tau)}{\partial u}(u_{p+j}+v_{P+j})+\frac{\partial^2 f_1(u_0,\tau)}{\partial u^2}(u_jv_P)+\ldots+\frac{1}{(j+1)!}\frac{\partial^{j+1}f_1(u_0,\tau)}{\partial u^{j+1}}(u_1^jv_P)-$$

$$-\left\langle\frac{\partial f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0}\right\rangle u_j-\ldots-\left\langle\frac{1}{j!}\frac{\partial^j f_0(u_0,0,0,....,0,\frac{\partial^p\Psi_p(u_0,\tau)}{\partial\tau^p},\tau)}{\partial e_0^j}\right\rangle u_1^j-$$

$$-\left\langle \sum_{s=0}^{j} \frac{\partial f_0(u_0,0,0,\dots,0,\frac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_{p-s}} \frac{\partial^{p-s} v_{p+j-s}}{\partial \tau^{p-s}} \right\rangle - -\left\langle \frac{\partial f_1(u_0,\tau)}{\partial u} v_{P+j} \right\rangle - \dots$$

$$-\left\langle \frac{1}{(j+1)!} \frac{\partial^{j+1} f_1(u_0,\tau)}{\partial u^{j+1}} (u_1^j v_p) \right\rangle \qquad .(18)$$

For v_{n+j} we get equation :

$$v_{n+j}(\tau) = \frac{\partial \psi_p(u_0,\tau)}{\partial u} u_j + \chi_j(u_0,\tau) \dots\dots\dots\dots (19)$$

Where χ_j-expression , depending on u_{r_1} and v_{r_2} at $0 \le r_1 \le j-1$ and $p \le r_2 \le n+j-1$. Coefficient $u_j, j \ge 1$ are solution linear problem :

$$\left\langle \frac{\partial f_0(u_0,0,0,\dots,0,\frac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_0} \right\rangle u_j + \frac{1}{2!}\left\langle \frac{\partial^2 f_0(u_0,0,0,\dots,0,\frac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_0^2} \sum_{m+n=j} (u_m u_n) \right\rangle + \dots +$$

$$\frac{1}{j!}\left\langle \frac{\partial^j f_0(u_0,0,0,\dots,0,\frac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_0^j} u_1^j \right\rangle + .. + \left\langle \sum_{s=0}^{j} \frac{\partial f_0(u_0,0,0,\dots,0,\frac{\partial^p \Psi_p(u_0,\tau)}{\partial \tau^p},\tau)}{\partial e_{p-s}} \frac{\partial^{p-s} v_{p+j-s}}{\partial \tau^{p-s}} \right.$$

$$\left\langle \frac{\partial f_1(u_0,\tau)}{\partial u} v_{P+j} \right\rangle + \left\langle \frac{\partial^2 f_1(u_0,\tau)}{\partial u^2} \partial \psi_p(u_0,\tau) \right\rangle u_j + \dots + \frac{1}{(j+1)!}\left\langle \frac{\partial^{j+1} f_1(u_0,\tau)}{\partial u^{j+1}} (u_1^j v_P) \right\rangle = 0 \ .$$

(From here , It is necessary equation) .

$$\Phi'(u_0) u_j = M_j \dots\dots\dots\dots (20)$$

Where M_j-expression as type that χ_j. We consider question about decidability constructed problems. Average problem (12) by condition has solution u_0 . substituting it in expression (8) we find $v_p(\tau)$. After that definable uniquely solution u_1 linear problems (20) with j=1 and by formula (9) at s=p+1 we can find v_{p+1} and etc.

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ملخص البحث

في بحثنا هذا تم دراسة دوال $(f_0\ and\ f1)$ الدورية الاتجاهية في معادلة تفاضلية اعتيادية من الدرجة (n) وفي هذا الحالة تكون عالية التردد) حيث وضعنا في بحثنا أدناه شروط معية وخاصة , حيث تميزنا بدراسة معادلة تفاضلية من الدرجة (n) ولأي دالتين دوريتين متجهتين وبهذا المعنى فان هذه الدراسة يمكن اعتبارها دراسة موسعة ومهمة.