Digital Signal Processing for Protection and Control - Laboratory

Exercise 3: *Quality evaluation of selected methods of digital estimation of signal magnitude (4 hours)*

Exercise contents:

f_s=(900+(‘*group number*’)*100) Hz (change this frequency if tested algorithm requires other value)

For the measurement algorithms (A, B and C) given below make comparative analysis with regard to:

1. measurement accuracy and dynamics for the undistorted 50Hz sine signal;
2. algorithms’ accuracy for the signals containing decaying DC component of various time constants (50-300ms);
3. influence of harmonic and inter-harmonic components on the measurement quality;
4. algorithms’ quality for the cases of frequency change in the range 50±2Hz;
5. influence of sampling frequency on the measurement accuracy.

The algorithms to be examined are as follows:

A – averaging methods

Groups 1 and 6 $$X_m(n)=\frac{2}{m}tg\left(\frac{\pi}{2N}\right)\sum_{k=0}^{m\frac{N}{2}-1}\left|x(n-k)\right|,\quad m=1$$

Groups 2 and 7 $$X_m(n)=\frac{2}{m}tg\left(\frac{\pi}{2N}\right)\sum_{k=0}^{m\frac{N}{2}-1}\left|x(n-k)\right|,\quad m=2$$

Groups 3 and 8 $$X_m(n)=\sqrt{\frac{2}{N}}\sqrt{\sum_{k=0}^{N-1}x^2(n-k)}$$

Groups 4 and 9 $$X_m(n)=\frac{\sqrt{2}\pi}{N}\sum_{k=0}^{\frac{N}{4}-1}x^*(n-k),\qquad x^*(n)=\max\left\{\left|x(n)\right|;\ \left|x\left(n-\frac{N}{4}\right)\right|\right\}$$

Groups 5 and 10 $$X_m(n)=\frac{2\pi}{N}\sum_{k=0}^{\frac{N}{6}-1}x^{**}(n-k),\quad x^{**}(n)=\max\left\{\left|x(n)\right|;\ \left|x\left(n-\frac{N}{6}\right)\right|;\ \left|x\left(n-\frac{N}{3}\right)\right|\right\}$$

B – orthogonal components

- orthogonalisation with

Groups 1, 4, 7 and 10 $$x_c(n)=x(n),\quad x_s(n)=\frac{x(n-k)-x(n)\cos(k\Omega_1)}{\sin(k\Omega_1)},\quad k=1$$

Groups 2, 5 and 8 $$x_c(n)=x(n),\quad x_s(n)=\frac{x(n-k)-x(n)\cos(k\Omega_1)}{\sin(k\Omega_1)},\quad k=5$$

Groups 3, 6 and 9 $$x_c(n)=x(n-k),\quad x_s(n)=\frac{x(n-2k)-x(n)}{2\sin(k\Omega_1)},\quad k=1$$

- measurement with

Groups 1, 4, 7 and 10 $$X_m(n)=\sqrt{x_c^2(n)+x_s^2(n)}$$

Groups 2, 5 and 8 $$X_m(n) = \sqrt{\frac{x_c(n)x_c(n-k) + x_s(n)x_s(n-k)}{\cos(k\Omega_1)}}, \quad k=1$$

Groups 3, 6 and 9 $$X_m(n) = \sqrt{\frac{x_s(n)x_c(n-k) - x_s(n-k)x_c(n)}{\sin(k\Omega_1)}}, \quad k=2$$

C – orthogonal components

Even group number: orthogonalisation with full-cycle sine/cosine filters
Odd group number: orthogonalisation with full-cycle Walsh 1/2-order filters

- measurement as above (in point B)