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(54) **PERIODICALLY RESETTING INTEGRATION ANGLE DEMODULATION DEVICE AND METHOD USING THE SAME**

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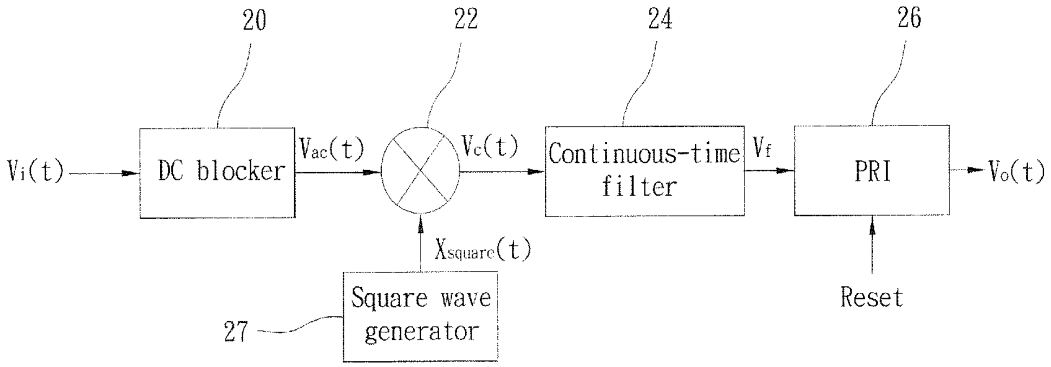
(57) **ABSTRACT**

A periodically resetting integration angle demodulation device and a method using the same is disclosed, which uses a waveform multiplier and a periodically resetting integrator to modulate a continuous-time angle modulation signal into a discrete-time signal. The waveform multiplier multiplies the continuous-time angle modulation signal by a square wave signal whose frequency is integer times a carrier frequency, and then transmits the continuous-time angle modulation signal to a periodically resetting integrated circuit. The periodically resetting integrated circuit performs integration during a carrier period to generate a discrete-time angle modulation output signal. The present invention can greatly reduce the difficulty for designing an optical sensing system in the front end without limiting a modulation depth. Besides, the present invention achieves a small volume, high speed, high sensitivity, high reliability, high performance and high condition-adapting properties.



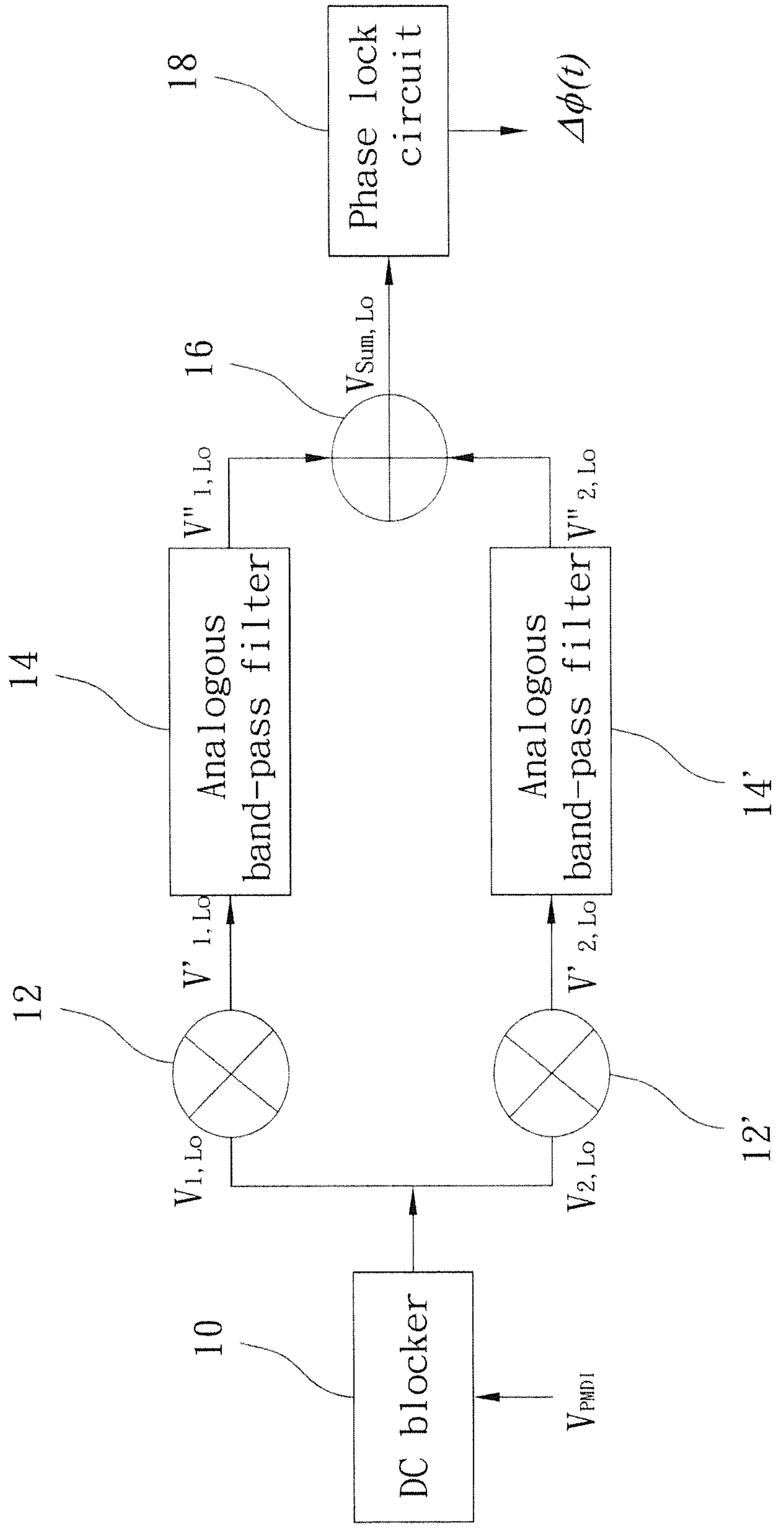


Fig. 1(PRIOR ART)

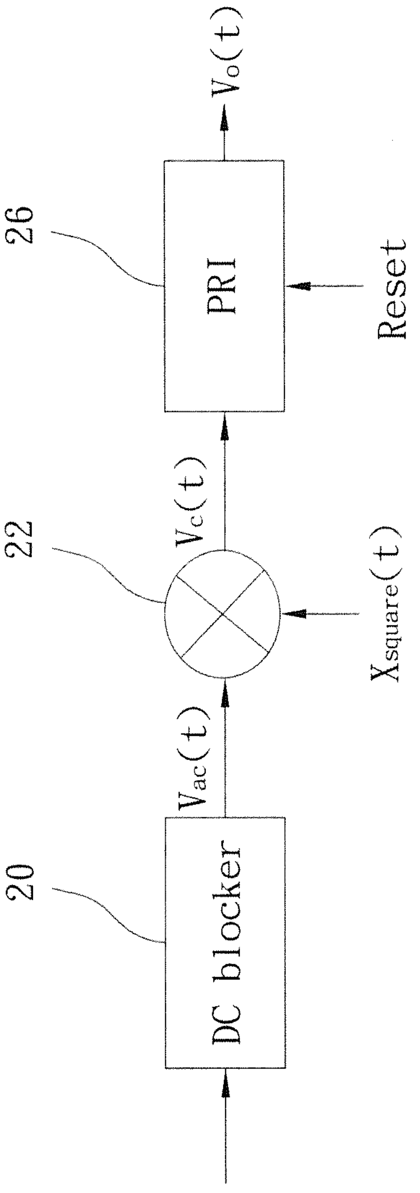


Fig. 2A

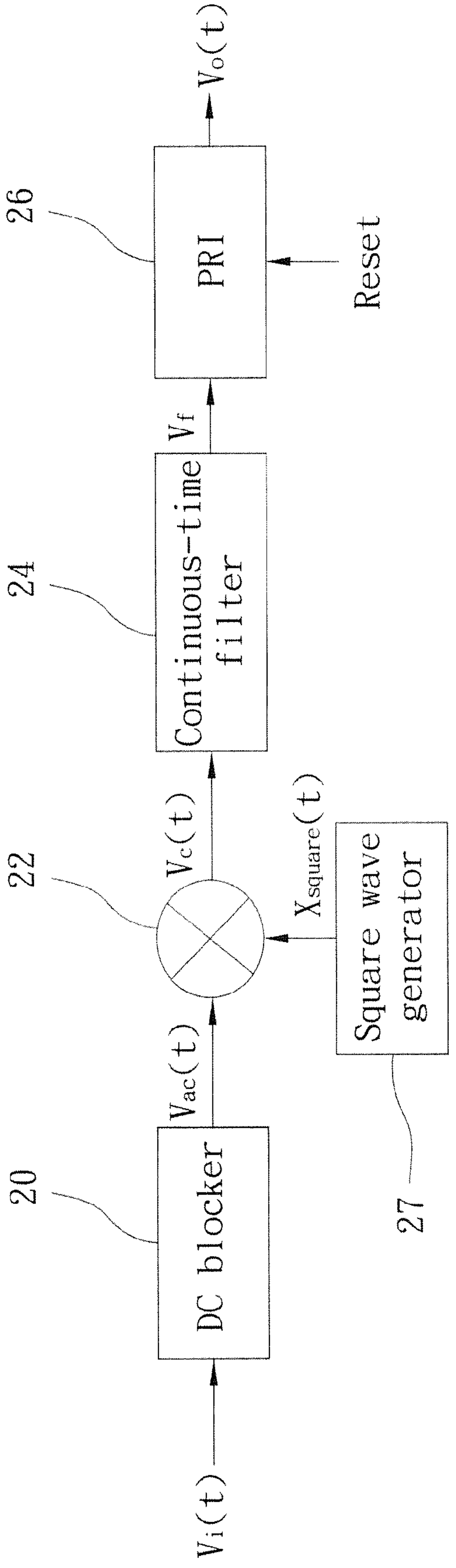

$V_i(t)$
DC blocker
20
$V_{ac}(t)$
22
$X_{square}(t)$
Square wave generator
27
$V_c(t)$
Continuous-time filter
24
V_f
PRI
26
Reset
$V_o(t)$

Fig. 2B

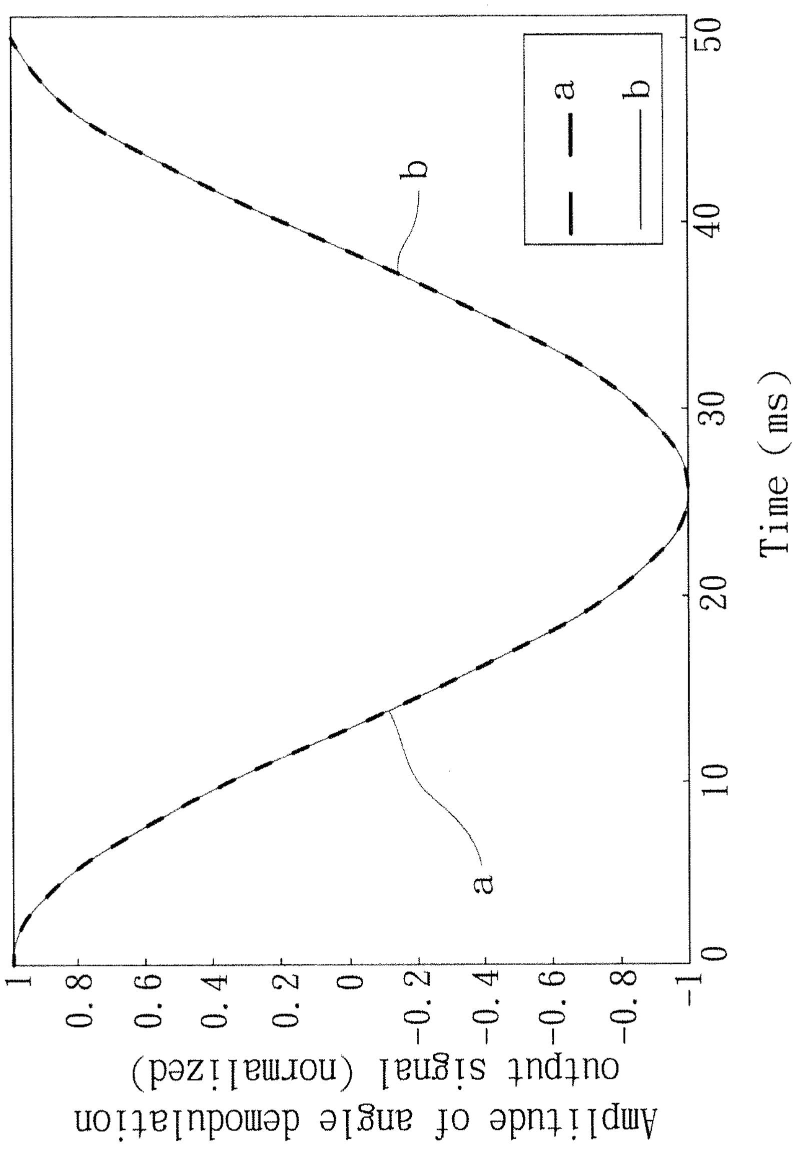

Amplitude of angle demodulation output signal (normalized)
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
0
10
20
30
40
50
Time (ms)
a
b
a
b

Fig. 3A

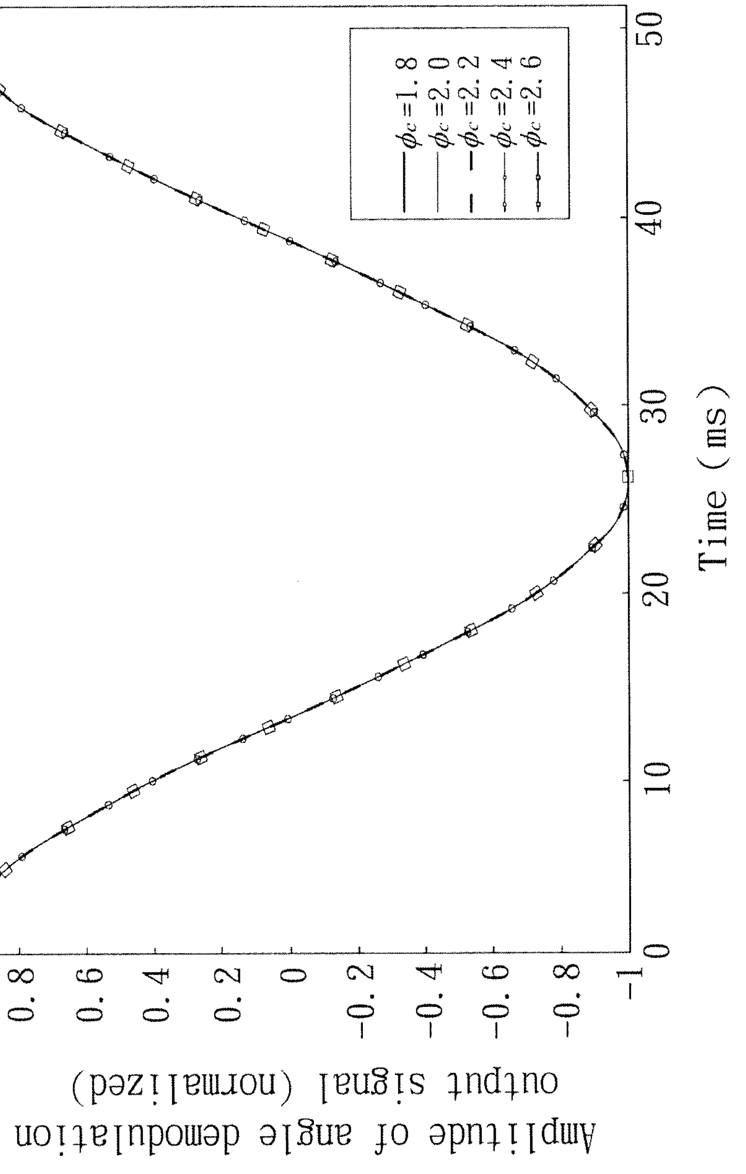

Amplitude of angle demodulation output signal (normalized)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
10
20
30
40
50
Time (ms)
ϕ_c=1.8
ϕ_c=2.0
ϕ_c=2.2
ϕ_c=2.4
ϕ_c=2.6

Fig. 3B

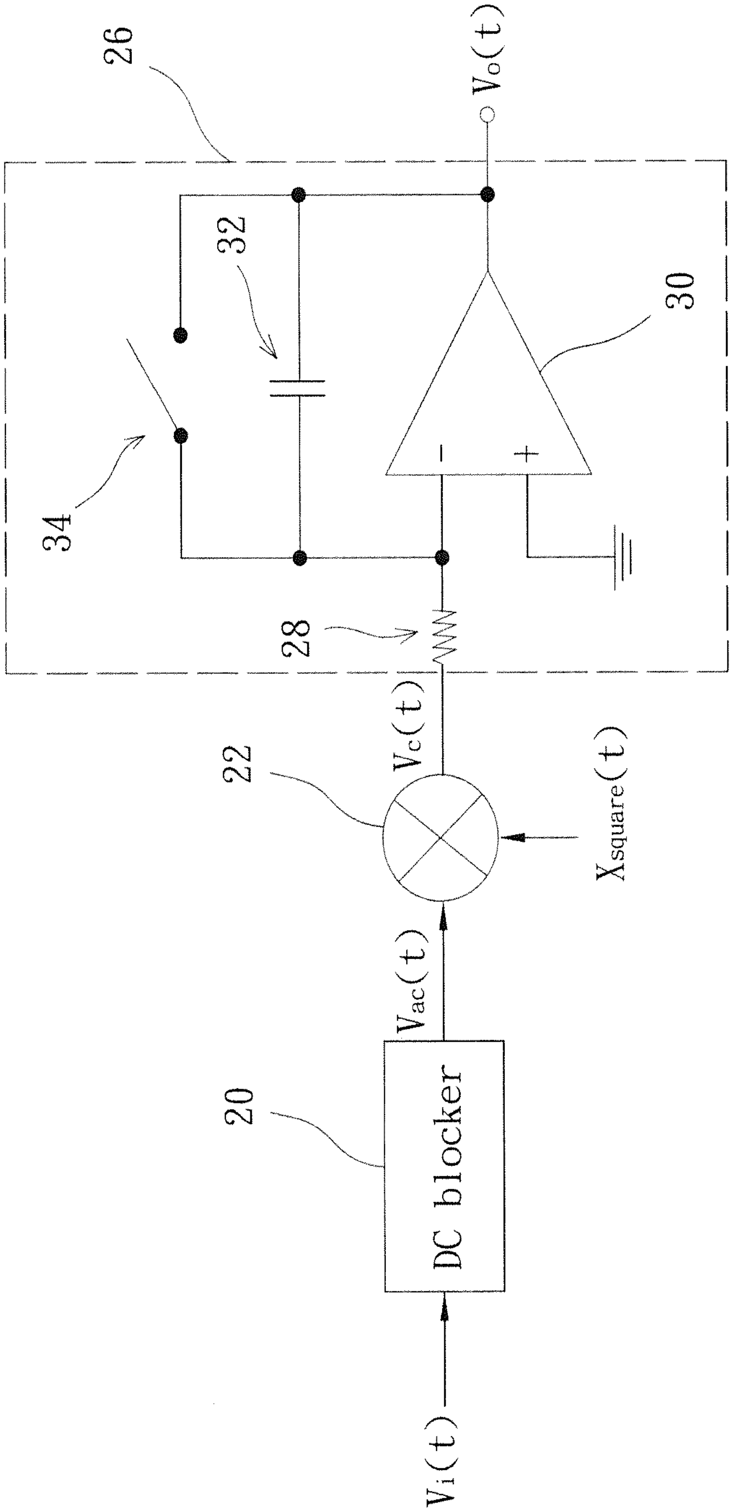


Fig. 4

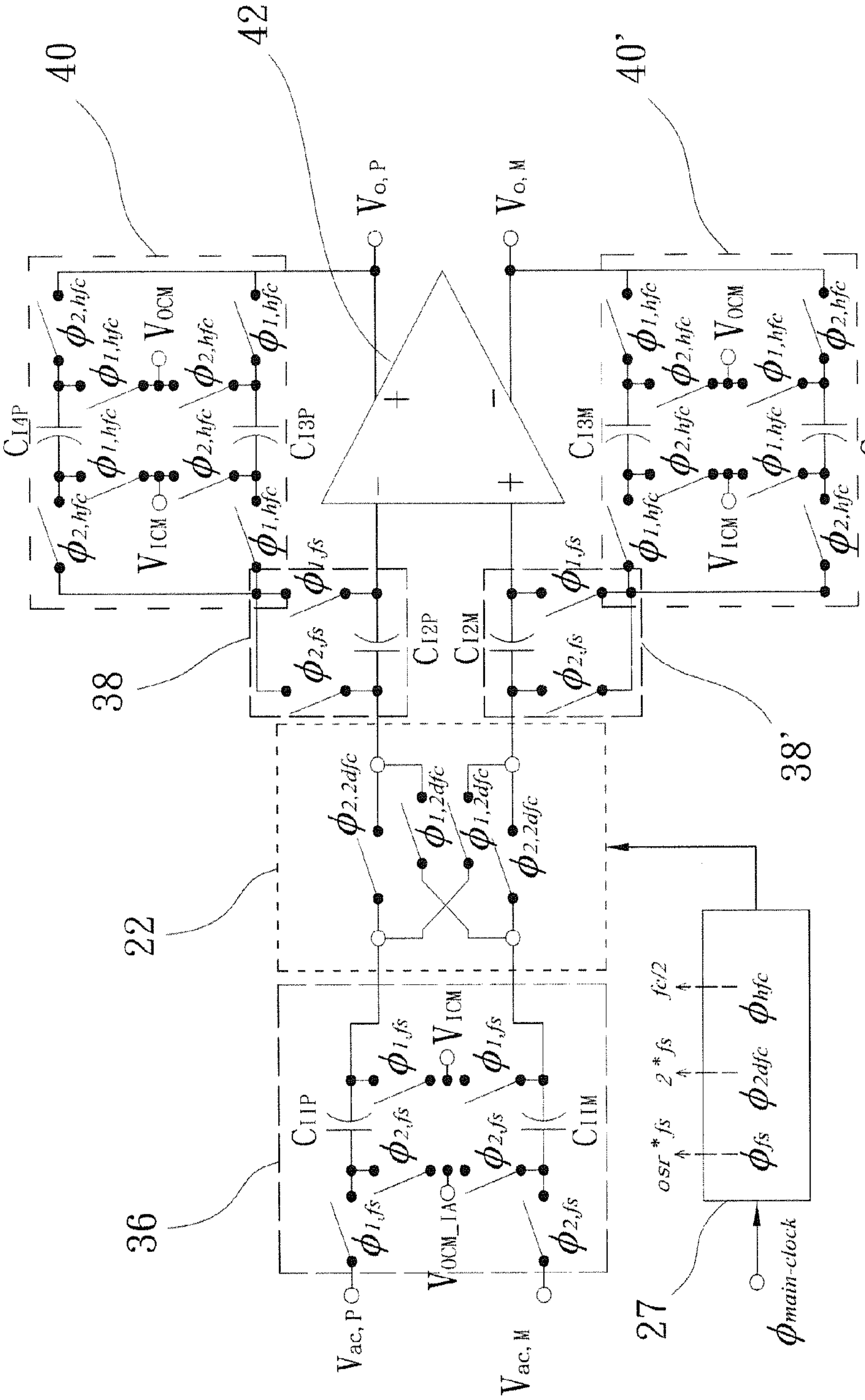

40
42
40'
$V_{o,P}$
$V_{o,M}$
C_{I4P}
C_{I3P}
C_{I3M}
C_{I4M}
$\phi_{1,hfc}$
$\phi_{2,hfc}$
V_{OCM}
V_{ICM}
+
−
$\phi_{1,fs}$
$\phi_{2,fs}$
C_{I2P}
C_{I2M}
38
38'
$\phi_{2,2dfc}$
$\phi_{1,2dfc}$
22
C_{I1P}
C_{I1M}
V_{OCM_IA}
36
$V_{ac,P}$
$V_{ac,M}$
$osr*fs$
$2*fs$
$fc/2$
ϕ_{fs}
ϕ_{2dfc}
ϕ_{hfc}
27
$\phi_{main\text{-}clock}$

Fig. 5

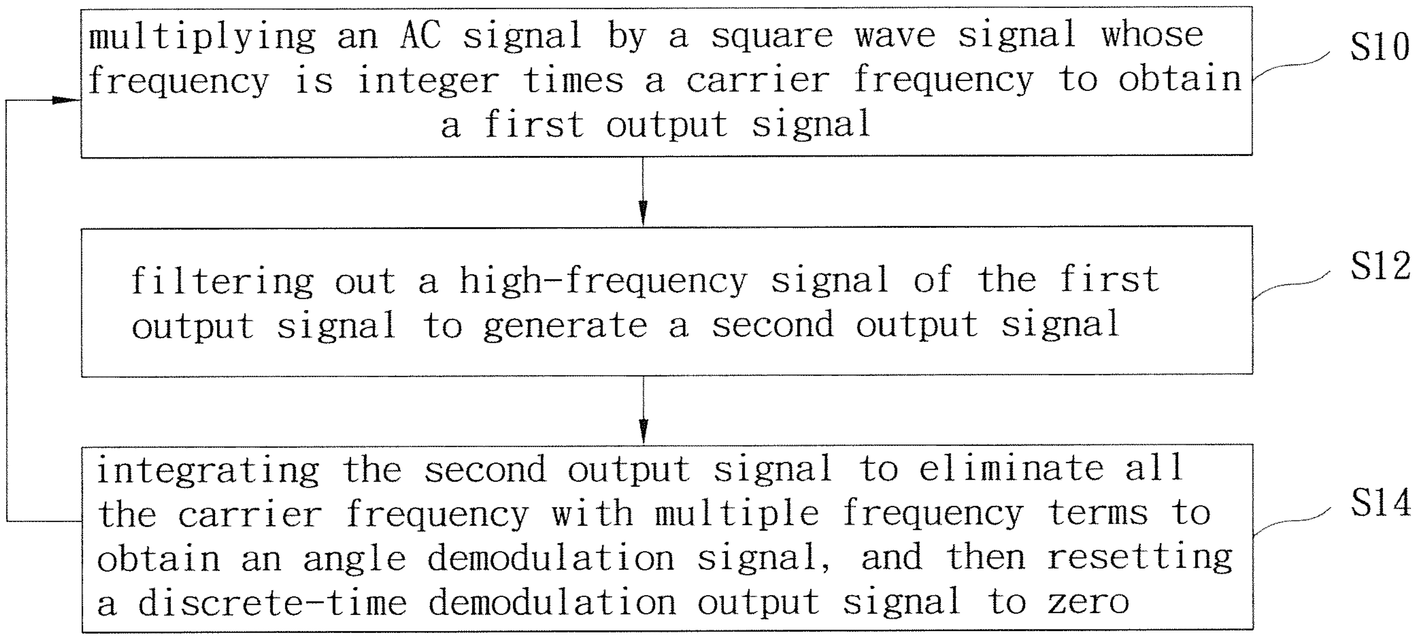

multiplying an AC signal by a square wave signal whose frequency is integer times a carrier frequency to obtain a first output signal
S10
filtering out a high-frequency signal of the first output signal to generate a second output signal
S12
integrating the second output signal to eliminate all the carrier frequency with multiple frequency terms to obtain an angle demodulation signal, and then resetting a discrete-time demodulation output signal to zero
S14

Fig. 6

PERIODICALLY RESETTING INTEGRATION ANGLE DEMODULATION DEVICE AND METHOD USING THE SAME

[0001] This application claims priority for Taiwan patent application no. 102117824 filed at May 21, 2013, the content of which is incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an angle demodulation device and method using the same, particularly to a periodically resetting integration angle demodulation device and a method using the same.

[0004] 2. Description of the Related Art

[0005] An optical sensing system is a sensor to measure acceleration, including those of a piezoresistive pressure sensor, a capacitive sensor, a piezoelectric sensor and an optical sensor, especially the optical sensor with better sensitivity. The optical sensor can apply to the system of high standard without disturbance of electromagnetic radiation, such as an advanced intelligent fuse system.

[0006] Among all kinds of optical accelerometers, Path Matched Differential Interferometry (PMDI) is an effective accelerometer. Presently, there are several kinds of demodulation systems which are references to process the rear-end signals. But circuits of the system are fabricated on a circuit board by using discrete elements. A large volume of the system is not only hard to apply to an optical sensing system but also achieves a purpose of microminiaturizing a whole system. As shown in FIG. **1**, the traditional technology has been provided a synthetic heterodyne demodulation circuit. Firstly, an optical fiber and an optical phase-measuring signal are modulated into an angle modulation signal by a sine wave, wherein the angle modulation signal is expressed by an equation (1):

$$V_{PMDI}(t)=A+B\cos[\phi_c\cos(2\pi f_c t)+\Delta\phi(t)] \tag{1}$$

[0007] Wherein A and B are constants, ϕ_c is a modulation depth, f_c is a modulation frequency, $\Delta\phi(t)$ is an angle variation resulted from acceleration. A direct-current (DC) blocker **10** receives the angle modulation signal and filters out a DC signal of the angle modulation signal to generate an alternative-current (AC) signal. According to Fourier-Bessel theory, the AC signal is expressed by an equation (2):

$$V_{PMDI}(t)= \tag{2}$$

$$A+B\left\{\begin{array}{l}\left[J_0(\phi_c)+2\sum_{k=1}^{\infty}(-1)^k J_{2k}(\phi_c)\cos(4k\pi f_c t)\right]\cos(\Delta\phi(t))- \\ \left[2\sum_{k=0}^{\infty}(-1)^k J_{2k+1}(\phi_c)\cos(2(2k+1)\pi f_c t)\right]\sin(\Delta\phi(t))\end{array}\right\}$$

[0008] The AC signals $V_{1,Lo}$ and $V_{2,Lo}$ are respectively transmitted to an analogous multipliers **12** and **12'** and the AC signal $V_{1,Lo}$ are multiplied by $\cos(2\pi f_c t)$ and simplified by a way of product to sum to obtain an equation (3):

$$V'_{1,Lo}(t)=V_{1,Lo}(t)\times\cos(2\pi f_c t)\Rightarrow V'_{1,Lo}(t)= \tag{3}$$

$$C'_{1,0}\sin(\Delta\phi(t))+C'_{1,1}\cos(2\pi f_c t)\cos(\Delta\phi(t))+$$

$$C'_{1,2}\cos(4\pi f_c t)\sin(\Delta\phi(t))+C'_{1,3}\cos(6\pi f_c t)\cos(\Delta\phi(t))+\ldots$$

[0009] Then, an analogous band-pass filter 14 with central frequency f ID receives $V_{1,Lo}(t)$ to generate an output signal expressed by an equation (4):

$$V'_{1,Lo}(t)='_{1,1}\cos(2\pi f_c t)\cos(\Delta\phi(t)) \tag{4}$$

[0010] Similarly, the AC signal $V_{2,Lo}(t)$ is multiplied by $\sin(4\pi f_c t)$ and simplified by a way of product to sum to obtain an equation (5). Another analogous band-pass filter **14'** with central frequency f_c receives $V'_{1,Lo}(t)$ to generate an output signal expressed by an equation (6).

$$V'_{2,Lo}(t)=V_{2,Lo}(t)\times\sin(4\pi f_c t)\Rightarrow V'_{2,Lo}(t)=C'_{2,1}\sin(2\pi f_c t)\sin(\Delta\phi(t))+ \tag{5}$$

$$C'_{2,2}\sin(4\pi f_c t)\cos(\Delta\phi(t))+C'_{2,3}\sin(6\pi f_c t)\sin(\Delta\phi(t))+\ldots$$

$$V''_{2,Lo}(t)=C'_{2,1}\sin(2\pi f_c t)\sin(\Delta\phi(t)) \tag{6}$$

[0011] Then, $V'_{1,Lo}(t)$ and $V'_{2,Lo}(t)$ are transmitted to analogous adder **16** and added, and a modulation depth is adjusted to comply with an equation (7):

$$C'_{1,1}=C'_{2,1}\Rightarrow B(J_3(\phi_c)-J_1(\phi_c))=-BJ_2(\phi_c) \tag{7}$$

[0012] When $V'_{1,Lo}(t)$ and $V'_{2,Lo}(t)$ comply with the equation (7), $V'_{1,Lo}(t)$ and $V'_{2,Lo}(t)$ are added to obtain a simple sine wave expressed by an equation (8):

$$V_{Sum,Lo}(t)=V''_{1,Lo}(t)+V''_{2,Lo}(t)\Rightarrow V_{Sum,Lo}(t)= \tag{8}$$

$$C'_{1,1}\cos(2\pi f_c t)\cos(\Delta\phi(t))+C'_{2,1}\sin(2\pi f_c t)\sin(\Delta\phi(t))\Rightarrow V_{Sum,Lo}(t)=$$

$$D\cos(2\pi f_c t-\Delta\phi(t))$$

[0013] After passing through a signal-demodulating process circuit, a signal becomes the sine wave. Finally, the sine wave is transmitted to a phase lock circuit **18** to be demodulated into an angle variation $\Delta\phi(t)$ required. As a result, sense data of a sensor is obtained.

[0014] According to the abovementioned derivation, the equation (7) is established to satisfy the equation (8), and a value of the modulation depth is very important. As a result, ϕ_c is limited to 2.2, which is not flexible enough to design the optical sensing system of PMDI. In addition, the upper limit of a carrier frequency is limited, thereby affecting a bandwidth of the sensor. Theoretically, the upper limit of the bandwidth of the sensor is 1/10 f. Thus, it is difficult for the circuit architecture to design an integrated circuit (IC) since each element of the circuit has complex design and the whole circuit area required is too large to be encapsulated in a chip. Specifically, two band-pass filters **14** and **14'** required have complex design and large volumes since the design requires the information of a single frequency (f_c, $2f_c$). Additionally, high-frequency harmonic waves of the equations (3) and (5) are completely filtered out by the analogous band-pass filters **14** and **14'**, otherwise the accuracy of an output signal is influenced.

[0015] In practice, each band-pass filter has a design of as high as ten or more order which means that the band-pass filter requires ten or more operation amplifiers and larger capacitors and resistors. The demand limits a possibility to use the architecture to realize an IC. Besides, the circuit architecture requires high linearity of the analogous multipliers **12** and **12'**. If the analogous multipliers have nonlinearity, harmonic waves appear in the result of the analogous multipliers to result in distortion. Also, the circuit architecture requires pure sine waves with frequency of f_c and $2f_c$. Either an external instrument or an oscillator can generate the sine wave. The instrument and the oscillator consume the cost and cannot provide pure sine waves with frequency of f_c and $2f_c$, which results in distortion of the demodulated signal. In other words, the angle variation $\Delta\phi(t)$ is precisely obtained by merely using a high-linearity analogous multiplier, a pure sine wave generator and a high-order band-pass filter, which is the present bottleneck for designing a micro integrated circuit. And, the problems of too large areas of resistors and capacitors, high design complexity, high power consumption and bad linearity exist. Accordingly, how to reduce circuit elements required should be solved whereby the circuit elements are realized in a limited chip area without affecting the normal function of the circuit. To overcome the abovementioned problems, the present invention provides a periodically resetting integration angle demodulation device and a method using the same, so as to solve the afore-mentioned problems of the prior art.

SUMMARY OF THE INVENTION

[0016] A primary objective of the present invention is to provide an angle demodulation device and a method using the same, which uses a periodically resetting integration technology to reduce circuit elements required and obtain a precise angle demodulation signal, thereby achieving a small volume, high speed, high sensitivity, high reliability, high performance and high condition-adapting properties.

[0017] A secondary objective of the present invention is to provide a periodically resetting integration angle demodulation device and a method using the same, which provides a simple architecture, greatly reduces the difficulty for designing an optical sensing system in the front end without limiting a modulation depth (ϕ_c), effectively resolves the problem of linearity and signal distortion of circuits, and reduces capacitances used whereby a integrated circuit can be realized and the yield of the optical sensing system is improved.

[0018] To achieve the abovementioned objectives, the present invention provides a periodically resetting integration angle demodulation device, which comprises a waveform multiplier, a continuous-time filter and a periodically resetting integrator (PRI). The continuous-time filter is connected between the PRI and the waveform multiplier. The waveform multiplier receives an alternative-current (AC) signal, multiplying the AC signal by a square wave signal whose frequency is integer times a carrier frequency to generate a first output signal. The continuous-time filter receives the first output signal and filters out a high-frequency signal of the first output signal to generate a second output signal. Finally, the output signal of the PRI is reset, and then the PRI receives the second output signal and integrates the second output signal during a carrier period to eliminate all the carrier frequency with multiple frequency terms. Then, the output of the PRI generates a discrete-time angle demodulation signal every carrier period.

[0019] The present invention also provides a periodically resetting integration angle demodulation method, which comprises steps of: multiplying an AC signal by a square wave signal whose frequency is integer times a carrier frequency to obtain a first output signal; filtering out a high-frequency signal of the first output signal to generate a second output signal; and integrating the second output signal to eliminate all the carrier frequency with multiple frequency terms to obtain an angle demodulation signal, and then resetting a discrete-time demodulation output signal of a periodically resetting integrator to zero, and continuing repeating the step of multiplying the angle modulation signal by the square wave signal to obtain the first output signal.

[0020] Below, the embodiments are described in detail in cooperation with the drawings to make easily understood the technical contents, characteristics and accomplishments of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. **1** is a schematic diagram illustrating a circuit in the traditional technology;

[0022] FIG. **2**A is a schematic diagram illustrating a circuit according to an embodiment of the present invention;

[0023] FIG. **2**B is a schematic diagram illustrating a circuit according to another embodiment of the present invention;

[0024] FIG. **3**A is a simulated waveform diagram illustrating an angle demodulation signal according to an embodiment of the present invention;

[0025] FIG. **3**B is a waveform diagram illustrating the angle demodulation signal by changing a modulation depth according to an embodiment of the present invention;

[0026] FIG. **4** is a schematic diagram illustrating a circuit using a continuous-time periodically resetting integrator according to an embodiment of the present invention;

[0027] FIG. **5** is a schematic diagram illustrating a circuit using a discrete-time periodically resetting integrator according to an embodiment of the present invention; and

[0028] FIG. **6** is a flowchart illustrating steps according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0029] The purpose of microminiaturizing a whole system is not achieved due to the fact that a synthetic heterodyne demodulation circuit is too large fabricated on a large circuit board. In order to overcome the problem, the present invention provides a periodically resetting integration angle demodulation device to simplify the circuit.

[0030] Refer to FIG. **2**A, which is a circuit of the present invention. The angle demodulation device comprises a direct-current (DC) blocker **20**, a waveform multiplier **22** and a periodically resetting integration (PRI) **26**. The DC blocker **20** is coupled to an optical sensing system (not shown) and uses the optical sensing system (PMDI) to send out an angle modulation signal ($V_{PMDI}(t)$) to the DC blocker **20**. The DC blocker **20** is coupled to the waveform multiplier **22**. The DC blocker **20** receives the angle modulation signal to filter out a DC signal of the angle modulation signal, and sends out an alternative-current (AC) signal ($V_{ac}(t)$) to the waveform multiplier **22**. The waveform multiplier **22** receives an AC signal, multiplying the AC signal by a square wave signal whose frequency is integer times a carrier frequency to generate a first output signal ($V_c(t)$). Finally, the output signal of the PRI **26** is reset, and then the PRI **26** receives the first output signal and integrates the first output signal during a carrier period to eliminate all the carrier frequency with multiple frequency terms. Then, the output of the PRI **26** generates a discrete-time angle demodulation signal every carrier period.

[0031] The first output signal outputted by the waveform multiplier **22** comprises a high-frequency signal. In order to obtain a more precise output signal, refer to FIG. **2**A and FIG. **2**B. FIG. **2**B is another circuit of the present invention. The angle demodulation device further comprises a continuous-time filter **24** coupled to the waveform multiplier **22** and the PRI **26**. The DC blocker **20** is coupled to the waveform multiplier **22**. The continuous-time filter **24** is a continuous-time low-pass filter or a continuous-time band-pass filter **24**. The continuous-time filter **24** is coupled to the waveform multiplier **22** and the PRI **26**. In order to understand the present invention for simplifying circuits and obtain the precise angle demodulation signal, the present invention is explained by the deviation of mathematical equations, wherein the angle modulation signal is expressed by an equation (9):

$$V_{PMDI}(t)=A+B\cos[\phi_c\cos(2\pi f_c t)+\Delta\phi(t)] \tag{9}$$

Wherein A and B are constants, ϕ_c is a modulation depth, f_c is a modulation frequency, $\Delta\phi(t)$ is an angle variation resulted from acceleration.

[0032] Then, according to Fourier-Bessel theory, the angle modulation signal is expressed by an equation $V_i(t)$ (10):

$$V_i(t)=V_{PMDI}(t) \tag{10}$$

$$\Rightarrow V_i(t)=$$

$$A+B\left\{\begin{array}{c}\left[J_0(\phi_c)+2\sum_{k=1}^{\infty}(-1)^k J_{2k}(\phi_c)\cos(4k\pi f_c t)\right]\cos(\Delta\phi(t))-\\ \left[2\sum_{k=0}^{\infty}(-1)^k J_{2k+1}(\phi_c)\cos(2(2k+1)\pi f_c t)\right]\sin(\Delta\phi(t))\end{array}\right\}$$

After $V_i(t)$ passing through the DC blocker **20**, the DC blocker **20** filters out the DC signal to obtain the AC signal ($V_{ac}(t)$) expressed by an equation (11):

$$V_{ac}(t)=B\left\{\begin{array}{c}\left[2\sum_{k=1}^{\infty}(-1)^k J_{2k}(\phi_c)\cos(4k\pi f_c t)\right]\cos(\Delta\phi(t))-\\ \left[2\sum_{k=0}^{\infty}(-1)^k J_{2k+1}(\phi_c)\cos(2(2k+1)\pi f_c t)\right]\sin(\Delta\phi(t))\end{array}\right\} \tag{11}$$

$$V_{ac}(t)=B\left\{\begin{array}{c}-2J_1(\phi_c)\cos(2\pi f_c t)\sin(\Delta\phi(t))-\\ 2J_2(\phi_c)\cos(4\pi f_c t)\cos(\Delta\phi(t))+\\ 2J_3(\phi_c)\cos(6\pi f_c t)\sin(\Delta\phi(t))+\\ 2J_4(\phi_c)\cos(8\pi f_c t)\cos(\Delta\phi(t))-\\ 2J_5(\phi_c)\cos(10\pi f_c t)\sin(\Delta\phi(t))-\\ 2J_6(\phi_c)\cos(12\pi f_c t)\cos(\Delta\phi(t))+\\ 2J_7(\phi_c)\cos(14\pi f_c t)\sin(\Delta\phi(t))+\\ 2J_8(\phi_c)\cos(16\pi f_c t)\cos(\Delta\phi(t))-\dots\end{array}\right\}$$

After the waveform multiplier **22** receives an AC signal, the waveform multiplier **22** multiplies the AC signal by the square wave signal ($x_{square(t)}$) whose frequency is integer times a carrier frequency (nf_c) to obtain a first output signal ($V_c(t)$) expressed by an equation (12):

$$V_c(t)=V_{ac}(t)\times x_{square}(t) \tag{12}$$

$$\Rightarrow V_c(t)=\begin{bmatrix}-2J_1(\phi_c)\cos(2\pi f_c t)\sin(\Delta\phi(t))-\\ 2J_2(\phi_c)\cos(4\pi f_c t)\cos(\Delta\phi(t))+\\ 2J_3(\phi_c)\cos(6\pi f_c t)\sin(\Delta\phi(t))+\\ 2J_4(\phi_c)\cos(8\pi f_c t)\cos(\Delta\phi(t))-\\ 2J_5(\phi_c)\cos(10\pi f_c t)\sin(\Delta\phi(t))-\\ 2J_6(\phi_c)\cos(12\pi f_c t)\cos(\Delta\phi(t))+\\ 2J_7(\phi_c)\cos(14\pi f_c t)\sin(\Delta\phi(t))-\dots+\\ 2J_8(\phi_c)\cos(16\pi f_c t)\cos(\Delta\phi(t))-\dots\end{bmatrix}\times$$

$$\left[\frac{4}{\pi}\sum_{k=1}^{\infty}\frac{\cos[(2k-1)2n\pi f_c t]}{(2k-1)}\right]$$

$$\Rightarrow V_c(t)=\begin{bmatrix}-2J_1(\phi_c)\cos(2\pi f_c t)\sin(\Delta\phi(t))-\\ 2J_2(\phi_c)\cos(4\pi f_c t)\cos(\Delta\phi(t))+\\ 2J_3(\phi_c)\cos(6\pi f_c t)\sin(\Delta\phi(t))+\\ 2J_4(\phi_c)\cos(8\pi f_c t)\cos(\Delta\phi(t))-\\ 2J_5(\phi_c)\cos(10\pi f_c t)\sin(\Delta\phi(t))-\\ 2J_6(\phi_c)\cos(12\pi f_c t)\cos(\Delta\phi(t))+\\ 2J_7(\phi_c)\cos(14\pi f_c t)\sin(\Delta\phi(t))-\dots+\\ 2J_8(\phi_c)\cos(16\pi f_c t)\cos(\Delta\phi(t))-\dots\end{bmatrix}\times$$

$$\frac{4}{\pi}\begin{bmatrix}+\cos(2n\pi f_c t)-\\ \frac{1}{3}\cos(6n\pi f_c t)+\\ \frac{1}{5}\cos(10n\pi f_c t)-\\ \frac{1}{7}\cos(14n\pi f_c t)+\dots\end{bmatrix}$$

$$\Rightarrow V_c(t)=V_{c1}(t)+V_{c2}(t)+V_{c3}(t)+V_{c4}(t)+\dots+V_{cn}(t)$$

Every terms expands:

$$V_{c1}(t)=V_{ac}(t)\times\frac{4}{\pi}[+\cos(2n\pi f_c t)]$$

$$\Rightarrow V_{c1}(t)=\frac{4}{\pi}\begin{bmatrix}-2J_1(\phi_c)\cos(2\pi f_c t)\cos(2n\pi f_c t)\sin(\Delta\phi(t))-\\ 2J_2(\phi_c)\cos(4\pi f_c t)\cos(2n\pi f_c t)\cos(\Delta\phi(t))+\\ 2J_3(\phi_c)\cos(6\pi f_c t)\cos(2n\pi f_c t)\sin(\Delta\phi(t))+\\ 2J_4(\phi_c)\cos(8\pi f_c t)\cos(2n\pi f_c t)\cos(\Delta\phi(t))-\\ 2J_5(\phi_c)\cos(10\pi f_c t)\cos(2n\pi f_c t)\sin(\Delta\phi(t))-\\ 2J_6(\phi_c)\cos(12\pi f_c t)\cos(2n\pi f_c t)\cos(\Delta\phi(t))+\\ 2J_7(\phi_c)\cos(14\pi f_c t)\cos(2n\pi f_c t)\sin(\Delta\phi(t))-\dots+\\ 2J_8(\phi_c)\cos(16\pi f_c t)\cos(2n\pi f_c t)\cos(\Delta\phi(t))-\dots\end{bmatrix}$$

-continued

$$\Rightarrow V_{c1}(t) = \frac{4}{\pi}\left[\begin{matrix} -J_1(\phi_c)[\cos((2+2n)\pi f_c t)+\cos((2-2n)\pi f_c t)]\sin(\Delta\phi(t)) - \\ J_2(\phi_c)[\cos((4+2n)\pi f_c t)+\cos((4-2n)\pi f_c t)]\cos(\Delta\phi(t)) + \\ J_3(\phi_c)[\cos((6+2n)\pi f_c t)+\cos((6-2n)\pi f_c t)]\sin(\Delta\phi(t)) + \\ J_4(\phi_c)[\cos((8+2n)\pi f_c t)+\cos((8-2n)\pi f_c t)]\cos(\Delta\phi(t)) - \\ J_5(\phi_c)[\cos((10+2n)\pi f_c t)+\cos((10-2n)\pi f_c t)]\sin(\Delta\phi(t)) - \\ J_6(\phi_c)[\cos((12+2n)\pi f_c t)+\cos((12-2n)\pi f_c t)]\cos(\Delta\phi(t)) + \\ J_7(\phi_c)[\cos((14+2n)\pi f_c t)+\cos((14-2n)\pi f_c t)]\sin(\Delta\phi(t)) - \dots + \\ J_8(\phi_c)[\cos((16+2n)\pi f_c t)+\cos((16-2n)\pi f_c t)]\cos(\Delta\phi(t)) - \dots \end{matrix}\right]$$

$$V_{c2}(t) = V_{ac}(t)\times\frac{4}{\pi}\left[-\frac{1}{3}\cos(6n\pi f_c t)\right]$$

$$\Rightarrow V_{c2}(t) = \frac{-4}{3\pi}\left[\begin{matrix} -2J_1(\phi_c)\cos(2\pi f_c t)\cos(6n\pi f_c t)\sin(\Delta\phi(t)) - \\ 2J_2(\phi_c)\cos(4\pi f_c t)\cos(6n\pi f_c t)\cos(\Delta\phi(t)) + \\ 2J_3(\phi_c)\cos(6\pi f_c t)\cos(6n\pi f_c t)\sin(\Delta\phi(t)) + \\ 2J_4(\phi_c)\cos(8\pi f_c t)\cos(6n\pi f_c t)\cos(\Delta\phi(t)) - \\ 2J_5(\phi_c)\cos(10\pi f_c t)\cos(6n\pi f_c t)\sin(\Delta\phi(t)) - \\ 2J_6(\phi_c)\cos(12\pi f_c t)\cos(6n\pi f_c t)\cos(\Delta\phi(t)) + \\ 2J_7(\phi_c)\cos(14\pi f_c t)\cos(6n\pi f_c t)\sin(\Delta\phi(t)) - \dots + \\ 2J_8(\phi_c)\cos(16\pi f_c t)\cos(6n\pi f_c t)\cos(\Delta\phi(t)) - \dots \end{matrix}\right]$$

$$\Rightarrow V_{c2}(t) = \frac{-4}{3\pi}\left[\begin{matrix} -J_1(\phi_c)\begin{bmatrix}\cos((2+6n)\pi f_c t)+\\ \cos((2-6n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \\ J_2(\phi_c)\begin{bmatrix}\cos((4+6n)\pi f_c t)+\\ \cos((4-6n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) + \\ J_3(\phi_c)\begin{bmatrix}\cos((6+6n)\pi f_c t)+\\ \cos((6-6n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) + \\ J_4(\phi_c)\begin{bmatrix}\cos((8+6n)\pi f_c t)+\\ \cos((8-6n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) - \\ J_5(\phi_c)\begin{bmatrix}\cos((10+6n)\pi f_c t)+\\ \cos((10-6n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \\ J_6(\phi_c)\begin{bmatrix}\cos((12+6n)\pi f_c t)+\\ \cos((12-6n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) + \\ J_7(\phi_c)\begin{bmatrix}\cos((14+6n)\pi f_c t)+\\ \cos((14-6n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \dots + \\ J_8(\phi_c)\begin{bmatrix}\cos((16+6n)\pi f_c t)+\\ \cos((16-6n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) - \dots \end{matrix}\right]$$

$$V_{c3}(t) = V_{ac}(t)\times\frac{4}{\pi}\left[+\frac{1}{5}\cos(10n\pi f_c t)\right]$$

$$\Rightarrow V_{c3}(t) = \frac{4}{5\pi}\left[\begin{matrix} -2J_1(\phi_c)\cos(2\pi f_c t)\cos(10n\pi f_c t)\sin(\Delta\phi(t)) - \\ 2J_2(\phi_c)\cos(4\pi f_c t)\cos(10n\pi f_c t)\cos(\Delta\phi(t)) + \\ 2J_3(\phi_c)\cos(6\pi f_c t)\cos(10n\pi f_c t)\sin(\Delta\phi(t)) + \\ 2J_4(\phi_c)\cos(8\pi f_c t)\cos(10n\pi f_c t)\cos(\Delta\phi(t)) - \\ 2J_5(\phi_c)\cos(10\pi f_c t)\cos(10n\pi f_c t)\sin(\Delta\phi(t)) - \\ 2J_6(\phi_c)\cos(12\pi f_c t)\cos(10n\pi f_c t)\cos(\Delta\phi(t)) + \\ 2J_7(\phi_c)\cos(14\pi f_c t)\cos(10n\pi f_c t)\sin(\Delta\phi(t)) - \dots + \\ 2J_8(\phi_c)\cos(16\pi f_c t)\cos(10n\pi f_c t)\cos(\Delta\phi(t)) - \dots \end{matrix}\right]$$

-continued

$$\Rightarrow V_{c3}(t) = \frac{4}{5\pi}\left[\begin{matrix} -J_1(\phi_c)\begin{bmatrix}\cos((2+10n)\pi f_c t)+\\ \cos((2-10n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \\ J_2(\phi_c)\begin{bmatrix}\cos((4+10n)\pi f_c t)+\\ \cos((4-10n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) + \\ J_3(\phi_c)\begin{bmatrix}\cos((6+10n)\pi f_c t)+\\ \cos((6-10n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) + \\ J_4(\phi_c)\begin{bmatrix}\cos((8+10n)\pi f_c t)+\\ \cos((8-10n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) - \\ J_5(\phi_c)\begin{bmatrix}\cos((10+10n)\pi f_c t)+\\ \cos((10-10n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \\ J_6(\phi_c)\begin{bmatrix}\cos((12+10n)\pi f_c t)+\\ \cos((12-10n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) + \\ J_7(\phi_c)\begin{bmatrix}\cos((14+10n)\pi f_c t)+\\ \cos((14-10n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \dots + \\ J_8(\phi_c)\begin{bmatrix}\cos((16+10n)\pi f_c t)+\\ \cos((16-10n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) - \dots \end{matrix}\right]$$

$$V_{c4}(t) = V_{ac}(t)\times\frac{4}{\pi}\left[-\frac{1}{7}\cos(14n\pi f_c t)\right]$$

$$\Rightarrow V_{c4}(t) = \frac{-4}{7\pi}\left[\begin{matrix} -2J_1(\phi_c)\cos(2\pi f_c t)\cos(14n\pi f_c t)\sin(\Delta\phi(t)) - \\ 2J_2(\phi_c)\cos(4\pi f_c t)\cos(14n\pi f_c t)\cos(\Delta\phi(t)) + \\ 2J_3(\phi_c)\cos(6\pi f_c t)\cos(14n\pi f_c t)\sin(\Delta\phi(t)) + \\ 2J_4(\phi_c)\cos(8\pi f_c t)\cos(14n\pi f_c t)\cos(\Delta\phi(t)) - \\ 2J_5(\phi_c)\cos(10\pi f_c t)\cos(14n\pi f_c t)\sin(\Delta\phi(t)) - \\ 2J_6(\phi_c)\cos(12\pi f_c t)\cos(14n\pi f_c t)\cos(\Delta\phi(t)) + \\ 2J_7(\phi_c)\cos(14\pi f_c t)\cos(14n\pi f_c t)\sin(\Delta\phi(t)) - \dots + \\ 2J_8(\phi_c)\cos(16\pi f_c t)\cos(14n\pi f_c t)\cos(\Delta\phi(t)) - \dots \end{matrix}\right]$$

$$\Rightarrow V_{c4}(t) = \frac{-4}{7\pi}\left[\begin{matrix} -J_1(\phi_c)\begin{bmatrix}\cos((2+14n)\pi f_c t)+\\ \cos((2-14n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \\ J_2(\phi_c)\begin{bmatrix}\cos((4+14n)\pi f_c t)+\\ \cos((4-14n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) + \\ J_3(\phi_c)\begin{bmatrix}\cos((6+14n)\pi f_c t)+\\ \cos((6-14n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) + \\ J_4(\phi_c)\begin{bmatrix}\cos((8+14n)\pi f_c t)+\\ \cos((8-14n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) - \\ J_5(\phi_c)\begin{bmatrix}\cos((10+14n)\pi f_c t)+\\ \cos((10-14n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \\ J_6(\phi_c)\begin{bmatrix}\cos((12+14n)\pi f_c t)+\\ \cos((12-14n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) + \\ J_7(\phi_c)\begin{bmatrix}\cos((14+14n)\pi f_c t)+\\ \cos((14-14n)\pi f_c t)\end{bmatrix}\sin(\Delta\phi(t)) - \dots + \\ J_8(\phi_c)\begin{bmatrix}\cos((16+14n)\pi f_c t)+\\ \cos((16-14n)\pi f_c t)\end{bmatrix}\cos(\Delta\phi(t)) - \dots \end{matrix}\right]$$

[0033] According to the abovementioned operations, $V_c(t)$ is obtained. The continuous-time filter **24** receives the first output signal ($V_c(t)$) and filters out a high-frequency signal of the first output signal to generate a second output signal (V_f). Finally, the PRI **26** receives the second output signal, integrates the second output signal to eliminate all the carrier frequency with multiple frequency terms to obtain an angle demodulation signal (V_o), and then resets a discrete-time demodulation output signal to zero. The angle demodulation device further comprises a square wave generator **27** coupled to the waveform multiplier **22** and using the waveform multiplier **22** to send out the square wave signal to the wave multiplier **22**.

[0034] For example, when the waveform multiplier **22** multiplies the AC signal by the square wave signal ($x_{square(t)}$) whose frequency is integer times the carrier frequency (nf_c), wherein N is a natural number, and N=1, 3, 5, 7 . . . , $V_c(t)=V_{c1}(t)+V_{c2}(t)+V_{c3}(t)+V_{c4}(t)+\ldots+V_{cn}(t)$ is expanded as an equation (13):

$$\Rightarrow V_{c,odd}(t)=\left[\begin{array}{c}C_{0,odd}\cos(0\pi f_c t)\sin(\Delta\phi(t))+\\ C_{1,odd}\cos(2\pi f_c t)\cos(\Delta\phi(t))+\\ C_{2,odd}\cos(4\pi f_c t)\sin(\Delta\phi(t))+\\ C_{3,odd}\cos(6\pi f_c t)\cos(\Delta\phi(t))+\\ C_{4,odd}\cos(8\pi f_c t)\sin(\Delta\phi(t))+\\ C_{5,odd}\cos(10\pi f_c t)\cos(\Delta\phi(t))+\ldots\end{array}\right] \tag{13}$$

[0035] After $V_c(t)$ passes through the PRI **26**, the angle demodulation signal ($V_c(t)$) expressed by an equation (14) is obtained:

$$V_{o,odd}(t)\big|_{t=nT_c}=v_{o,odd}(n)=\int_{(n-1)T_c}^{nT_c}[V_{c,odd}(t)]\,dt \tag{14}$$

$$\Rightarrow V_{o,odd}(t)=\int_{(n-1)T_c}^{nT_c}\left[\begin{array}{c}C_{0,odd}\cos(0\pi f_c t)\sin(\Delta\phi(t))+\\ C_{1,odd}\cos(2\pi f_c t)\cos(\Delta\phi(t))+\\ C_{2,odd}\cos(4\pi f_c t)\sin(\Delta\phi(t))+\\ C_{3,odd}\cos(6\pi f_c t)\cos(\Delta\phi(t))+\\ C_{4,odd}\cos(8\pi f_c t)\sin(\Delta\phi(t))+\\ C_{5,odd}\cos(10\pi f_c t)\cos(\Delta\phi(t))+\ldots\end{array}\right]dt$$

$$\Rightarrow v_{o,odd}(n)=C'_{0,odd}\sin(\Delta\phi(n))$$

$$\Rightarrow \Delta\phi(n)=\arcsin\left(\frac{V_{o,odd}(n)}{C'_{0,add}}\right)$$

[0036] From the result, it is known that the PRI **26** integrates the second output signal to eliminate all the carrier frequency with multiple frequency terms (C_1~C_5), so as to obtain the angle demodulation signal (V_o)required, thereby obtaining the discrete-time angle demodulation output signal being a sine wave.

[0037] For example, suppose N=2 4, 6, 8 . . . , and $V_c(t)=V_{c1}(t)+V_{c2}(t)+V_{c3}(t)+V_{c4}(t)+\ldots+V_{cn}(t)$ is expanded as an equation (15):

$$\Rightarrow V_{c,even}(t)=\left[\begin{array}{c}C_{0,even}\cos(0\pi f_c t)\cos(\Delta\phi(t))+\\ C_{1,even}\cos(2\pi f_c t)\sin(\Delta\phi(t))+\\ C_{2,even}\cos(4\pi f_c t)\cos(\Delta\phi(t))+\\ C_{3,even}\cos(6\pi f_c t)\sin(\Delta\phi(t))+\\ C_{4,even}\cos(8\pi f_c t)\cos(\Delta\phi(t))+\\ C_{5,even}\cos(10\pi f_c t)\sin(\Delta\phi(t))+\ldots\end{array}\right] \tag{15}$$

After $V_c(t)$ passes through the PRI **26**, the angle demodulation signal ($V_o(t)$) expressed by an equation (16) is obtained:

$$V_{o,even}(t)\big|_{t=nT_c}=v_{o,even}(n)=\int_{(n-1)T_c}^{nT_c}[V_{c,even}(t)]\,dt \tag{16}$$

$$\Rightarrow V_{o,even}(t)=\int_{(n-1)T_c}^{nT_c}\left[\begin{array}{c}C_{0,even}\cos(0\pi f_c t)\cos(\Delta\phi(t))+\\ C_{1,even}\cos(2\pi f_c t)\sin(\Delta\phi(t))+\\ C_{2,even}\cos(4\pi f_c t)\cos(\Delta\phi(t))+\\ C_{3,even}\cos(6\pi f_c t)\sin(\Delta\phi(t))+\\ C_{4,even}\cos(8\pi f_c t)\cos(\Delta\phi(t))+\\ C_{5,even}\cos(10\pi f_c t)\sin(\Delta\phi(t))+\ldots\end{array}\right]dt$$

$$\Rightarrow v_{o,even}(n)=C'_{0,even}\cos(\Delta\phi(n))$$

$$\Rightarrow \Delta\phi(n)=\arcsin\left(\frac{V_{o,even}(n)}{C'_{0,even}}\right)$$

[0038] From the result, it is known that the PRI **26** integrates the second output signal to eliminate all the carrier frequency with multiple frequency terms (C_1~C_5), so as to obtain the angle demodulation signal (V_o) required, thereby obtaining the discrete-time angle demodulation output signal being a cosine wave.

[0039] From the abovementioned derivation, it is known that the phase variation required is modulated to baseband by multiplying the input signal by the square wave signal. Then, the PRI **26** eliminates all the carrier frequency with multiple frequency terms, thereby achieving the purpose of demodulation.

[0040] Refer to FIG. **3**A which is a simulated waveform diagram illustrating the angle demodulation signal. In order to verify that the simple circuit of the angle modulation device of the present invention is not affected by the modulation depth, each term of the following equation is set:

$$V_{PMDI}(t)=A+B\cos[\phi_c\cos(2\pi f_c t)+\Delta\phi(t)]$$

Wherein A=0.7, B=0.01,ϕ_c=2.2, f_c=100 kHz

$$\Delta\phi t)=K_{ramp}t[\text{Ramp}]'1/T_1=f_s=256f_c$$

[0041] Wherein $\Delta\phi(t)$ is set as ramp function ranging from 0 to 2π. The expected ideal waveform is a segment, and the result is $\overline{V_o}(n)=\cos(K_{ramp}nT_c)$. The simulated waveform of the angle demodulation device of the present invention is b segment, and the result is $V_{o,behavior}(n)=\cos(k_{ramp}nT_c)$. As shown in FIG. **3**A, a and b segments are almost overlapped, which means that the present invention has high precision. Refer to FIG. **3**B, which is the comparison result by changing ϕ_c. From the figures, it is observed that the demodulated result is not related to ϕ_c. As a result, the optical system can be designed more flexibly. Specifically, the traditional technology strictly limits the modulation depth (ϕ_c) to a fixed value (ϕ_c=2.2), otherwise the demodulation signal is distorted. On the contrary, the present invention can greatly reduce the difficulty for designing an optical sensing system in the front end without limiting the modulation depth. The present invention also avoids the signal distortion due to imprecise ϕ_c.

[0042] The present invention has other advantages except that the angle demodulation device of the present invention can improve the disadvantages of the traditional technology by the abovementioned derivation. Refer to FIG. **2**B and FIG. **4**. FIG. **4** is a schematic diagram illustrating a circuit using a continuous-time periodically resetting integrator. The waveform multiplier **22** receives an AC signal and multiplies the AC signal by a square wave signal whose frequency is integer times a carrier frequency to obtain a first output signal. The continuous-time filter **24** filters out a high-frequency signal of the first output signal to generate a second output signal. A continuous-time periodically resetting integrator receives the second output signal from the continuous-time filter **24**. The continuous-time periodically resetting integrator further comprises a resistor **28**, an operation amplifier **30**, a capacitor **32** and a switch **34**. The resistor **28** is coupled to the continuous-time filter **24** and an input of the operation amplifier **30**, and the capacitor **32** is coupled to the resistor **28** and an output of the operation amplifier **30**, and the switch **34** is coupled to the capacitor **32** in parallel. In operation, the second output signal charges the capacitor **32** through the resistor **28** and drives the operation amplifier **30** to perform integration. After the operation amplifier **30** performs integration, the switch **34** switches a conduction state thereof to discharge the capacitor **32** so that an output signal of the operation amplifier **30** in the PRI **26** is reset to zero, so as to avoid saturating the output signal of the operation amplifier **30** due to long-time integration.

[0043] Refer to FIG. **2**B and FIG. **5**. FIG. **5** is a schematic diagram illustrating a circuit using a discrete-time periodically resetting integrator. The waveform multiplier **22** is integrated in the discrete-time periodically resetting integrator **26**. The discrete-time periodically resetting integrator **26** further comprises a fully-differential periodically resetting integrated switched-capacitor sampling and holding circuit **36**, fully-differential correlated-double sampling switched-capacitor circuits **38** and **38'**, fully-differential periodically resetting integrated switched-capacitor circuits **40** and **40'** and an operation amplifier **42**. The fully-differential periodically resetting integrated switched-capacitor sampling and holding circuit **36** is coupled to the waveform multiplier **22**, and the fully-differential correlated-double sampling switched-capacitor circuits **38** and **38'** are coupled to the waveform multiplier **22** and an input of the operation amplifier **42**. The fully-differential periodically resetting integrated switched-capacitor circuit **40** is coupled to the fully-differential correlated-double sampling switched-capacitor circuit **38** and an output of the operation amplifier **42**. The fully-differential periodically resetting integrated switched-capacitor circuit **40'** is coupled to the fully-differential correlated-double sampling switched-capacitor circuit **38'** and the output of the operation amplifier **42**. In operation, capacitors C_{I1M} and C_{I1P} of the fully-differential periodically resetting integrated switched-capacitor sampling and holding circuit **36** sample the continuous AC signal outputted by the DC blocker **20** by switching the switches $\phi_{1,f^{s}}$ and $\phi_{2,f^{s}}$, so as to convert the continuous AC signal into a non-continuous AC signal, and transmits the non-continuous AC signal to the waveform multiplier **22**. The waveform multiplier **22** switches the switches $\phi_{1,2dfc}$ and $\phi_{2,2dfc}$ to achieve the effect of using the square wave generator and the analogous multiplier without linearity issue. The waveform multiplier **22** receives the non-continuous AC signal from the fully-differential periodically resetting integrated switched-capacitor sampling and holding circuit **36**, and multiplies the non-continuous AC signal by the square wave signal whose frequency is integer times the carrier frequency to obtain the first output signal. The capacitors C_{I1M} and C_{I1P} of the fully-differential correlated-double sampling switched-capacitor circuits **38** and **38'** calibrate an operation error of the operation amplifier **42** by periodically switching switches $\phi_{1,f^{s}}$, $\phi_{2,f^{s}}$. The continuous-time filter **24** filters out the high-frequency signal of the first output signal to generate the second output signal. Finally, the fully-differential periodically resetting integrated switched-capacitor circuits **40** and **40'** reset the discrete-time angle demodulation signal to zero. Specifically, after the integration period, the capacitor is discharged, otherwise an incorrect integration result is generated or the output signal of the operational amplifier **42** is saturated. As a result, the fully-differential periodically resetting integrated switched-capacitor circuits **40** and **40'** use two equal capacitors ($C_{I3P}$and C_{I4P}) to replace each other. When the capacitor C_{I3P} is integrated, the capacitor C_{I4P} is discharged. After a period, the capacitor C_{I4P} is integrated, the capacitor C_{I3P} is discharged for a next period. Thus, the function of periodically resetting integration is continuously performed whereby the signal is still demodulated during the capacitor is discharged.

[0044] Using the discrete-time PRI has a lot of advantages. 1. Resistors are not used, and reduce capacitance to design an integrated circuit (IC). 2. More deeply tolerate the variation for fabrication process, voltage, and temperature, and precisely design the frequency response of the PRI to improve the yield of a chip. 3. The problem that the traditional technology is hard to achieve the best linearity by using an analogous multiplier and a square wave generator is resolved. And, the waveform multiplier **22** replaces the two analogous circuits of the traditional technology by integrating the PRI **26** and the waveform multiplier **22**, so that the demodulation circuit possesses well linearity.

[0045] Refer to FIG. **2**B and FIG. **6**. FIG. **6** is a flowchart of the present invention. In Steps **S10**, multiply an AC signal by a square wave signal whose frequency is integer times a carrier frequency to obtain a first output signal, wherein the square wave signal is generated by the square wave generator. In Step **S12**, the continuous-time filter **24** filters out the high-frequency signal of the first output signal to generate a second output signal. Finally, the PRI **26** integrates the second output signal to eliminate all the carrier frequency with multiple frequency terms to obtain an angle demodulation signal, and then resets an output signal of the operational amplifier therein, namely a discrete-time demodulation output signal, to zero, and continues repeating Step **S10**, thereby continuing performing the function of periodically resetting integration.

[0046] In conclusion, the present invention uses periodically resetting integration to reduce circuit elements required and effectively obtains the angle modulation signal with high precision. For example, analogous multipliers, frequency multipliers, continuous-time analogous band-pass filters and phase lock circuits of the traditional technology are omitted. Further, the simple circuit of the present invention can greatly reduce the difficulty for designing an optical sensing module in the front end without limiting the modulation depth, effectively resolve the problem of linearity and signal distortion of circuits, and reduce capacitances used whereby an integrated circuit can be realized. Therefore, the present invention achieves a small volume, high speed, high sensitivity, high reliability, high performance and high condition-adapting properties.

[0047] The embodiments described above are only to exemplify the present invention but not to limit the scope of the present invention. Therefore, any equivalent modification or variation according to the shapes, structures, features, or spirit disclosed by the present invention is to be also included within the scope of the present invention.

What is claimed is:

1. A periodically resetting integration angle demodulation device comprising:

a waveform multiplier receiving an angle modulation signal, multiplying said angle modulation signal by a square wave signal whose frequency is integer times a carrier frequency to obtain a first output signal;

a continuous-time filter coupled to said waveform multiplier, receiving said first output signal, and filtering out a high-frequency signal of said first output signal to generate a second output signal; and

a periodically resetting integrator (PRI) coupled to said continuous-time filter, receiving said second output signal, integrating said second output signal to eliminate all said carrier frequency with multiple frequency terms to obtain an angle demodulation signal, and then resetting a discrete-time demodulation output signal to zero.

2. The periodically resetting integration angle demodulation device according to claim **1**, wherein said continuous-time filter is a continuous-time low-pass filter or a continuous-time band-pass filter.

3. The periodically resetting integration angle demodulation device according to claim **1**, further comprises a direct-current (DC) blocker coupled to said waveform multiplier, receiving an angle modulation signal to filter out a direct-current (DC) signal of said angle modulation signal, and then sending out an alternative-current (AC) signal to said waveform multiplier.

4. The periodically resetting integration angle demodulation device according to claim **3**, wherein said DC blocker coupled to an optical sensing system, and said optical sensing system sends out said angle modulation signal to said DC blocker.

5. The periodically resetting integration angle demodulation device according to claim **1**, further comprises a square wave generator coupled to said waveform multiplier, and said square wave generator sends out said square wave signal to said waveform multiplier.

6. The periodically resetting integration angle demodulation device according to claim **1**, wherein said periodically resetting integrator is a continuous-time periodically resetting integrator or a discrete-time periodically resetting integrator.

7. The periodically resetting integration angle demodulation device according to claim **6**, wherein said continuous-time periodically resetting integrator further comprises a resistor, an operation amplifier, a capacitor and a switch, and said resistor is coupled to said continuous-time filter and an input of said operation amplifier, and said capacitor is coupled to said resistor and an output of said operation amplifier, and said switch is coupled to said capacitor in parallel; said second output signal charges said capacitor through said resistor, and after said operation amplifier performs integration, said switch switches a conduction state thereof to discharge said capacitor.

8. The periodically resetting integration angle demodulation device according to claim **6**, wherein said waveform multiplier is integrated in said discrete-time periodically resetting integrator, and said discrete-time periodically resetting integrator further comprises a fully-differential periodically resetting integrated switched-capacitor sampling and holding circuit, fully-differential correlated-double sampling switched-capacitor circuits, fully-differential periodically resetting integrated switched-capacitor circuits and an operation amplifier, and said fully-differential periodically resetting integrated switched-capacitor sampling and holding circuit is coupled to said waveform multiplier, and said fully-differential correlated-double sampling switched-capacitor circuits are coupled to said waveform multiplier and an input of said operation amplifier, and said fully-differential periodically resetting integrated switched-capacitor circuits are respectively coupled to said fully-differential correlated-double sampling switched-capacitor circuits and an output of said operation amplifier; and said waveform multiplier receives a non-continuous alternative-current (AC) signal from said fully-differential periodically resetting integrated switched-capacitor sampling and holding circuit, and multiplies said non-continuous AC signal by said square wave signal to obtain said first output signal, and said fully-differential correlated-double sampling switched-capacitor circuits calibrate an operation error of said operation amplifier by periodically switching switches, and said continuous-time filter filters out a high-frequency signal of said first output signal to generate said second output signal, and said fully-differential periodically resetting integrated switched-capacitor circuits reset an output signal of said operation amplifier to zero.

9. A periodically resetting integration angle demodulation method comprising steps of:

multiplying an angle modulation signal by a square wave signal whose frequency is integer times a carrier frequency to obtain a first output signal;

filtering out a high-frequency signal of said first output signal to generate a second output signal; and

integrating said second output signal to eliminate all said carrier frequency with multiple frequency terms to obtain an angle demodulation signal, and then resetting a discrete-time demodulation output signal to zero, and continuing repeating said step of multiplying said angle modulation signal by said square wave signal to obtain said first output signal.

* * * * *