

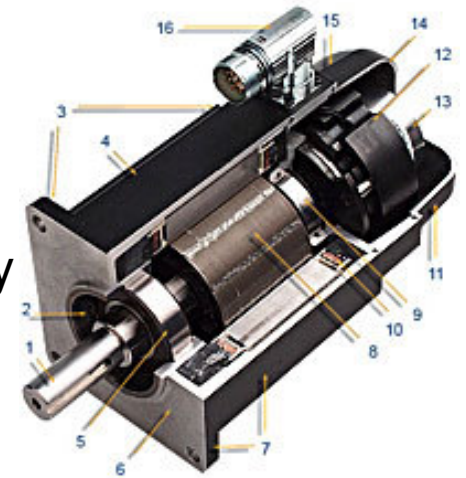
# Sensorless PMSM Technology

© Copyright 2010 Servotronix Motion Control Ltd.

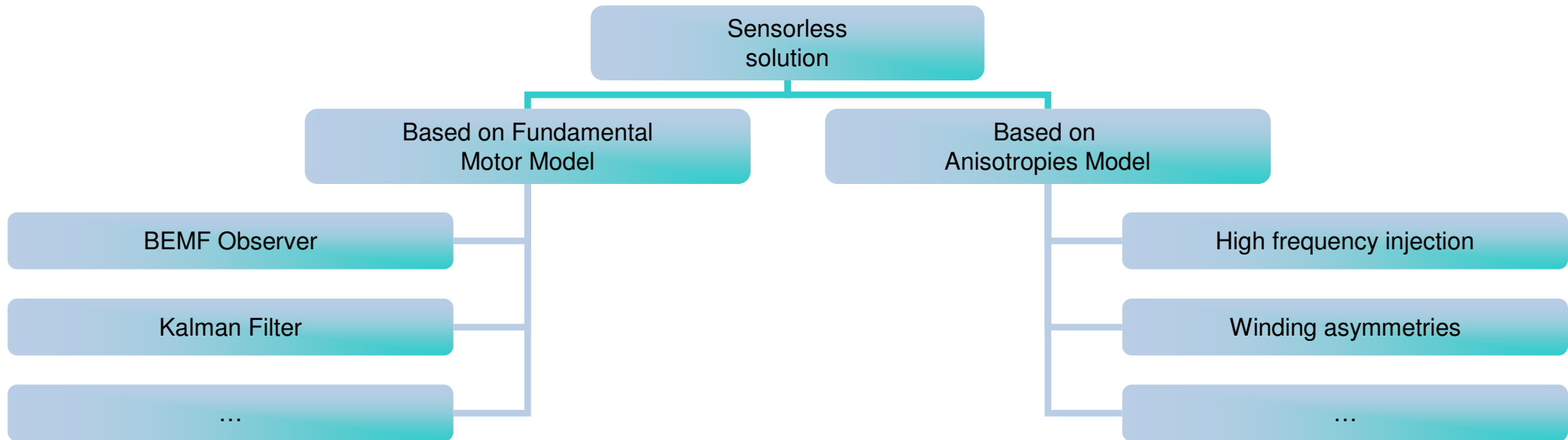
Servotronix Motion Control Ltd.  
21C Yagia Kapayim • P.O.B. 3919 • Petach Tikva 49130 • Israel  
Tel: +972.3.9273800 • Fax: +972 3 922 8075  
[www.servotronix.com](http://www.servotronix.com) • [info@servotronix.com](mailto:info@servotronix.com)

# Sensorless ?

- Proper operation of a PMSM requires aligning the commutation phase with motor shaft position.
- Many applications use an external sensor for this purpose. These sensors add cost weight and reduce the reliability of the system.
- Sensorless control means commutation without the need for position sensor, as well as closing velocity and/or position control loops.
- Allows reducing cost and HW complexity
- Increased mechanical robustness and noise immunity (no feedback related noises)
- May be used as redundant position\speed estimation for safety purposes
- High performance control in difficult environments



# Sensorless Solutions



## Fundamental

- Simple solution
- Fails at low speeds (2~10Hz electrical)
- No position estimation at stand still

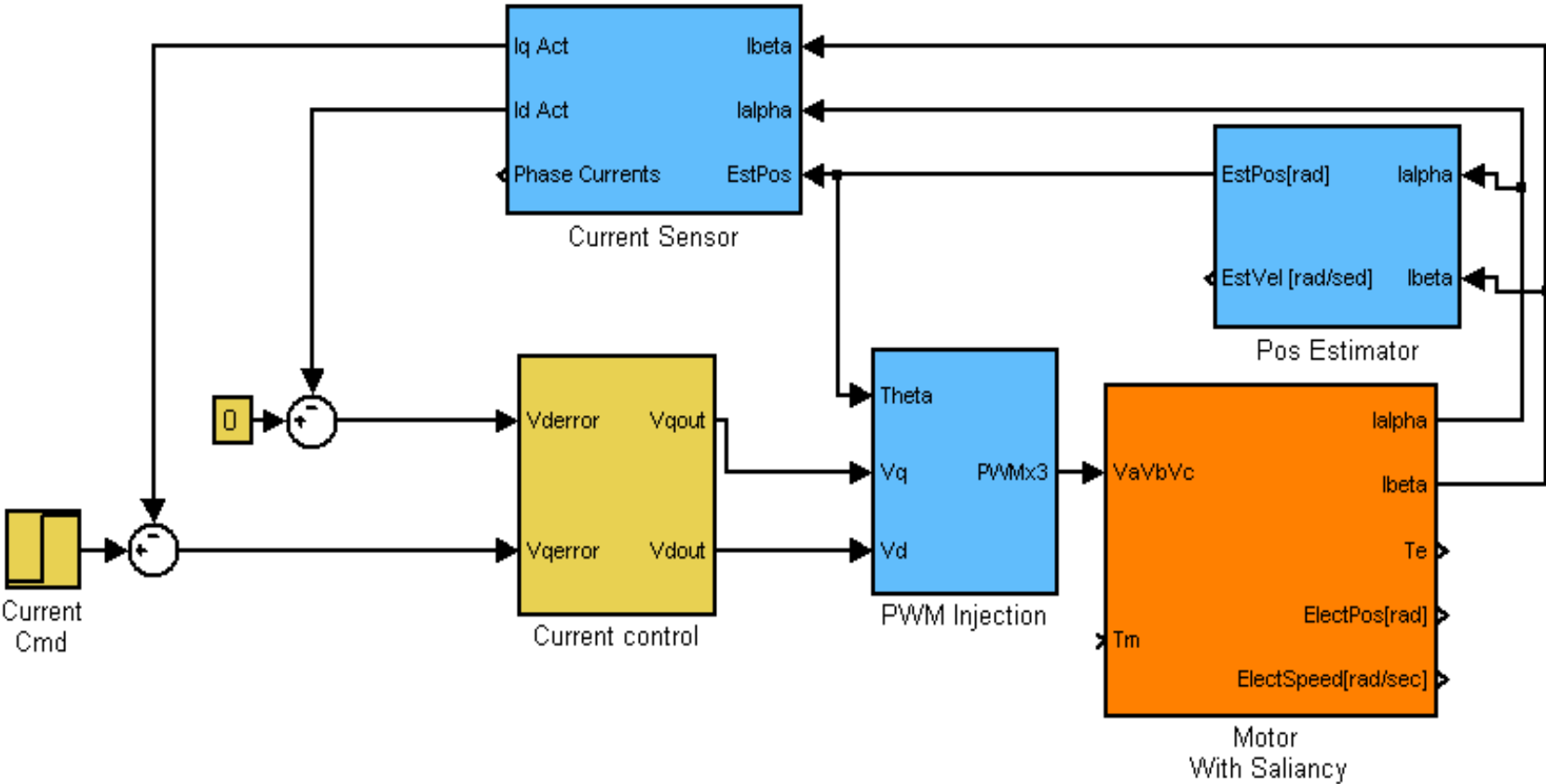
## Anisotropies

- Requires anisotropies\saliency
- May allow low and zero speed position
- Independent of motor parameters

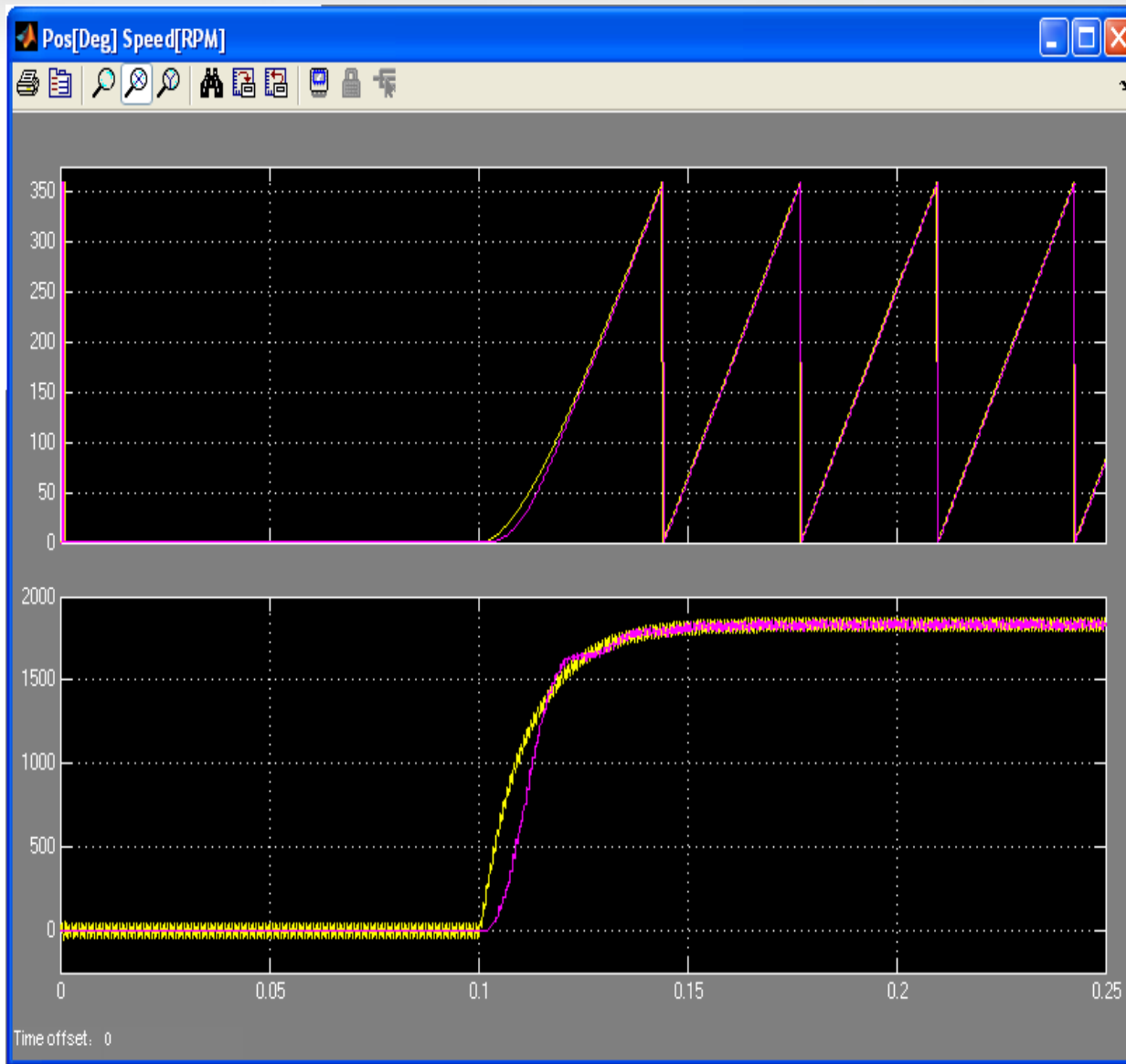
# Servotronix solution

- **Utilizes high frequency injection for position estimation starting from zero speed**
  - High frequency signal is injected at the drive's PWM output.
  - Requires VERY little saliency ( $L_d \neq L_q$ )
  - Demodulation performed on phase currents. It is independent of current amplitude variations
  - The injected signal limits the available bus voltage for control
- **Utilizes a fundamental solution for high speeds**
- **Seamless transition between the two methods**

# Matlab Model



# Matlab Simulation

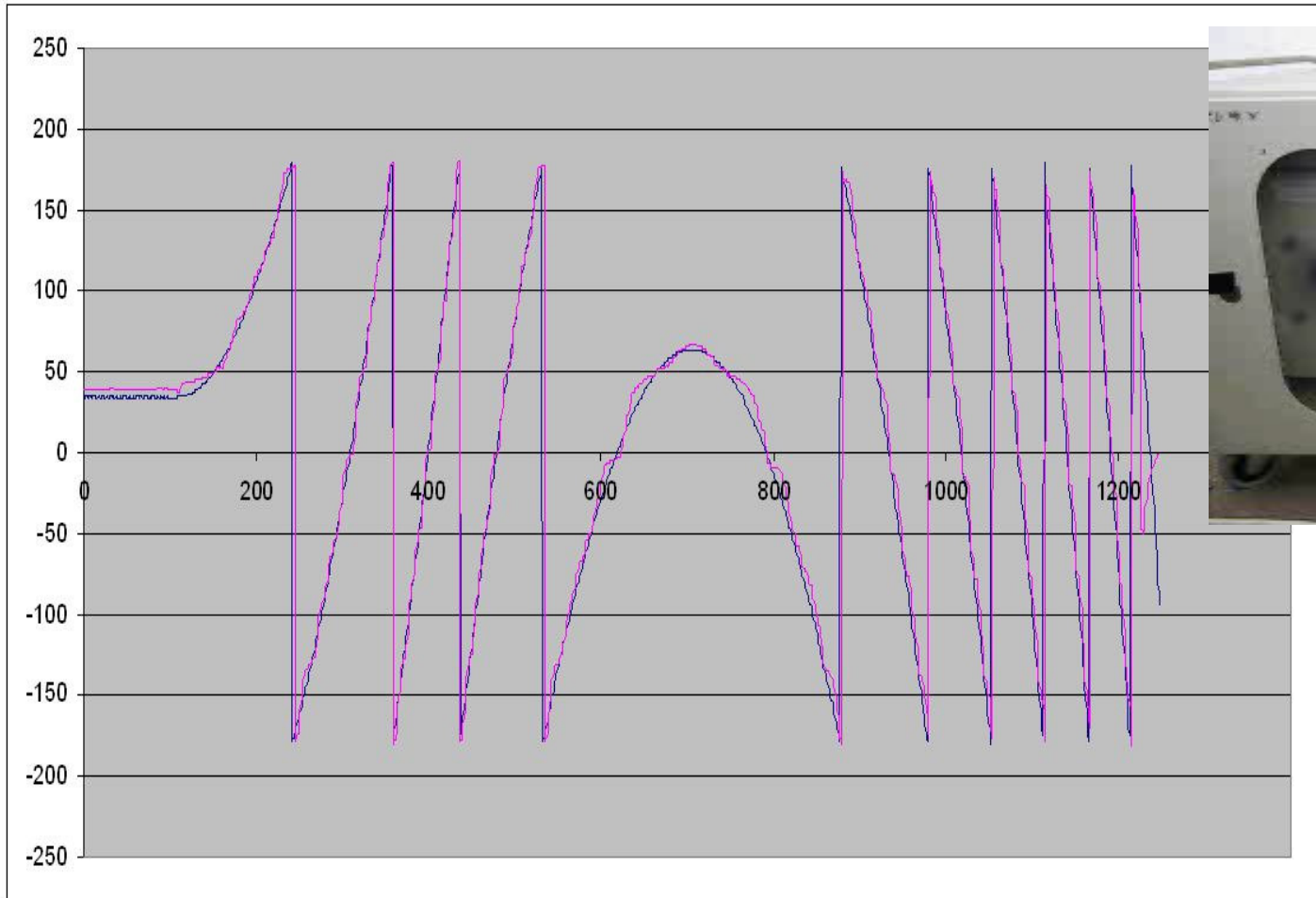


- Current loop step command
- Motor accelerating from zero speed
- Steady state error: ~4 electrical degrees
- Max error (acceleration) : ~12 electrical degrees

Yellow – Resolver

Red - Sensorless

# Actual results



## Drive record – stand still and plug reversal. Velocity loop

- Max abs(error)  $10^{\circ}$  electrical – at acceleration phase (=1.5% torque reduction affect)
- Seamless transition

# Applications

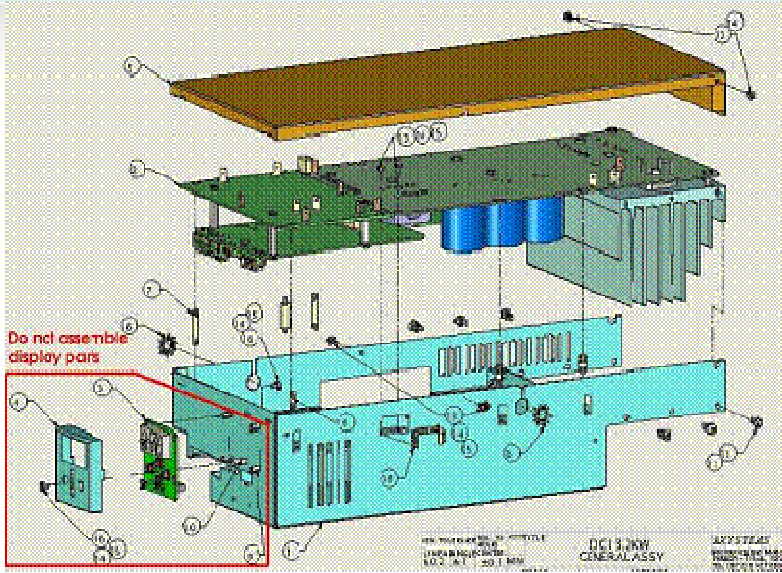
- Zero cost product safety feature : allows controlling an axis after an external feedback device failure
- May be used as a redundant feedback in military and medical applications
- Brushless UAV motors

# A/C controller – A Sensorless product example

- Variable speed Inverter A\C
- 1 Outdoor unit 3.2KW
- Up to 4 indoor units
- Servotronix solution
  - Total A/C control solution
  - Sensorless compressor control (Sinusoidal commutation) (outdoor unit)
  - Fan control
  - Additional A\C – related I/O's
    - Include Power Factor Correction
- More than 20,000 units in the field



# A/C controller – A Sensorless product example



- Cost effective solution – single DSP does it all
- Software is divided into two layers:
  - Low level – compressor variable speed control, Fan variable speed control, stepper valves control , I/O management
  - Upper level – A/C control application, Design by the customer , implementation by Servotronix