Application of SR Motors

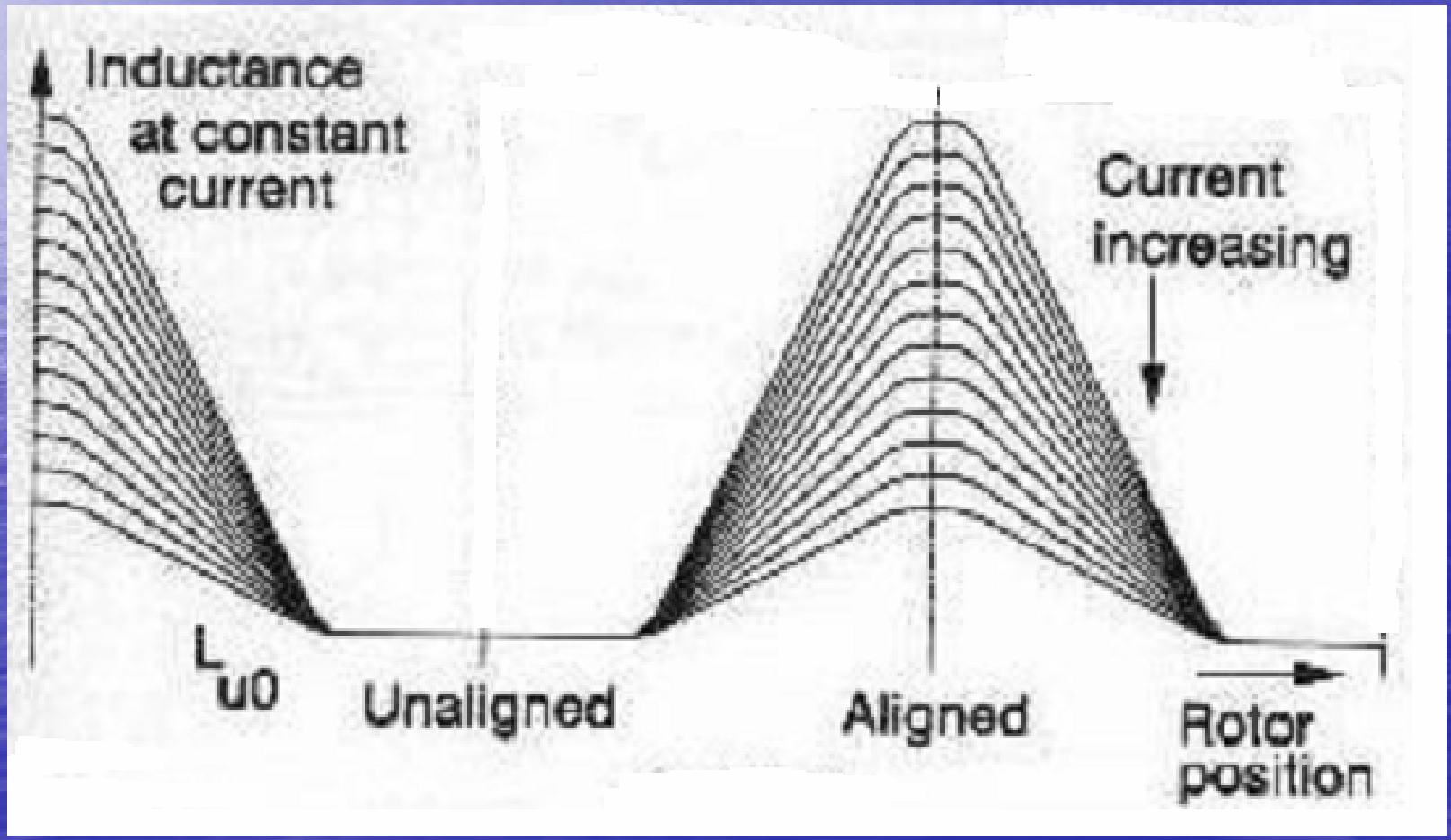
George Holling
Rocky Mountain Technologies Inc.
PO 1595, Riverton, UT 84065
ph.: (801) 446-8403
e-mail: George.Holling@RockyMountainTechnologies.com

Overview

- The SR motor – physics and characteristics
- Where to apply SR Motors
- Pittfalls when applying SR motors
- The future

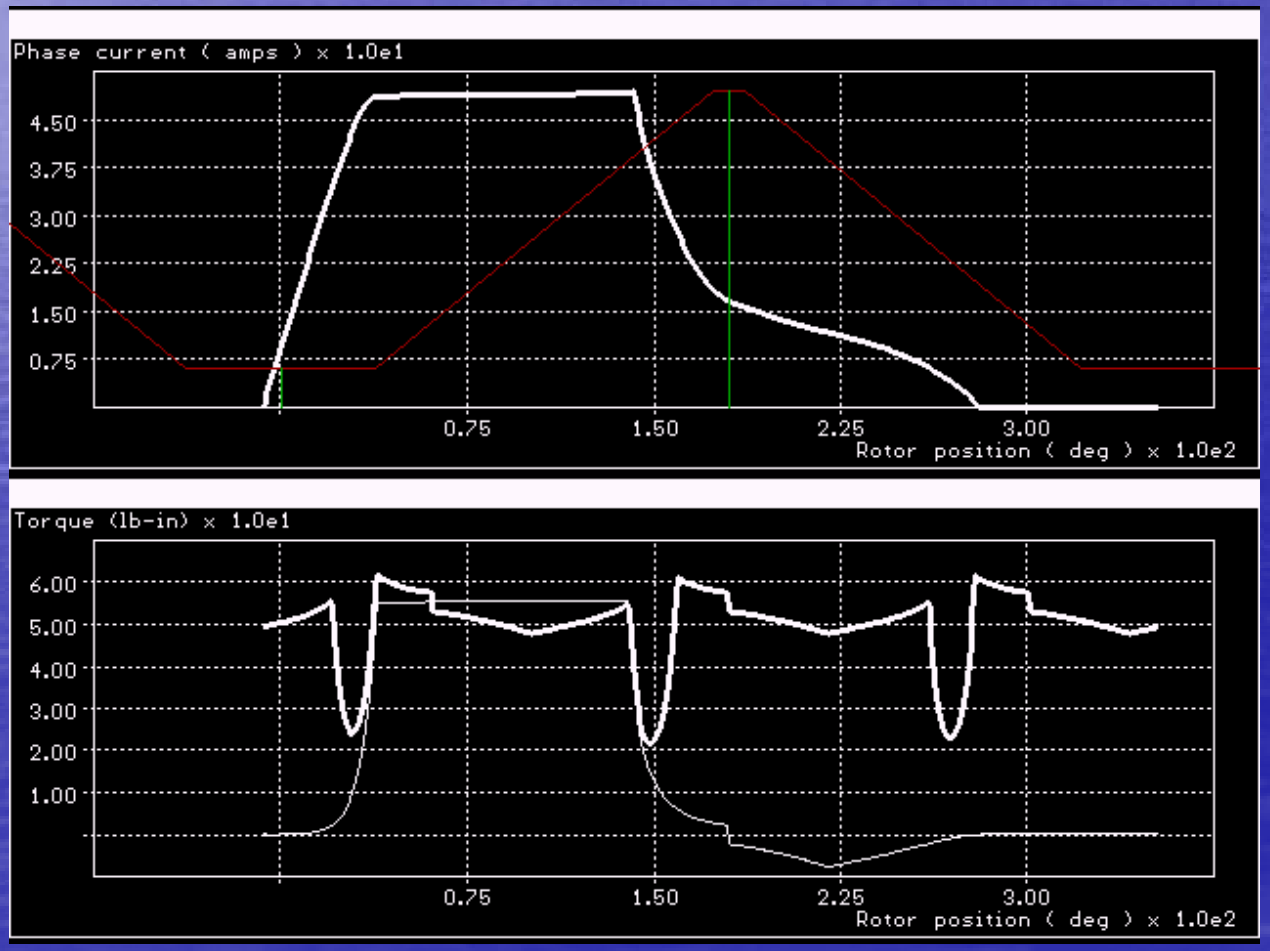
The SR motor

- the torque profile



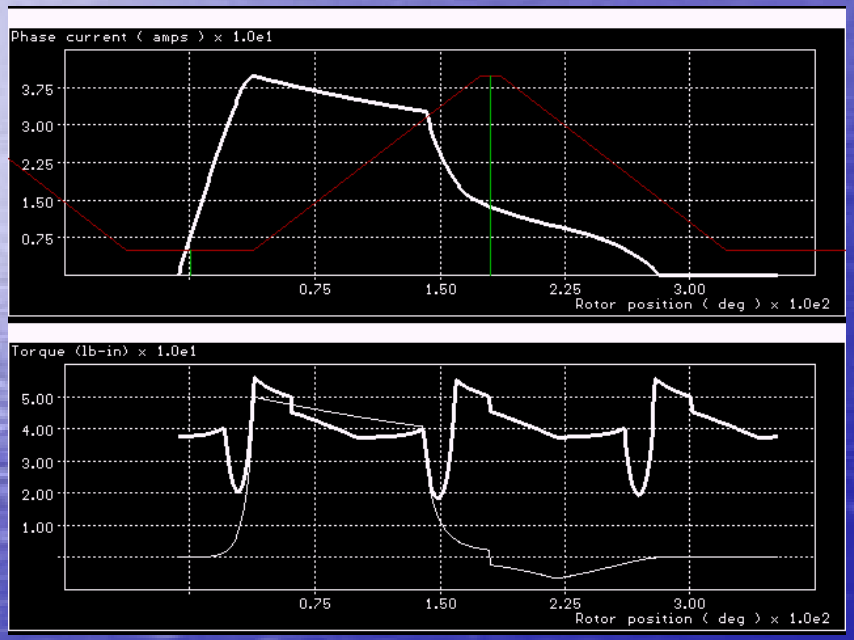
The SR motor

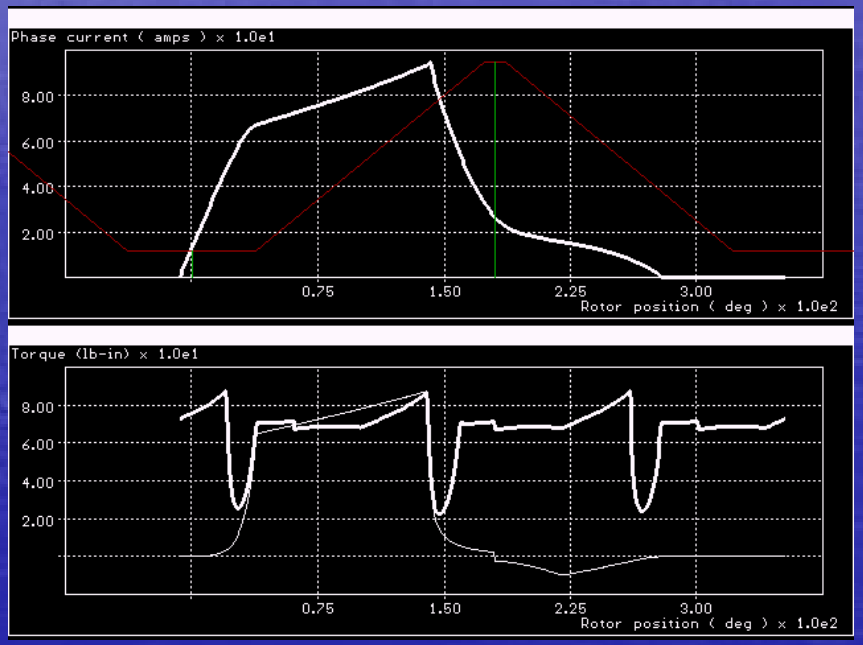
- the torque profile – at base speed



The SR motor

- the torque profile – at base speed





efficiency 90.4% (above)

efficiency 87.6% (below)

The SR motor

- the torque profile
  - changes with speed and load
  - changes with the motor geometry
    - rule of thumb: more phases less ripple
    - 4 phase vs. 3 phase motors

The SR motor

- audible noise
  - audible noise and torque are related
    - reduced torque ripple -> reduced audible noise
    - more phases -> less noise
    - short flux path -> less noise
  - reducing audible noise results in
    - reduced performance, or
    - increased cost

The SR motor

- size and geometry
  - it appears that SR motors require certain geometries to be efficient
  - length = diameter appears to be good geometry
    - pancake motors appear less desirable
    - Very small diameter motor (<70mm) appear less desirable
  - low number of poles per phase appears to improve performance
    - exceptions exist
    - thermal considerations

The SR motor

- efficiency
  - the efficiency of the SR motor is maximized at its rated load
  - while the SR motor will operate efficiently over a wide speed range it will not do so over a wide load range

Applying the SR motor

- Advantages (perceived):
  - no magnets
    - cost
      - favors large motors
    - contamination
      - may not be significant in most applications
    - internal and ambient temperature
      - subject to magnet materials
      - sensorless SR motors can potentially operate in high temperature environments
  - excitation waveform
    - no waveform shaping
      - generic, simple, low cost control
    - hall/optical sensor are very suitable
      - rugged, low cost solutions
      - hall sensors are more rugged that optical sensors
    - very good performance at high speeds

Applying the SR motor

- Advantages (perceived):
  - ease of sensorless control
    - large inherent inductance changes
      - efficient algorithms to determine sensorless position feedback
    - low cost
      - cost of electronics less that sensors
      - no sensor wiring
    - no feedback devices on the motor
      - small size
      - high temperature environments
    - reliability
      - no sensor wiring

Applying the SR motor

- Disadvantages (perceived):
  - small airgap
    - contamination
    - bearings and materials
    - assembly cost
  - audible noise
  - new technology
    - lack of infrastructure
    - lack of experience
    - inherent risk

Applying the SR motor

- applications should focus on those areas where the SR is clearly superior
  - high efficiency at rated loads
    - pumps
    - compressors
    - fans
  - ease of sensorless feedback
    - highly efficient, hermetically sealed compressors
  - high temperature ambient environments
    - aerospace
    - drilling
  - cost sensitive, large motors with high power density
    - traction drives
    - linear SR motors
  - good power density and efficiency at high speed
    - high speed compressors
    - turbine starter/generators

Applying the SR motor

- Single phase SR motors
  - Specialty applications
    - generators
    - electric assisted bike

Applying the SR motor

- Two phase SR motors
  - low starting torque
  - audible noise
    - some patented technologies perform better
  - most suited for unidirectional operation
    - bi-directional operation is possible under certain conditions
  - typical applications include
    - blower
    - fan
    - pump
    - electric assist

Applying the SR motor

- Three phase SR motors
  - variable speed applications
  - bi-directional operation
  - personal note:
    - least likely to succeed

Applying the SR motor

- Four phase SR motors
  - fault tolerant operation
    - aerospace
    - fuel pump
    - drilling
  - low cost alternative
    - traction drives
  - high speed motor
    - generator

Applying the SR motor

- More than four phase SR motors
  - Specialty applications

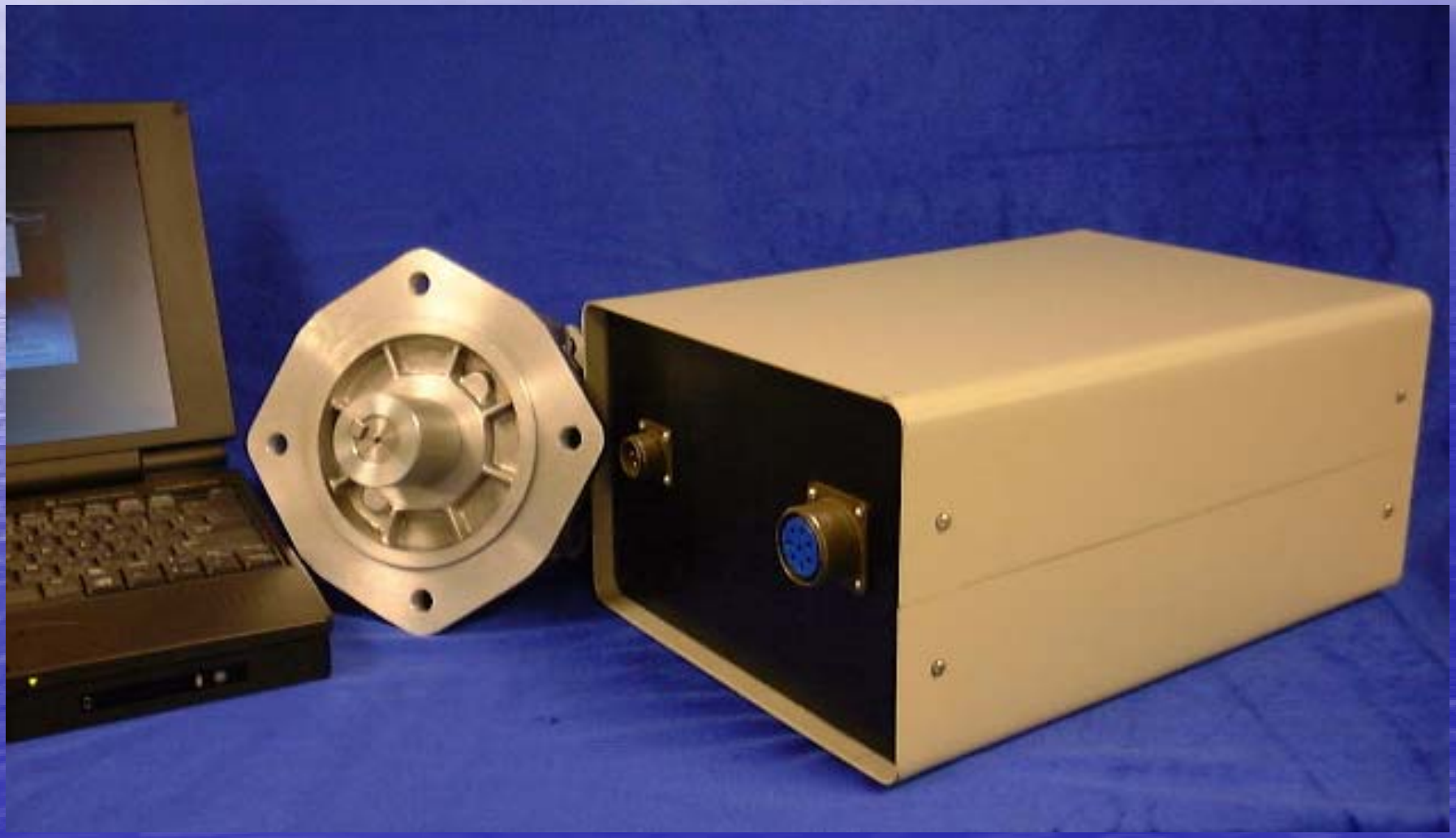
Pittfalls when applying SR motors

- operation with suboptimal firing angles
  - power and efficiency can be significantly reduced
  - audible noise can be significantly higher
  - heating losses can be significantly higher
- feedback sensors
  - Hall sensor can reduce performance
    - duty cycle distortions reduce performance
    - sensors and magnet wheels are subject to heat related failure
  - Optical sensors can reduce performance
    - duty cycle distortions reduce performance
    - sensors and magnet wheels are subject to heat related failure
    - sensors are subject to contamination

Pittfalls when applying SR motors

- operation significantly below rated power
  - efficiency can be VERY poor
- production variations
  - production variations can be significantly larger than those of BLDC motors
  - high quality motor steels and good production methods are mandatory

Examples of SR motors & drives



Sensorless SR drive

Examples of SR motors & drives

SR Production Motor

Examples of SR motors & drives

SR Traction Drive

The future of SR motors

- SR motor applications are proliferating
- many OEM develop custom SR products in-house due to lack of "off the shelf" components
- SR motors will most likely penetrate selected niche applications at the OEM level