Why Frequency Inverter?

- Possibility for infinite speed modulation with 3-phase asynchronous motors
  - stepless capacity regulation
  - Capacity increase by operation higher than synchronous speed (trans-synchronous speed)
- Soft Start
  - significant reduction of starting current with full motor torque
    - ➔starting current 100 to 160 % of RLA
    - ➔no start unloader required
  - reduced mechanical loading on compressor
  - minimized danger of oil and liquid slugs during start-up

The Use of Frequency Inverters
with BITZER Screw Compressors

Function of Frequency Inverter

- **Frequency Modulation**

$$n_{Motor} = \frac{f \times 60}{\text{No. of Pole Pairs}} - n_{Schlupf}$$

- **Ratio Voltage / Frequency U / f ⇨ constant**
  - reduction of frequency leads to
    ⇨ lower winding resistance

    Consequences if no voltage adaption
    ⇨ increasing motor current
    ⇨ magnetic saturation of motor iron
    ⇨ resulting in overheating

The Use of Frequency Inverters with BITZER Screw Compressors

Requirements on Motor Characteristics and Layout of Frequency Inverter

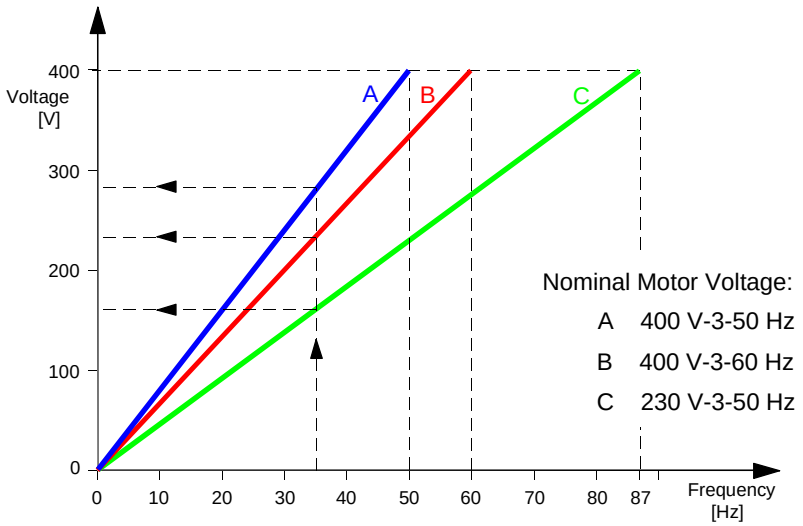
- **Positive Displacement Compressors ⇨ Torque* Remains "Constant" with Speed Change**
  - Power absorbed changes approx. proportionally in relation to the speed

$$M = \frac{P \times 9{,}55}{n\ (1/min)}\ [Nm]$$

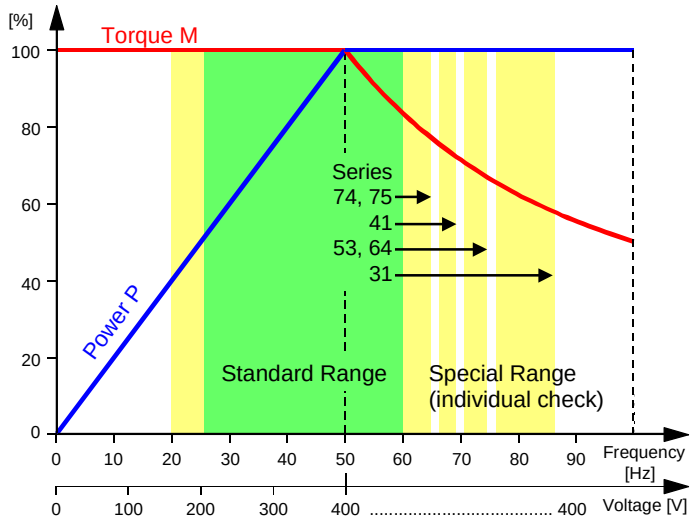
$$P = U \times I \times \sqrt{3} \times \cos\varphi\ [W]$$

* with fans and pumps **M** changes in square to **n**

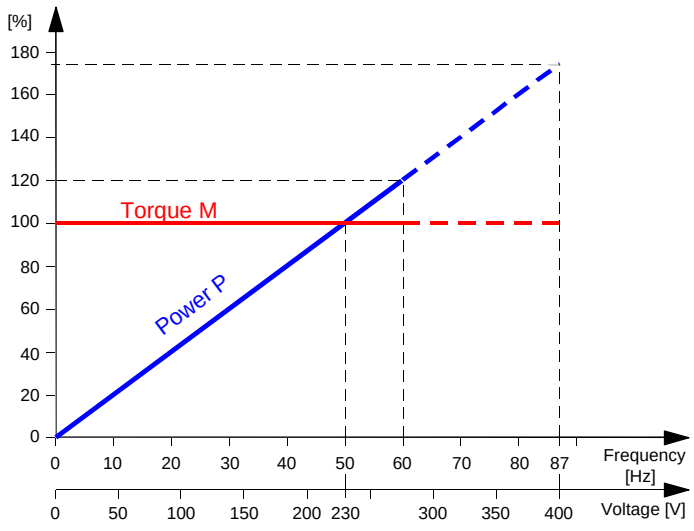
Frequency Inverter -- Voltage & Frequency with Constant Torque (Supply 400 V-3-50 Hz)



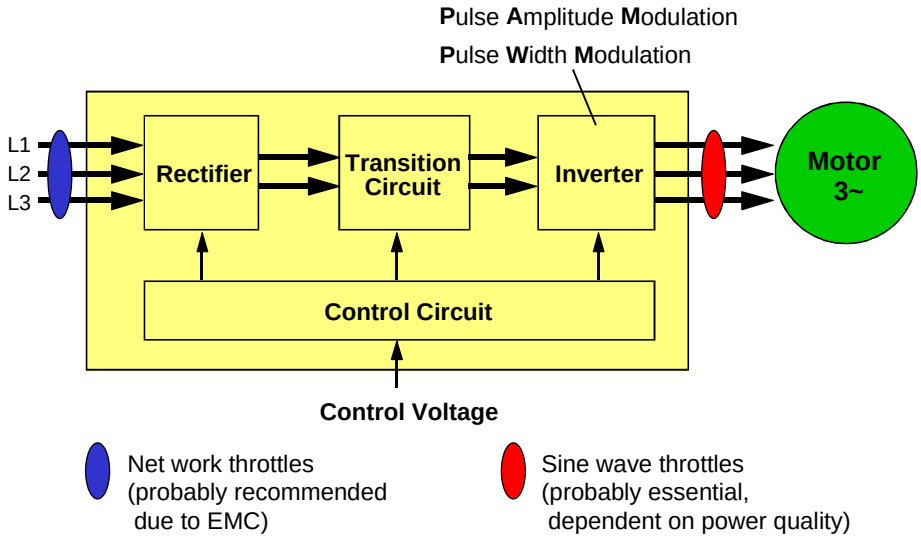
Frequency Inverter – Power & Torque with Winding Layout 400V-3-50 Hz



Frequency Inverter – Power & Torque with Winding Layout 230V-3-50 Hz



Frequency Inverter – Basic Priciple



Net work throttles (probably recommended due to EMC)

Sine wave throttles (probably essential, dependent on power quality)

The Use of Frequency Inverters with BITZER Screw Compressors

Semi-Hermetics + Hermetics - General Selection Criteria (1)

- Frequency and Speed Ranges
  - Standard range 25 to 60 Hz / 1450 to 3500 RPM
  - Extended range (individual investigation required!!)
    - ➔ HS.53 & HS.64 HSKC 64 20 to 75 Hz / 1200 to 4500 RPM
    - ➔ HS.74 HSKC74 & CS75 20 to 67 Hz / 1200 to 4000 RPM
    - ➔ VSK 31 20 to 87 Hz / 1200 to 5200 RPM
    - ➔ VSK 41 20 to 70 Hz / 1200 to 4200 RPM

Semi-Hermetics + Hermetics – General Selection Criteria (2)

- Critical Frequency and Speed Ranges
  - dependent on operating conditions resonances may occur in certain frequency (speed) ranges
    ➔Compressor & Pipe lines
  - Examination by tests under real conditions
    ➔critical frequency ranges must be "jumped" by adequate programming of the inverter

Semi-Hermetics + Hermetics – General Selection Criteria (3)

- Motor Selection / Voltage & Frequency for 50 Hz power supply
  - Standard Motors (400V-3-50Hz) --
    Suitable up to **60 Hz** (400V) if 25 % spare capacity at 50 Hz
  - Special Motors (400V-3-60 Hz or 230V-3-50 Hz)
    for trans-synchronous operation with full motor load

Consequence: Operation not possible with direct supply (400V / 50Hz) – larger inverter required

Note! Dependant on inverter design and quality of sine wave, additional spare capacity for the motor may be needed

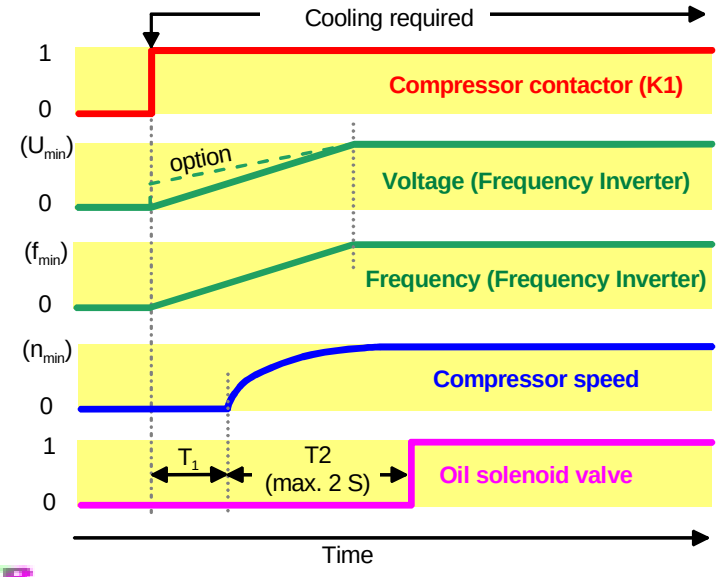
Semi-Hermetics + Hermetics – General Selection Criteria (4)

- Motor protection

  Due to the harmonics created by the inverter the protection unit INT 389R is limited in its operating range (will trip with low frequency).

  Alternative system:
  - INT 69VSY-II combined with additional anti short cycling timer
  - possibly additional external overloads (dependent on inverter overload protection system)

- Control of oil injection solenoid valve
  - ensure energizing of the solenoid two seconds after start
    - ➔too early oil supply leads to blocking of the compressor
    - ➔too long delay provokes mechanical damage & shaft seal leakage

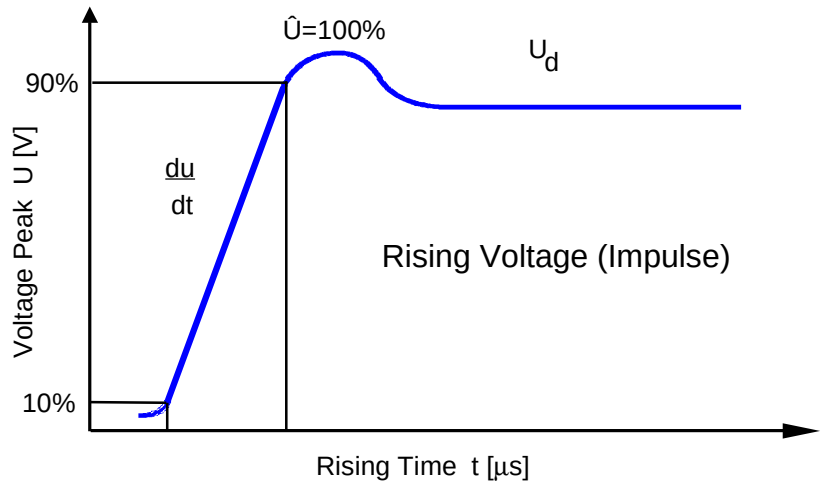


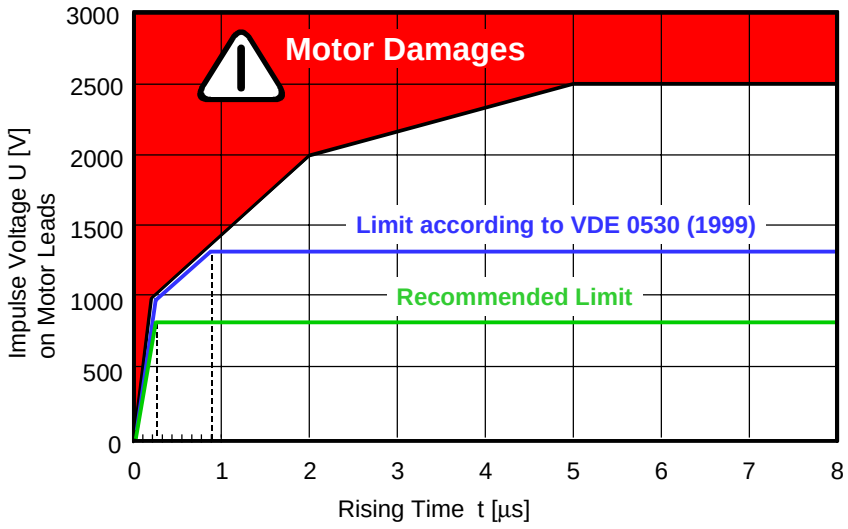
The Use of Frequency Inverters with BITZER Screw Compressors

Special Requirements on Frequency Inverter and Connection Wires

- Voltage magnitude due to diagram
  - Consider length of wire in manufacturer's documentation!!
  - Possible problems: Motor noise / Insulation failures
- Exceeded voltage magnitude: Use of sine wave throttles
- Inverter selection for "1.6 times max. torque" (one minute)
- In case the inverter can be programmed for "Optimized Energy Consumption" an adaption to the real motor efficiency is needed
- Screened wires (incl. grounding) from inverter to motor

The Use of Frequency Inverters with BITZER Screw Compressors





Open Type Compressors – General Design Criteria (1)

- Speed ranges OS.53
  - Standard range 1450 to 4500 RPM
  - Extended range 1200 to 4500 RPM
    - ➔individual investigation required !!!
- Speed ranges OS.74
  - Standard range 1450 to 4000 RPM
  - Extended range 1200 to 4000 RPM
    - ➔individual investigation required !!!

Open Type Compressors – General Design Criteria (2)

- Critical Frequency and Speed Ranges
  - dependent on operating conditions resonances may occur in certain frequency (speed) ranges
    - ➔Compressor & Pipe lines
    - ➔Coupling (observe moment of inertia & natural frequency)
    - ➔Belt drive (possibly idle pulley required)
  - Examination by tests under real conditions
    - ➔critical frequency ranges must be "jumped" by adequate programming of the inverter
- Control of oil injection solenoid valve
  - ensure energizing of the solenoid two seconds after start (see further information on slide No. 8)

The Use of Frequency Inverters
with BITZER Screw Compressors

Open Type Compressors – Selection Criteria for Motor and Inverter

- Motor selection according to manufacturer's requirements
  Special Criteria:
  - Air flow is not in proportion to the motor speed
    - ➔increased power with trans-sychronous operation
    - ➔possibly insufficient cooling with sub-synchronous operation
- Motor Selection / Application Range
  - dependent on inverter design and quality of sine wave additional spare capacity for the motor may be required
- Inverter selection according to specification of motor and inverter manufacturers