

# Drivecon's VF61 S/V Flux Vector AC Drive

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A number of advancements have been made in the AC motor control field in recent years. One of the most notable is the wide-spread application of the AC flux vector controller. The advent of this technology has been brought about through the development of high capacity microprocessors which are capable of churning out millions of computations per second. Without such processors vector drives would suffer from slow response, high cost and generally poor performance. Through the use of 32 bit D.S.P. (Digital Signal Processor) and the latest IGBT technology Drivecon can offer high performance open and closed loop flux vector drives. Selecting an optimum motor will provide precise response at a fraction of the cost of servo or brushless systems, especially in high capacity sizes. All this performance capability is made possible with the use of a standard vector duty AC induction motor. The flux vector control can be considered the AC equivalent to a DC machine. Typical applications for flux vector controls are classical "DC only" never approached by an AC machine such as:

- \* Hoists and winches
- \* Traction drives
- \* Center driven re/unwinders
- \* Dynamometers
- \* Machine tools
- \* Elevator drives
- \* Test equipment
- \* Torque regulators
- \* Web processing

Advantages of AC flux vector controls versus DC controls are numerous due to the simplicity and ruggedness of the prime mover; 3 phase induction motors. Some basic advantages are:

- \* Ideal for upgrades and retrofits
- \* Wider speed range of operation
- \* Higher speeds of operation exceeding 10,000 RPM
- \* No brushes, reduced maintenance
- \* Quicker response due to lower rotor inertias
  - \* Higher output to size ratios
  - \* Full torque at zero speed
  - \* Cooler operating motors
- \* Speed or torque control mode
- \* Standard NEMA frame motors



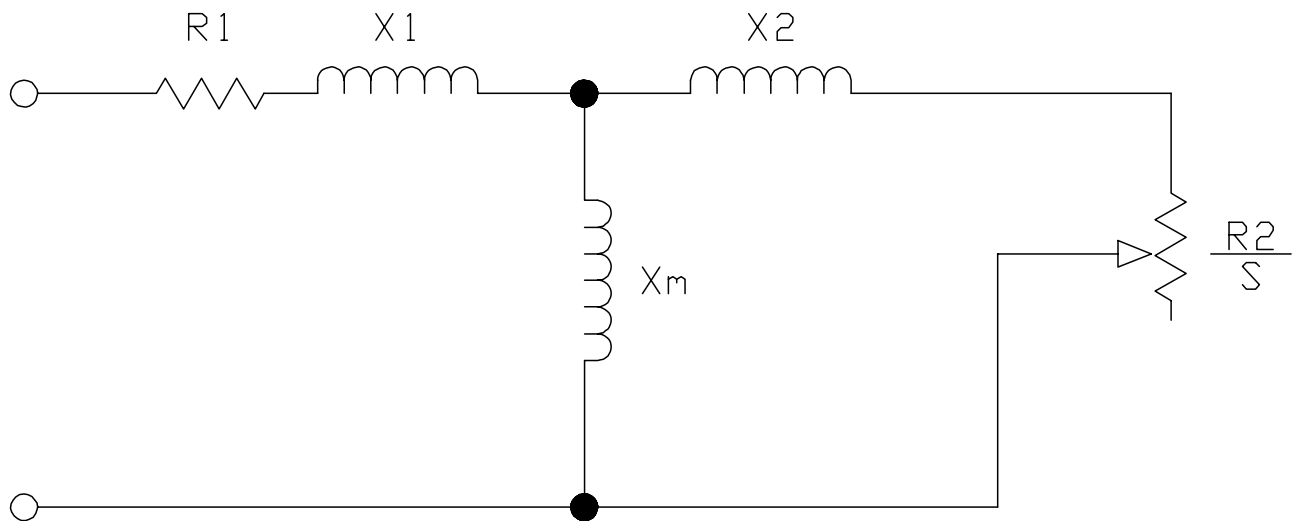
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## Principles of Operation

A DC motor's armature and field flux relationship is controlled by the brush gear and commutator. Since the AC motor produces an induced secondary voltage and obviously has no commutator, some mechanism must be used to control torque producing flux vectors. This is where the DSP proves its usefulness. Through real time data feedback of motor speed by encoder or induced feedback, motor current feedback, and stored values of the motor equivalent circuit parameters, the flux vector drive will calculate and control the stator excitation. Figure 1 shows the motor's equivalent circuit and parameters.

Induction Motor Equivalent Circuit.

Figure 1



Induction motor equivalent circuit per phase.

Variables:

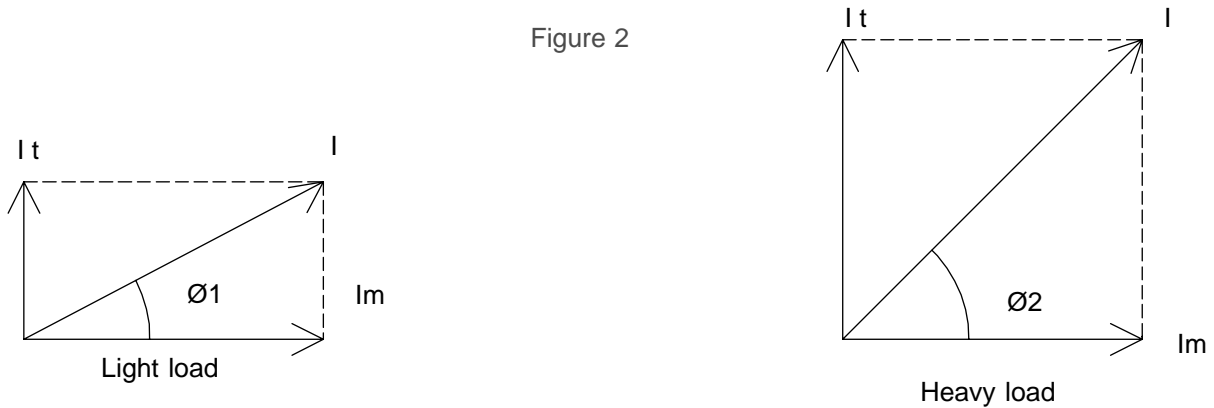
- $R_1$ = Primary resistance
- $X_1$ = Primary inductance
- $R_2$ = Secondary resistance
- $X_2$ = Secondary inductance
- $X_m$ = Mutual inductance or leakage inductance
- $S$ = Slip

These parameters must be either given by the motor manufacturer or measured by the drive during auto-tuning process. There is generally tolerable error margins of 5% between actual values and measured values. Drivecon's VF61 offers the most advanced and easiest tuning processes available. Just connect your motor, enable tuning process, and hit the jog button once. That's it! Tuning will be complete in about 60 seconds.

## Inverter Application Note

Two components of motor current are precisely controlled as shown in Figure 2. The magnetization current remains constant for all load conditions. Torque producing current will vary with load conditions.

Figure 2



$I_m$  = Magnetization current  
 $I_t$  = Torque current  
 $I$  = Motor current  
 $\theta_1, \theta_2$  = Phase angle

Notice magnetization current doesn't change with load, however torque current increases with increased load.

Standard AC variable frequency drives can never match the performance of DC machines or AC flux vector controls. A standard AC drive provides an effective means of varying the speed of AC motors, but cannot control the torque output of the motor. The only means of torque control is the familiar V/F boost adjustment. This is an open loop voltage bias gain adjustment which increases the output torque of the motor at specific operating frequencies or over the entire frequency range.

Increases of the V/F ratio leads to excessive motor temperature rise and current draw; even at light or no-load conditions, since magnetization current will increase. Flux vector control differs from normal AC drives by supplying the exact 3 phase excitation to the motor required to produce the specific torque and speed dictated by the load conditions and speed command. Therefore, during operation at light load, the terminal voltage at the motor shall be significantly reduced versus full load conditions. Ideally, the motor's rated voltage will be wound for 10% below the line voltage to produce sufficient torque capability at full speed operation, allowing the vector drive to 'over drive' the motor.

The flux vector control requires a speed reference input to command the operating speed of the motor under no load to full load (up to 150% overload) conditions. Speed regulation is excellent (up to .01%), due to the closed loop encoder feedback. Motor speed operating range is normally available up to 1000:1 ratios with full load torque output available at the motor's shaft all the way down to zero speed.

Drivecon's approach to flux vector control is amazingly simple, since we use the same basic drive as our standard VF61 series of AC variable frequency drives. Two different vector options are available from the VF61 variable frequency drive. The flux vector options are 'V' closed loop or 'S' open loop. Both options produce the same output speed and torque response, however the 'S' version will not produce stall torque. Maximum speed ratio of 100:1 can be achieved with the 'S' spacial vector drive. The application will determine which option is required. Constant tension winders and unwinders normally operate in a torque loop mode down to stall speed, which would require VF61V type controls.

## Inverter Application Note

Flux vector duty motors are available in various configurations. All are normally equipped with an encoder. Due to the flux vector's capable low speed operation motors are usually fitted with a forced air cooling fan. Motor manufacturers have accommodated this by adding auxiliary blower and encoder kits to standard frame motors.

NEMA framed motors, however, are not ideally suited for use with vector controls involving very quick response times. Specifically designed flux vector duty motors, similar to servo motors in design, have been developed for high performance use. Drivecon suggests the use of a performance matched UF induction motor to compliment the VF61V/S vector control. The UF series motor is a high performance servo-like AC induction motor with integral optical encoder and auxiliary blower. The main benefit for packaging the UF motor with a VF61V/S vector drive is optimizing performance through factory tuning. When supplying a matched pair, the motor's characteristics are programmed into the flux vector control for optimum response and guaranteed performance at time of shipment. Mating flux vector controls with untested motors could lead to unsure results from the combination. This should not be a cause for concern since Drivecon's auto-tuning process is very accurate. Key motor parameters, which are to be programmed into the VF61V/S are:

- \* Motor full load current
- \* Slip frequency
- \* Motor voltage rating
- \* Pole count of motor
- \* Rated full load speed of motor
- \* Primary resistance -x
- \* Secondary resistance -x
- \* Primary inductance -x
- \* Secondary inductance -x
- \* Mutual inductance - x

Most data required will be read directly from the motor's name plate or measured. The data marked with an x must be supplied by motor manufacturer or measured through auto-tuning.

VF61V/S series of vector controls offer extremely flexible configurations due to a modular approach. Size range of 3HP to 400HP is possible by using the standard variable frequency drive structure. Other options such as dynamic brake resistors or continuous line regeneration are available. A typical vector system will consist of the following:

- 1) VF61V-3744 50HP Flux Vector Control
- 1) UF2751V-37-1800 50HP Vector Duty Motor
- 1) VF61R-3744 50KVA Line Regenerative Converter or VFDB plus resistors

Drivecon is available for technical assistance and application know-how of Flux Vector controlled AC drives. Contact an application engineer at 800-374-8266. Flux Vector control is your answer to continued DC motor problems - step in to the next generation of motor control technology.

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