3-Phase Induction Motor Drive

These Industrial Devices have been in use for several years. At the begginigs, they were built arround SCRs in arrays that were called 'forzed switching' pairs. This early type has many disadvantages, since rapid fuses were needed. Later on high power bipolar transistors were used. Since twenty years ago, IGBTs are used. Isolated Gate Bipolar Transistors are a combination of the Low Collector-Emmiter Voltge and High impedance and Isolation of the Gate. IGBTs can be found as single, double or sextuple modules. Some include reverse voltage diodes. Some include zener diodes to protect the gate.

The basic principle behind AC drives is the control of frequency and true power. PWM (Pulse Width Modulation) is the technique used to control the timming and the width of the pulses. Older types had velocity feedback from the shaft , but newer use phase shift between current and voltage at the output to compensate for loaded shaft. For this porpuse, they use DSP (Digital Signal Processors) to achive the rapid control based on mathematical models of the induction motor.

My prototype has no feedback and uses no DSP. Simple TTL logic (divide by 6, shift register, VCO) is used. It uses simple household 127 VAC 60 Hz. It cand scroll from 2 Hz up to 180 Hz. It uses power bipolar transistors arranged in a casquade known as Darlington. Each of them has a separate power source to trigger them, no electrical connection is made between them. It has an overcurrent-protection instant relay. It compares the voltage drop across a 1 Ohm 25 Watt wire resistance and compares it with a preset voltage. When preset value is reached, a SCR is triggered and a relay NC switch opens the +HV (positive rectified High Voltage) connection to the inverter. A push button is pressed to reset the fault.

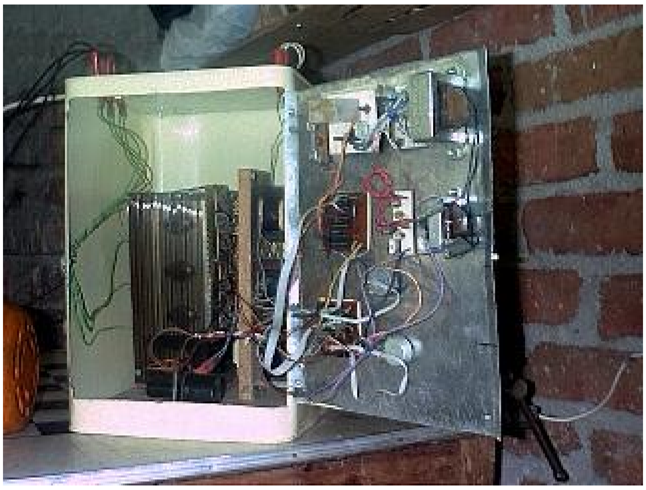
Mainly overcurrents occur when the frequency is shifted to fast for the motor to catch up. Its rotor has certain inertia (if loaded, add the load's own inertia) which cuases a counter force due to angular acceleration If it goes from low frequency to high frequency too fast, a high delay causes an overcurrent due to the low reactance of the motor under high delays. If it goes from high frequency to low frequency, then the motor acts like a generator feeding current to the inverter, this causes a low impedance, and therefore a overcurrent occurs.

I used my Macinstosh Powerbook 160 + Desktop PC DAQ plus a Current Transformer (TC) made of an old 60 Watt soldering iron and a rectifying bridge to get a DC voltage proportional to current on a AC line.

1/12 hp Motor, Prototype AC drive and

DAQ on background.

Closeview of the motor.

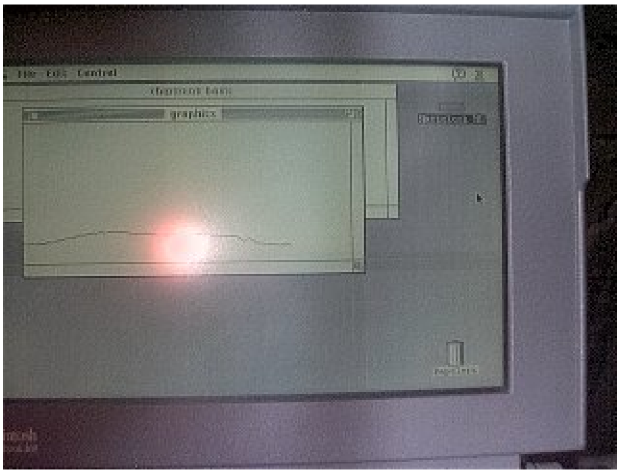

Inside of the AC drive. Power Bip. Transistors inside cooling tower.
Rectifier bridge and bank of HV electrolitic capacitors in front of tower.


Capacitor bank (4 caps. 220uF x 200V).


Control circuitry. Overcurrent relay on top, VCO+div by 6+Shift register and PWM. As well as power supplies for them.


Current Transformer to measure current flowing to the AC drive.


General view of AC drive, motor and DAQ.


Plotting of current vs. Frequency. It shows that current is not constant on this drive. Commercial types do have constant current control logic. (Apologize for the flash light!)

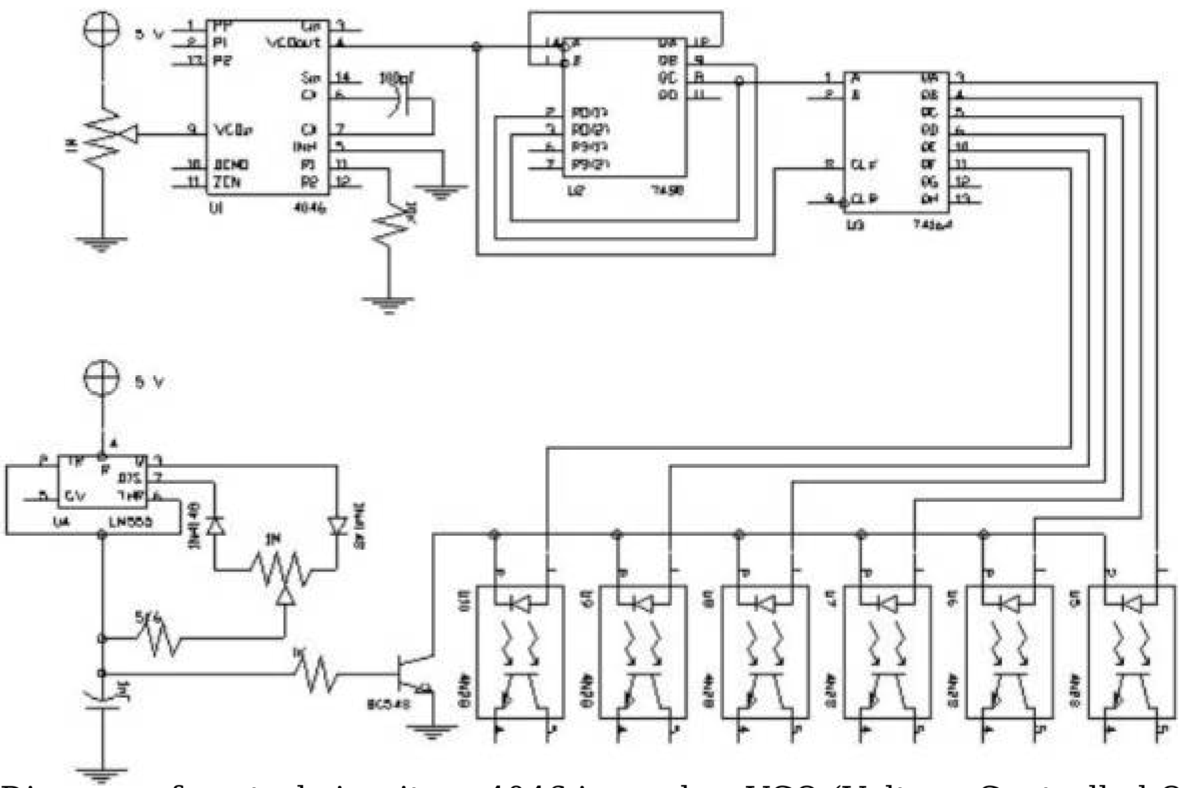
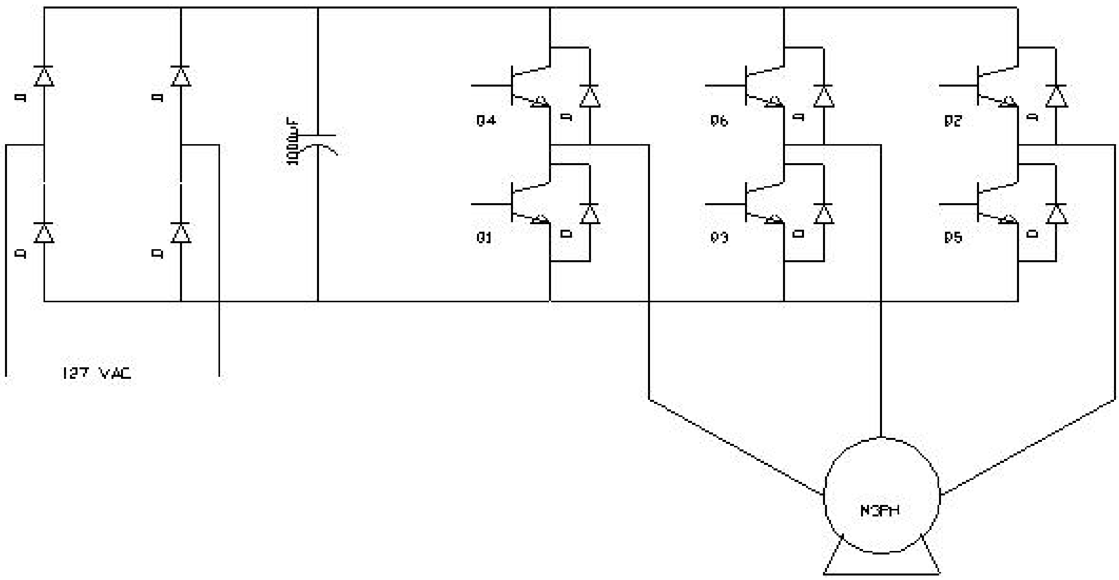


Diagram of control circuitry. 4046 is used as VCO (Voltage Controlled Oscilator) to have the base frequency. 7490 is used as a frequency divide by 6. 74164 is used as a shift register. NE555 is used as a 50% Duty Cycle PWM.
VCO controls velocity. PWM controls torque. Outputs from opto-isolators (from right to left: Q1,Q2,Q3,Q4,Q5,Q6) drive high power darlintong stages, in turn this stages form a three phase inverter to drive a motor.



AC voltage is rectified and a capacitor bank is used to smoothen the rectified wave. The higher the value, the more continous the DC HV will be.   The inverter generates a stepped wave at every phase, so there is a lot of harmonics (3rd, 5th, 7th, 9th,..)
Motors are typically designer for a certain rpm, if driven higher than this rpm, after a time, damage will occur to the bearings.

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