

2005 International Future Energy Challenge

Topic A: Motor Drive Competition

Specification Review

Program Vision

- **Encourage development of technologies to bring dramatic improvements to low-cost single-phase motor systems for home use**
- **Incorporate practicality, manufacturability, and affordability into competition process**
- **Improve education through development of innovative team-based solutions to complex problems**

Technical Goals

- **Construct adjustable speed motor system costing less than US \$40 for a 500 W unit**
- **Achieve maximum efficiency and operating requirements**
- **Maintain acceptable levels of performance, reliability, and safety**

Design Specifications

- **Single-phase source**
- **Motor mount compatibility – NEMA #48 Frame Size**
- **Coupling dimensions – see specifications**
- **Maximum input current 150% of full load current**
- **Speed regulation and command – linear 0-10V analog, referenced to the unit case; 2V/1000 rpm; $\pm 5\%$ speed regulation; except for starting, no testing will be performed below 150 RPM**
- **Efficiency $> 70\%$ @ 1500 rpm (150-5000 rpm, 50W – 500W)**
- **PF $> 80\%$ @ 1500 rpm, 500 W**
- **IEC 320 input connection**
- **Power on/off switch – input power $< 1W$ when unit turned off. Output must be fully de-activated**

Design Specifications

- **Electrical noise – FCC Class A**
- **Acoustic noise – Less than 50 dBA sound level measured 0.5 m from the unit**
- **Self-protect against continuous stall, over temperature, or loss of input source**
- **Environment – Ambient -20C to +40C; suitable for indoor or outdoor domestic applications.**
- **10 years maintenance free**
- **< 8 kg for complete system**
- **Metal casing must be connected to safety ground**

Finalists

- **First and second progress reports are due November 1, 2004 and February 1, 2005, respectively. Last progress reports are due May 1, 2005. The reports will be judged by a similar expert panel.**
- **By May 15, 2005, judges will select up to 4 finalist teams. These teams will be invited to the competition event that will begin August 15, 2005. A Final Report will be due at the competition event.**
- **Selection is based upon likelihood of deliverable hardware, quality of design, and likelihood of success in meeting all competition objectives**
- **Finalists ship hardware for testing to MPC Products Corporation, 7426 North Linder Avenue, Skokie, Illinois 60077, USA. URL: <http://www.mpcproducts.com/>.**
- **Teams not selected as finalists are encouraged to attend final competition (present their design)**

Competition Description

- **Finalists will ship their hardware to arrive at MPC Products by close of business August 15th**
- **Shipment must include operating documentation**
- **Final competition: August 15-19, 2005**
- **Testing order will be determined by lottery**
- **All designs are required to pass safety inspection prior to testing. No hardware tested until approved by judges.**

Test Procedure

- **Pretest Inspection (Team representative/judges)**
 - Confirm conformance to mechanical specifications
 - Check for live electrical elements
 - Check direction of rotation (ccw looking at shaft end)
 - Confirm command signal referenced to case
 - Judges approval for safety issues and other aspects
 - Short power on test to confirm operation
- **Prep for test (MPC Products technicians)**
 - Install thermocouple on the motor case for temperature monitoring
 - Mount motor in test stand
 - Set up of instrumentation

Test Procedure

- **Initial operation test**
 - Motor started - inrush current measured using Fluke 336 clamp on current meter
 - Check speed control signal
 - Run at 1500 rpm with 50 W, 150 W, 250 W, 350 W, 500 W loads
 - Judges assess if equipment ready for full testing
- **Low speed range test – dyno fixed at 3.18 Nm and lower**
 - Step commanded speed from 150 rpm to 1500 rpm – slew rate will be a few seconds, controlled externally
- **Speed regulation test - commanded speed fixed at 1500 rpm**
 - Step dyno load from 50 W to 500 W

Test Procedure

- **High speed range test - fix dyno power @ 500W and lower**
 - Adjust commanded speed from 1500 rpm to 5000 rpm
- **Test machine over wide range of operating points**
 - 5000 rpm @ 50 W
 - 150 rpm @ .318 Nm
 - 2500 rpm @ 200W
 - 450 rpm at 1 Nm
- **Specification test @ 1500 rpm, 500 W**
 - Measure radiated electromagnetic field
 - Measure acoustic noise
 - Temporarily remove control voltage
 - Temporarily remove supply voltage
 - Once thermo-stabilized, measure efficiency, power factor
- **Vary load 50W-500W @1500 rpm, measure efficiency**

Test Procedure

- **Remove cooling, test for 5 minutes @ full load**
- **Continuous stall test with commanded speed set @1500 rpm**
- **Overnight test under fan load**

Judging

- **Judges will be experts from machine/drive industry/academia**
- **Spreadsheets provided for comparative cost analysis**
- **Design, operating documentation, test results, presentation, final report (including cost analysis) all considered**
- **Oral presentation at the final competition will be done only by undergraduate students (or students pursuing their first university degree). These students will be interviewed by the judging panel.**

Rule Issues

- **Repair or maintenance work on hardware on site must be approved by judges**
- **Units with major failures or obvious severe shipping damage may not be approved for testing**
- **Once at MPC Products, hardware may not be taken off site**
- **Appeals of rulings can be made to full judging committee – their decisions are final**
- **Teams must follow safety regulations established by MPC Products or IFEC**

Prizes

- **The team achieving the best overall results that meet all the requirements will receive a Challenge Award of no less than US \$10,000 (and more based on sponsorship levels). The best results in individual categories, including engineering design, engineering report quality, technical presentation, innovation, and other categories to be determined, will win special monetary prizes of approximately \$1,000 to \$5,000 each. In addition, an special award on undergraduate educational impact will be given.**

Time Schedule

- **November 1, 2004: 1st summary progress reports due (Progress reports are limited to 10 double-spaced, single-column pages total, including all diagrams, attachments, and appendixes.)**
- **February 1, 2005: 2nd summary progress reports due (Progress reports are limited to 10 double-spaced, single-column pages total, including all diagrams, attachments, and appendixes.)**
- **May 1, 2005: Final progress reports due (Final progress reports must include preliminary experimental results; final progress reports are limited to 25 single-column pages total, including all diagrams, attachments, and appendixes.)**
- **May 15, 2005: Finalists notified (Selection is based upon likelihood of deliverable hardware, quality of design, and likelihood of success in meeting all the challenge objectives.)**
- **August 15, 2005: Final reports and working units due (Final reports are limited to 50 single-column pages total, including all diagrams, attachments, and appendixes.)**
- **August 15-19, 2005: Final competition**