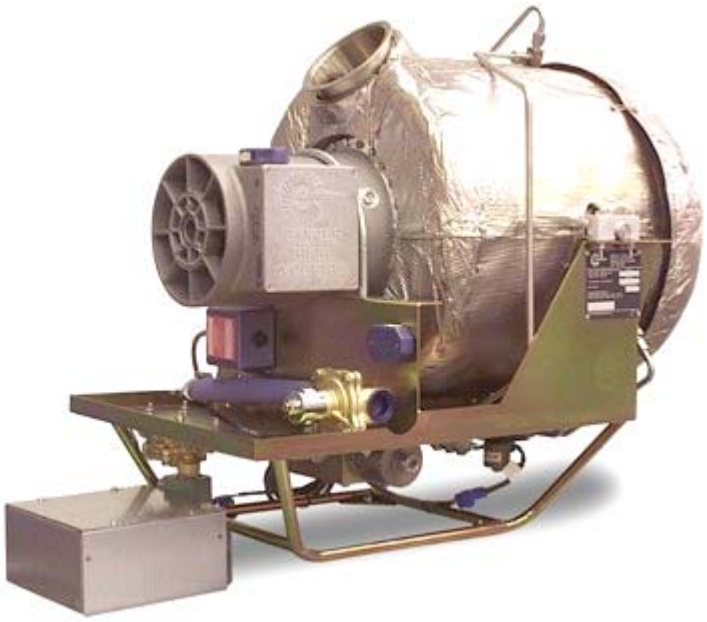
Capstone Turbine Corporation • 21211 Nordhoff Street • Chatsworth • CA 91311 • USA
Telephone: (818) 734-5300 • Facsimile: (818) 734-5320 • Website: www.microturbine.com

Technical Reference

Capstone Model C30 Electrical, HEV Model

This document defines the electrical performance ratings of the Capstone Turbine Corporation® Model C30 MicroTurbine™ for DC output Hybrid Electric Vehicle (HEV) operation.

This information is intended for use in the evaluations of applications for the Capstone Model C30 MicroTurbine.



Electrical Performance Ratings Disclaimer	Many of the electrical performance ratings are software dependent. Capstone reserves the right to change its electrical performance ratings at any time without notice. The electrical performance of any unit may change whenever the software is changed or upgraded. Additionally, the electrical performance of any unit may deviate from the listed ratings due to the installation environment. The characteristics of the utility or connected load may also cause out-of-tolerance performance of any unit.

Table of Contents

Introduction

The Capstone Model C30 MicroTurbine provides electrical DC power generation for HEV integration.

The Hybrid Electric Vehicle (HEV) configuration uses the MicroTurbine to source current into a DC Battery Pack based on a commanded power demand.

Purpose

The purpose of this document is to define the electrical performance ratings of the Capstone Model C30 MicroTurbine in the Hybrid Electric Vehicle configurations. This information is intended for use in the evaluations of applications for the Capstone Model C30 MicroTurbine.

Scope

This document defines only the electrical ratings and characteristics of the Capstone Model C30 MicroTurbine single unit. Other documentation is available for defining the ratings and characteristics of the other various MicroTurbine components.

MicroTurbine Compliance Listing

The Model C30 MicroTurbine has been designed, evaluated, tested, and certified to meet various directives and standards. Areas of compliance are noted in the Capstone MicroTurbine Compliance Listing.

Definitions

The following table presents General Terms and Definitions as used within this document.

General Terms and Definitions

General Terms	Definitions
A	Amp (or Ampere): The unit of measurement of electric current.
BSOC	Battery State-of-Charge
°C	Degree Celsius. A temperature scale. 0 Celsius (or 0 Centigrade) is the freezing point of water (32 °F)
°F	Degree Fahrenheit. The thermometric scale on which, under standard atmospheric pressure, the boiling point of water is at 212 degrees above the zero of the scale and the freezing point is 32 degrees above that zero
Capstone	Capstone Turbine Corporation
DC	Direct Current
H	Henry (or henries)
HP	High Pressure
Hz	Hertz; The frequency of electrical alternations (cycles) per second. One Hz is equal to one cycle per second.
ISO	International Standards Organization
IRMS	Current (or Amps) Root Mean Square

General Terms and Definitions (Continued)

General Terms	Definitions
I/O	Input/Output
k	Thousand (kilo or $1x10^3$)
kohms	Thousand ohms
kV	Thousand volts
kVA	Thousand volt amperes
kVAR	Thousand volt amperes reactive
kW	Thousand watts
kW-Hr	Thousand watt-hours
L	Stands for Inductor (as in L1 = Inductor 1).
M	Mega; designation for one million (or $1x10^6$)
m	Milli; designation for one thousandth (or $1x10^{-3}$)
mA	Milliamp; one thousandth amp
N/A	Not Applicable
RMS	Root Mean Square
RS-232 Port	Defines three types of interfaces, electrical, functional, and mechanical. Ideal for the data-transmission range of 0-20 kbps/50 feet. It employs unbalanced signaling and is used with 25-pin D-shaped connectors (DB25) to interconnect various components. Serial data exits through an RS-232 port via the Transmit Data (TD) lead and arrives at the destination device's RS-232 port through the Receive Data (RD) lead.
TB	Terminal Board (TB1 stands for Terminal Board 1)
V	Volt (or volts)
VAC	Volts Alternating Current
VDC	Volts Direct Current
VRMS	Volts Root Mean Square
W	Watt (or watts)

Electrical Ratings

Table 1 presents the Electrical Ratings for the HEV configuration.

Table 1. Electrical Ratings: Hybrid Electric Vehicle Operation

Description	Single Unit
Battery Voltage Operating Range	150 to 700 VDC (Note 1)
Output Voltage Connection	2 Wire + Ground
Output Power	0 (Note 2) to 30 kW HP and liquid fuel
Output Power Ramp Rate	± 1 kW/second, maximum or ± 3 kW/second, maximum with software version 2.05 or higher
Output Current	125 Amps DC, maximum steady state
Ripple Current	The DC output power is filtered within the Capstone equipment by both common mode and differential mode filters. The actual amount of ripple current is determined by the total system load on the vehicle battery.
Power Required @ Start Command (per MicroTurbine)	3.5 kW peak, 0.014 kW-Hr, 30 Seconds
Cool Down Power (per MicroTurbine)	2.8 kW peak, 0.147 kW-Hr, 5 minutes, typical
Standby Power	0.5 kW
Grounding. Consult the HEV System Manual for details.	All components star grounded to DPC ground stud. DPC ground stud is single connect to physical ground.

Note 1: Max. Power Output will be reduced at lower battery voltages due to output current limitations.

Note 2: The minimum available power to the battery is 750 Watts when the Power Demand is 0 kW.

Instrumentation Accuracy

The displays of the output voltages, currents, and power have typical accuracies and coefficients as presented in Table 2.

Table 2. Typical/Maximum Instrumentation Accuracy and Coefficients

Instrumentation Item	Accuracy and Coefficients (Typical/Maximum)
Current	±1.4% of Full Scale (typical) / ±2.4% (maximum)
Current Temperature Coefficient	± 0.2% of Full Scale over –20 to +60 °C range
Voltage	± 0.6% of Full Scale (typical) / ±1.3% (maximum)
Voltage Temperature Coefficient	± 0.2% of Full Scale over –20 to +60 °C range
Output Power	± 2.0% of Full Scale (typical) / ±3.7% (maximum)
Output Power Temperature Coefficient	± 0.4% of Full Scale over –20 to +60 °C range
Real Time Clock	±1 minute per month

Primary Settings and Adjustments

Primary settings and adjustments may be made from the Display Panel (optional) or via the RS-232 User Interface or Maintenance Ports on the DPC Control Board.

Table 3 presents the Primary Settings and Adjustments for the HEV configuration.

Table 3. Primary Settings/Adjustments

Parameter	Setting and/or Adjustment
Power Demand	Sets the output power: 0 kW (Note 1) to 30kW with 0.1 kW resolution. Default = 0
Auto Restart	Automatically restarts after event-driven shut down, (Yes/No). Default = No (Maximum number of auto restarts is 5, after which restarting will be locked out.)

Note 1: The minimum available power to the battery is 750 Watts when the Power Demand is 0 kW.

Protective Settings and Adjustments

Protective settings and adjustments are used to shut down the output of the MicroTurbine should any abnormal conditions appear on the output.

Table 4 presents the Protective Settings and Adjustments for the HEV configuration.

Table 4. Protective Settings/Adjustments

Parameter	Setting and/or Adjustment
Under Voltage	MicroTurbine will cease to energize output if the battery voltage droops below this setting for a period of Under Voltage Time. Adjustable from the Fast Under Voltage to the Over Voltage value. Should be set to battery End of Discharge voltage. Default = 220 VDC.
Under Voltage Time	Period of time that the battery voltage can droop below the Under Voltage setpoint before output power is ceased. Adjustable from 0.01 to 10 seconds. Default = 1.00 seconds.
Over Voltage	MicroTurbine will cease to energize output if the battery voltage exceeds this setting for a period of Over Voltage Time. Adjustable from the Under Voltage value to the Fast Over Voltage Value. Should be set to battery Equalization Charge voltage. Default = 382 VDC.
Over Voltage Time	Period of time that the battery voltage can exceed the Over Voltage setpoint before output power is ceased. Adjustable from 0.01 to 10 seconds. Default = 1.00 seconds.
Fast Under Voltage	MicroTurbine will cease to energize output if the battery voltage droops below this setting for a period of 10 msec. Adjustable from 40 VDC to the Under Voltage value. Should be set to battery End of Discharge voltage. Default = 200 VDC.
Fast Over Voltage	MicroTurbine will cease to energize output if the battery voltage exceeds this setting for a period of 10 msec. Adjustable from the Over Voltage value to 740 VDC. Should be set to battery Equalization Charge voltage. Default = 400 VDC.
Operational Current Limit	Operating current limit. Adjustable from 0 to 128 Amps. Requires adjustment for battery voltages below 235 VDC to achieve full power. Should be set to I where I = 30000 / battery voltage. Default = 128 Amps.

Communications

User Connection Bay

The Communications Bay provides the interconnection means for contact closure inputs and 12 volt DC power supply. The data is presented in Table 5.

Table 5. Terminal Board TB1 - User Connection Bay Inputs

Pin	Signal	Parameter
TB1-1	12 VDC Power Supply input	Power supply is required to power up the system prior to a start and through completion of Cooldown. 11.5 to 14.5 VDC, 8 Amps
TB1-2	12 VDC Power Supply Ground	Isolated return for power of TB1-1
TB1-3	(Not Applicable)	
TB1-4	E-Stop	Dry circuit contact closure. Closed for normal operation, open for E-Stop. (+) 13.8 VDC @ 135 mA
TB1-5	E-Stop	Return for TB1-4, ground referenced

Communications Ports

Serial communications ports are available on the DPC Control Board providing RS-232 communication for command, control and troubleshooting of the MicroTurbine. The data is presented in Table 6.

Table 6. Serial Communication Ports

Pin	Signal	Parameter
J4	User Interface Port	DB9 (male polarity) and RS-232 protocol. Maximum null modem cable length is 50 feet.
J2	Maintenance Interface Port	DB25 (male polarity) and RS-232 protocol. Maximum cable length is 50 feet.