INNOVATIVE ON-BOARD INSTRUMENTATION FOR EV BATTERY CHARACTERIZATION

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Purpose

(i) To characterize EV performance with emphasis on the battery. This is necessary due to lead–acid traction battery limitations.

(ii) To compress and store data unique to EVs as acquired both under test track conditions and during actual on-road operation:

(a) For short-term (one day) and immediate presentation,

(b) For long-term (one month) and immediate presentation as a function of battery discharge characteristics.

General system description

Versatile data acquisition system (VDAS)

Versatile because:

(i) modular design — all major functions are independent and can be changed,

(ii) operates in time and frequency domains (real time operation and data compression as a function of frequency of occurrence),

(iii) contains both EPROM and RAM memory with capability to expand,

(iv) magnetic tape or easily read formated printout.

Sensors

(i) Hall effect probes

For direct measurement of power in EVs with chopper controllers.

Temperature compensated from −25 to +50 °C.

A.C. linearity ± 0.5% to 10 kHz.

Cost similar to shunt and analog multiplier without higher frequency phase shifts and waveform distortions, and isolated from current carrying cable.

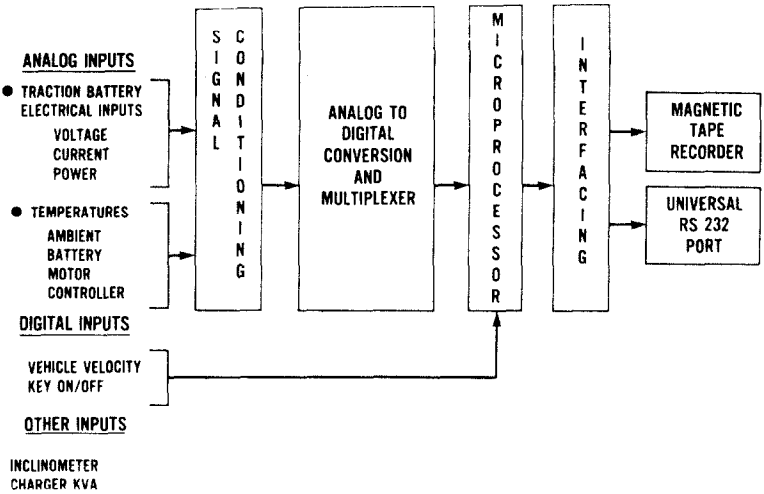

Fig. 1. Block diagram of the versatile data acquisition system showing inputs from battery powered electric vehicle.

(ii) Temperature probes

Compensated temperature-measuring semiconductor chips, absolute error of ± 2.0 °C from −55 to +150 °C.

(iii) Velocity transducer

High resolution shaft encoder (500 pulses per 360 degrees), connected to speedometer cable, 183.7 pulses per foot of vehicle travel, velocity resolution of 0.0272 ft. s^{-1}, ideally, and acceleration resolution of 0.0680 ft. s^{-2}, ideally.

Analog section

Contains up to 8 temperature channels, up to 12 analog input voltages, low pass filtering for temperature channels, and integrator sums each signal input for 0.1 s and resultant is digitized; the average value over the interval is stored, virtually no data are lost.

Digital section

(i) Multiplexer and analog to digital conversion

12 BIT A/D converter with 16 input channels; multiplexing of input channels and conversion are accomplished independently of microprocessor.

(ii) Microprocessor card

Texas instrument TMS 9900, 16 BIT with powerful instruction set, 8K bytes of EPROM expandable to 16K bytes, and 4K bytes of RAM expandable to 8K bytes.

(iii) Interface card

Transfers data from microprocessor to digital tape recorder and to RS 232 port.

(iv) Digital tape recorder

86 m (282 ft.) tape can store 2.2×10^6 bits, estimated 30 days of VDAS operation, and tape cassettes specified over temperature range of −40 to + 70 °C.

Software and data records

Eight base data records are produced:

(i) Mechanical power *versus* velocity histogram
(ii) Incline array
(iii) Maximum/minimum record
(iv) Cumulative data record
(v) Stop analysis record
(vi) Charge record
(vii) Initialization/termination record
(viii) Discharge power profile array

Software and data records description

(i) Mechanical power versus velocity histogram — conceptualization basis relationships

$$P_v = mv(a + g \sin \theta)$$

where: P_v = vehicle mechanical power, m = gross vehicle mass, v = vehicle velocity, a = vehicle acceleration, g = acceleration due to gravity, and θ = angle of incline.

Each cell in the array contains: (a) average vehicle mechanical power, (b) average electrical power, (c) average velocity, and (d) number of counts.

(ii) Incline array

Percent grade *versus* average velocity with counts.

(iii) Maximum/minimum record

Diagnostic tool.

Contains maximum and minimum of: ambient temperature, mechanical power, electrical power, battery voltage and current.

Contains maximums of: motor, controller and battery electrolyte temperature.

Stored with each of the above: velocity, distance and time.

(iv) Cumulative data record (trip record)

Cumulative trip time, total distance traveled, total electrical energy consumed, and total regenerative energy.

(v) Stop analysis record

Count of number of stops, total time stopped with key on, and time trip record written to magnetic tape.

(vi) Charge record

Battery current and voltage, ambient and battery electrolyte temperature, sample time, and data are stored based on either a voltage or a current floating window being traversed.

(vii) Initialization/termination record

Power up initialization time, time elapsed since power up, tape sequence number, and vehicle identification number.

(viii) Discharge power profile array

Average electrical power in 4 kW increments from + 80 to − 80 kW with cumulative counts (duration).

Economic considerations

(i) Modularity — easy to change or eliminate capabilities, can expand memory, can replace cards for repair, can eliminate tape recorder.

(ii) Usable data available immediately, reducing cost and time to process data off line.

(iii) Can run real time without hardware change.

(iv) Analog to digital conversion controlled independently of microprocessor.

(v) Cost is about one third of other systems with similar capabilities.

Summary and conclusion

The versatile data acquisition system has the following characteristics:

Unobtrusive in EV, acquires data unattended, presents EV data in immediately useful form, sensors developed for EVs, and cost is about one third of that of other systems.