DATA COLLECTOR MODEL 21820
THEORY OF OPERATION

The Data Collector Module is designed to be attached to forklift and lift truck batteries for the purpose of gathering battery performance and vehicle utilization data. This data is transmitted by radio frequency to a Universal Transceiver which is attached to a Base Station PC. Each Data Collector is polled on a periodic basis and the received data is sent to a central collection site via a modem, the Internet and an E-mail process. The transmitter and receiver operate at a frequency of916.500mhz.

The Data Collector Module consists of a microprocessor controlled radio frequency transmitter and receiver, a temperature sensor integrated circuit, a ferrite flux concentrator and hall effect sensor, an analog circuit for measuring battery voltage and a power supply. . A main power cable from the battery passes through a hole in the center of the device. This cable is surrounded by a ferrite core which serves as a portion of the current measuring circuit.

Referring to the schematic, the circuit receives its power from a 12 volt source on the vehicle battery. Circuit protection is provided by a .375 amp fuse (F!). Transient voltage protection is provided by a combination of L1 and D3. Reverse polarity protection is provided by D2.

A power supply consisting of U1, C1,C2,C3,and C4 provides regulated 5 volts to the microprocessor and monolithic microwave integrated circuit (MMIC). A second power supply circuit consisting of U2, C6, C8 and C9 provides a regulated 3 volts to the transmitter,operational amplifier, and receiver sections of the device.

Microprocessor U5 is operated at a frequency of 8.00mhz which is provided by a combination of an internal oscillator circuit and ceramic resonator Y1. During assembly of the device, certain signals are brought to the edge of the PC board for programming, communication and test purposes. Since the entire device is potted after assembly, these signals become inaccessible to the end user.

The receiver and transmitter portions of the device consist of essentially "cookbook" circuits provided by the IC manufacturer, RF Monolithics. The receiver IC, U7 is an RX2056 amplified sequential hybrid or ASH type receiver. The nature of this type of receiver is that it bit slices the incoming data and thus has no need for such circuit functions as a local oscillator. The receiver essentially has no detectable emissions in the radio frequency range A. detailed data sheet for the receiver is included with this application. In the receive mode of operation, RF transistor Q6 is turned off. RF energy from the loop antenna (PC traces) is fed through impedance matching inductor L6. ESD protection is provided by the combination of diode D11 and inductor L3. Diode D11 is selected to provide approximately 3pf of capacitance to resonate with L3. The RF signal is AC coupled to the input of the MMIC (U6) by capacitor C18. The output of the MMIC is also its DC supply line. The RF signal is AC coupled from the output of U6 through capacitor C34 to the input of receiver IC U7. Data output from U7 is fed through a voltage level translation circuit consisting of R17,R19 and Q22. A small capacitor C26 bypassed any residual RF energy to ground.

Baseband level data signals from Receiver IC U7are fed to an automatic gain control circuit consisting of resistors R20,R24, R28, capacitor C27,resistorR31, operational amplifier IC U9,capacitor C28,and resistors R29,R32,R37,R38and R33. Resistors R31 and R35 form a voltage divider which is connected to the voltage reference output of receiver IC U7.The function of the AGC circuit is to reduce input signal gain in the presence of high signal levels. This is accomplished by comparing the DC level of the baseband voltage output from receiver IC U9 with the reference voltage output.

As the baseband voltage level increases beyond the reference level, the supply voltage to MMIC U6 is reduced through the output and voltage level translation circuit consisting of resistors R30,R33,R34,R36 and transistor Q5.

In the transmit mode, the AGC circuit is defeated through the operation of resistorR25, and diode D9. A signal from the microprocessor IC U5 is presented to resistor R25 serving the twofold purposed of defecting the AGC circuit (by removing power to the MMIC IC U6) and also providing bias to RF transistor Q6 which passes RF energy from the transmitter IC U8 to the antenna.

The transmitter IC employed in the device is an RF Monolithics HX2000. A detailed data sheet on the IC is included with this application. . A control signal from the microprocessor drives transistor Q3 through resistorR15. This circuit translates the 5volt logic of the micro to the 3volt input to the receiver. Data to be transmitted is output from the microprocessor to a voltage level translation circuit consisting of resistors R4 and R15, and transistor Q3.. Inductors L2 and L4 serve to prevent stray RF energy from entering other portions of the circuit. Capacitor C23 serves to bypass any residual RF energy present on the 3volt supply pin of transmitter IC U8 to ground.

From a functional standpoint, the device gathers data for a predetermined period of time that may extend from 8 hours to 7 days. It then attempts to reach either the Universal Transceiver Module (which is attached to a Base Station PC) or other Data Collectors by transmitting a coded message.. In a second mode of operation, the Data Collector will respond to a query from the Universal Transceiver/Base Station by transmitting its data and beginning the process over again.

Transmissions are thus infrequent and short. A total of less than 200 bytes of data is transmitted at a rate of approximately 12k bits per second which takes approximately 300 milliseconds to complete.

Data Collection Module

The Data Collection Module shall consist of a power supply circuit, an RF transmitter, an RF receiver, an ***internal*** antenna and a microprocessor controller all mounted to a PC board and packaged in a solid potting material within a plastic case. Functionally, the Data Collection Module shall acquire and maintain battery data and shall transmit the data when polled.

Transmitter

Carrier Frequency	916.5 MHz
Transmit frequency tolerance	+- 200khz
Harmonics	<-32dbc
Data Rate	9600 baud nominal
Power output	-5dbm minimum, +5dbm maximum
Operating Temperature	0° to 50 ° C
Packaging	2.0" wide X 6.5" long X 2.5 high" potted
Power requirements	12Vdc nominal @ <25ma
Required transmission range	200' in warehouse environment
Transmission method	Amplitude modulation (on-off keying)
Data format	CMOS 5vdc interface to microprocessor
Power connector	16ga wires X 32"
Antenna impedance	50 ohm
Antenna connector	Hardwired or optional internal SMA connector
Antenna	Micro stripline PC board trace

Receiver

Packaging	see transmitter
Power requirements	see transmitter
Center Frequency	916.5 MHz
3db bandwidth	+-200Khz
Out of band rejection	>60db @+-30Mhz from center frequency
Dynamic range	-72dbm to –10dbm (not incl front end amplifier)
Total Sensitivity	-95dbm with 20db MMIC front end
Emissions	Negligible
Data format	CMOS 5vdc interface to microprocessor
Other Specifications	see transmitter

Microprocessor

Crystal Frequency	10Mhz
Clock Frequency	2.5Mhz

FCC CERTIFICATION :

Transmitter subject to operation under CFR47 Part15.249
Receiver subject to operation under CFR47 Part 15.101(a), 15.101(b)
Microprocessor section exempt per CFR47 Part 15.103(a)