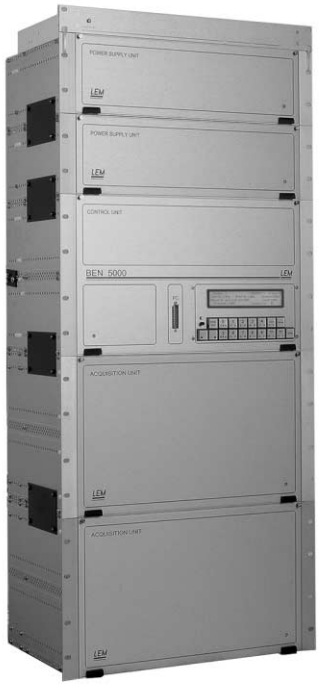
Digital Fault Recorder
BEN 5000

- High Immunity
- High Reliability
- High Performance
- Application Versatility
- Flexibility
- User – Friendly
- Serivce – Friendly
- High Performance Analysis



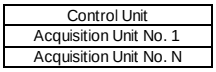
General

The BEN5000 is a fully digital fault recorder which can be configured at the customers' request as a centralized or decentralized architecture. It can monitor up to 192 analog and 576 digital channels. Remote acquisition units are connected to the control unit by means of optical fibers providing a high degree of immunity to outside interference.

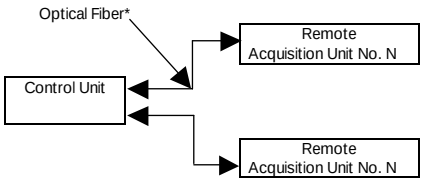
BEN5000 system

The **BEN5000** system consists of one control unit and one or more acquisition units which are either assembled in one centralized cabinet or delivered as multiple modules for installation in remote locations.

BEN5000
Centralized System



BEN5000
Decentralized System



* Optical fiber – fast – high immunity.

Isolation characteristics

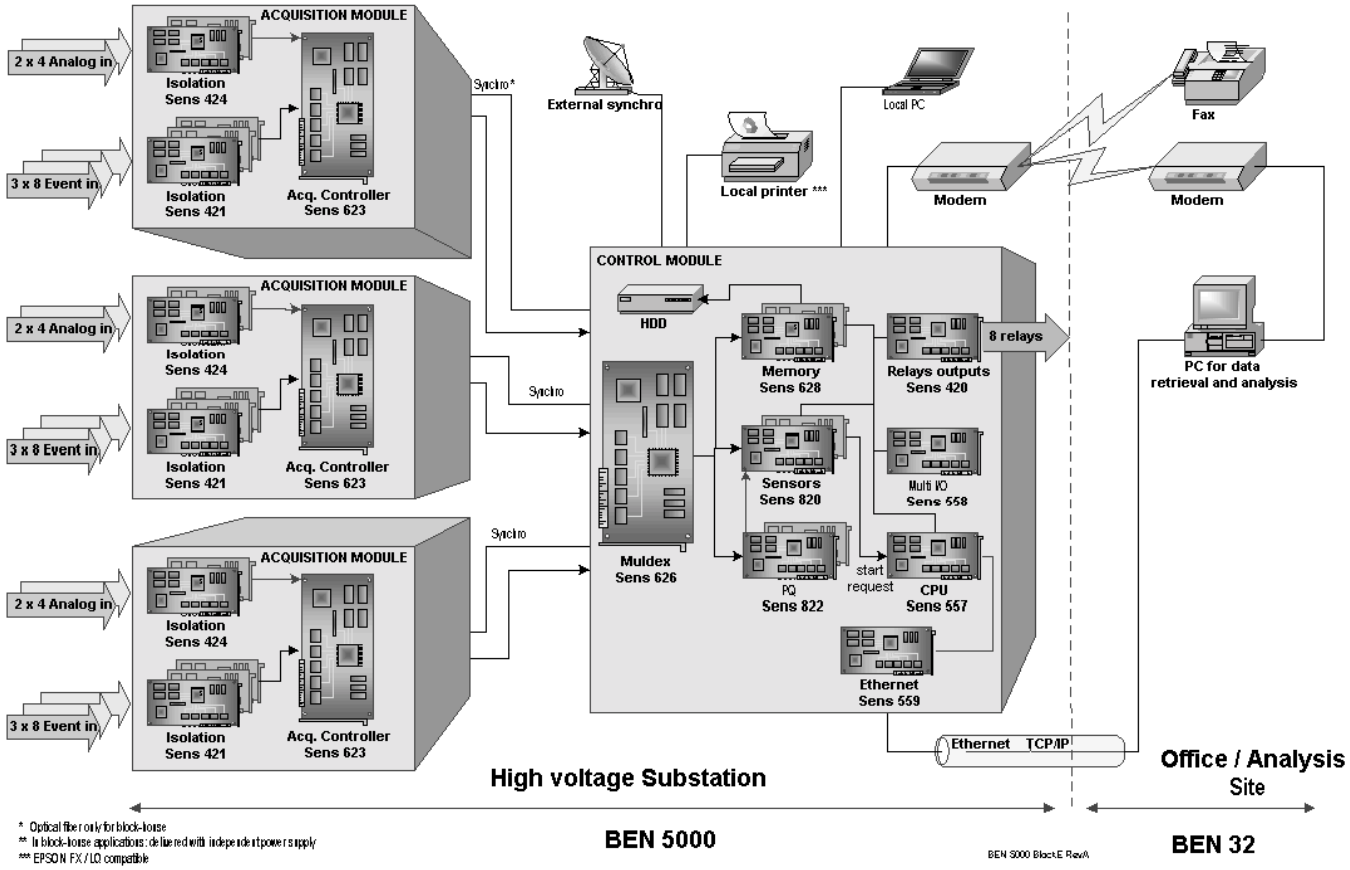
- Input isolation for digital signals and analog signals
- Analog input signals fully-isolated and DC coupled
- 6 selectable input ranges 2,5,12,30,110,220 VRMS
- Current shunt inputs for 1 or 5 A nominal
- Digital input signals full-isolated or common return
- Input signal filtering (EFT/SWC)

Acquisition characteristics

- Anti-aliasing filtering
  Characteristics:
  - Butterworth 6th order 36db/octave
    Auto-adaptation to the sampling frequency 0.35 bit resolution
- A/D conversion
  - sample and hold before A/D conversion
  - 12 bit resolution
- Sampling rate 1-10.000 samples/sec programmable locally or remotely
- Standard memory capacity:
  - From 1 to 32 Mega samples/64 channels
- Communication with control unit
  - input data are serialized
  - send data to control module
  - receive control commands from control unit (synchronisation, - RMS/DC ON/OFF, calibration data)

Block diagram and characteristics

The system is designed so thast the acquisition unit samples and digitalizes the data synchronously. The decision to start a record and the management of pre-fault and post-fault memory are carried out in the control unit.



System control

- Stores data in solid state semiconductor memory
- Controls presence of starting conditions (one or more starting sensors, different types of starting criteria)
- Controls and dispatches data flow from semiconductor memory to:
  - a printer port for external printer (optional)
  - a thermal printer (optional)
  - a communication port (Modem)
  - a hard disk optional
- Controls relay outputs in order to show system status
- Receives external sync pulse or data from time code receiver in order to synchronize the system clock
- Controls:
  - LCD screen
  - Keyboard
- Input for external clock receiver (IRIG-B)

CPU

- 68000 processor –fast access to acquisition memory
- OS-9 operating system
- Programs written in C-language
- Open architecture BUSG96 Gespac

Memory

- SIM type memory
- Flexible memory width and depth
- One or more memory cards
- From 1 to 8 Megasamples/memory card
- Minimum of ½ Megasample/channel at maximum configuration
- Cyclic memory principle (blocking or overwriting following user's choice):
  Recording capacity:

$$Ttotal = \frac{\text{Numer of samples**}}{\text{Number of channels X samples speed}}$$

** One sample = a word of 16 bits (12 ANA + 3 DIG + STATUS)

Starting sensors

- DSP based
- Local or remote configuration of all operational parameters

Possible starting criteria

Single digital level
Tri-digital level
Digital edge starter
Tri-digital edge
1 Phase level starter (over/under current or voltage)
3 Phase level starter (over/under current or voltage)
Frequency starter
Rate of change (dU/dt)
Pendling (swing)
Power step
dP/dt 1 or 3 phase
dQ/dt 1 or 3 phase
Negative sequence
Positive sequence
Zero sequence starter
Active power 1 and 3 phase
Reactive power 1 and 3 phase

Analog inputs:

Trec= Tprefault+Tfault+Tpost
with Tfault+Tpost ≤ Tmax*
(Tprefault, Tpost and Tmax are programmable)

Digital inputs:

- **Edge:**
  Trec = Tprefault + Tprefixed
  (Tprefault and Tprefixed are programmable)
- **Level:**
  Trec = Tprefault + Tfault + Tpost
  With Tfault + Tpost + ≤Tmax*
  (Tprefault, Tpost and Tmax are programmable)

* Tmax = maximum detection time of sensor

Sensor functionality

BEN5000 fault recording systems are self-reliant due to their wide rangte of **software** trigger sensors which can be set and configured via a remote PC. The fault recorder logic decides whether or not to register channels based on the input criteria. Sensors are programmed to look for various types of analog values and digital input changes. The user need not to worry about external transducer delay.

Electronic Instruments sensors are completely adjustable either on site or remotely to meet user requirements, threshold, polarity, minimum recording time added to fault detection time, maximum recording time, etc. …
- Voltage, current, frequency, rate of change and digital input starting sensors available
- Fully adjustable Tmin, Tmax logic
- Inhibition
- Fast start condition detection

Sensor output can also be used as an internal digital signal to be processed like any other external digital input.

The system may be configured in order to perform one or more of the functions listed above.

Starting criteria like frequency, zero-sequence component, pos.seq. component, neg. seq. component dQ/dt and dP/dt are based on the internal calculation of the concerned criteria. This allows these signals to be internally reinjected and as such they can be recorded as supplementary analog signals.

Adjustable Sampling frequency

Several acquisition sampling rates on the same system with dynamic allocation of memory are available. This allows conservative use of memory according to the signals being recorded.
1 to 4 different and simultanous speeds between 1 Hz and 10 kHz with automatic adjustment of the anti-aliasing filter at 0.35 from samling frequency

- same channel may be scanned at different samling frequencies (slow and fast record in the same system) without additional external wiring.

Data transmission

The **BEN5000** can transmit the fault directory, data and status, and receive commands either locally by connection to a PC, or remotely through a modem. All commands and statuses described further can be accessed by remote control.

As far as the recorded data is concerned, several ways are available to transmit it efficiently:
- complete transmission of entire fault (without compression or with Huffman's compression), or transmission of digital channels only.
- Transmission of part of the fault only.
- Transsmission of some groups of analog channels only.

This transmission is done according to a high immunity and low overhead protocol with cyclic redundancy check and re-transmission of bad data.

Auto-Call

The **BEN5000** has automatic calling capabilities. When activated, the system tries to call one or more analysis centres when a new fault has been recorded. This call is generated according to a programmable sequence which allows up to four different numbers to be called as long as no connection has been established. The user may program the time between successive calls.

The sensor logic is configured to determine whether a new fault launches an auto-call procedure or not. The user may give a weight to boolean combinations of sensors. At the end of the fault recording, the weights of the groups in which at least one sensor has been triggered are added. If the sum exceeds a programmable threshold, the calling procedure is started.

Automatic call function charactersitics

- Initiated by the starting equations result
- Managed by the MODEM port RS232-V24
  From 300 to 115.000 Baud (V24)
- Possibility of calling: 4 different offices x 4 numbers/office (total=16)
- Up to 4 waiting delays if the number is busy:
  1 first call + 4 retries = 5 attempts/number

System start-up and calibration

- The calibration program is easy and almost automatic to run
- "Units" used, are user-definable

Specific techical datas

All specifications are given at 25 degrees centigrade for the entire system except when otherwise specified.
Humidity: 80 %

Inputs

Analog Channels
All specifications are given from DC to 60 Hz.

Full scale (RMS)	Zin Min.	Vin max* (RMS)
2V	10kΩ	70V
5V	25kΩ	100V
12V	60kΩ	130V
30V	150kΩ	200V
110V	500kΩ	300V
220V	1MΩ	300V

Resolution:	12 bits
Precision:	0.5 % max. error (DC 60 Hz)
Max. input current:	100 A RMS for 1 sec. max. on shunts 0.1 Ω 30 A RMS for 1 sec. max. on shunts 0.47 Ω 0.06 A Pk on shunts 143 Ω
Bandwidth:	DC to 0.31 x Fs ± 1dB
Cut-off frequency:	0.35 x Fs (-3dB) without RMS/DC converter 10kHz with RMS/DC converter
Attenuation at Fs/2	19dB min. (Butterworth 6th order)
Setting time of RMS converter	365ms
Common mode rejection	70dB min. (DC to 60 Hz)
Signal/Noise ratio	69dB min.
Time skew between channels at same FS	25µs max.
Crosstalk between channels	< -80dB
Common mode isolations**	2.5kV RMS (50Hz – 60 Hz) 2.5kV (1MHz according to IEC255-4)
Differential isolation***	2.5kV CM (IEC1000-4-5, ANSI C 37.90)
Fast transient capability	2kV DM (IEC1000-4-4) 2.kV CM (IEC1000-4-4)

* Above 1.5kHz the input voltage should not exceed 130V.

** Common mode refers to isolation between terminal and earth and between terminals of separate circuits. Differential mode refers to terminals of the same circuit.

*** Not on inputs with 141Ω shunt

Event Channels

Vnom	Zin	Vil min.	Vil max.	Vih min.	Vih max.
24V	5k	- 70V	8V	15V	70V
48V	9k	- 80V	10V	30V	80V
60V	14k	- 95V	15V	40V	95V
110V	23k	- 160V	25V	60V	160V
220V	47k	- 300V	50V	120V	300V

All values given in VDC

Propagation delay (Vin = Vnom)	Low to high : 40µs max. High to low: 60 µs max.
Time skew between channels	25µs max.
Common mode isolation	2.5kV RMS (50Hz-60Hz) 2.5kV (1MHz according to IEC255-4)
Differential isolation	1.0kV (1MHz according to IEC255-4)
Surge withstand capability	1kV DM (IEC 1000-4-5) 5kV CM (IEC 1000-4-5)
Fast transient capability	1kV DM (IEC1000-4-4) 2.5kV CM (IEC1000-4-4)

Acquisition

Sampling frequency [5-50°]	1Hz to 10kHz ±20ppm
System clock	0.2, 4, 5, 6, 7.2, 8.4, 9, 10kHz
Ratio between highest and lowest samling value	4095 max.
Total memorycapacity	up to 32 M samples in 1 M sample steps for each 64 channel group
Pre-fault memory	1 sample to ½ memory capacity in steps of 1 sample
Time resolution	records tagged to 0.1ms
Absolute time precision	5ms typ with external synchron (pulse or IRIG-B)
Absoulte time drift	20ppm max. without external synchron

Sensors

Under/Over and Zero-sequence	resolution: 12 bits Range: 0 to 100% of input range Detection delay: instantaneous delay for Under-Voltage; 1.1 cycles
Frequency	threshold range: 9Hz around 50 or 60Hz threshold resolution: 10mHz detection delay: 200 ms measure range: 16Hz around 50 or 60Hz
dU/dt	voltage range: 0.75 to 100 % of input range voltage resolution: 12 bits time range: 1, 2, 4 or 8 periods input frequency: 40 to 70Hz starting delay: 14 ms output result: RMS value of input signal
dP/dt, dQ/dt	voltage or current range: 0 to 100% of input range voltage or current resolution: 12 bits time range: 1 msec. To 20 sec. detection delay: time window (3 cycles min.) power output precision: 1%
Pendling	time range: 50ms to 100s by step of 10 ms
Tpost	0 to 24 hours (resolution: 0.002%, min. 10 ms)
Tmax	0 to 24 hours (resolution: 0.002%, min. 10 ms)
Tdetect	0 to 24 hours (resolution: 0.002%, min. 10 ms)
Digital detection delay	5 samplex typ

Status relays

Contacts rated (NO/NC)	250VRMS – 5ARMS (resistive load) 220VDC – 150mADC
Delay from start bus	10ms
Common mode isolation	2.5kV RMS (50 Hz) 2.5kV (1MHz according to IEC255-4)
Surge withstand Capability	500V DM (IEC1000-4-5) 5kV CM (IEC1000-4-5)

Communication lines

Common mode isolation	1kV RMS (50Hz)
Fast transient resistivity	2kV CM (IEC1000-4-4)
Effective serial data transmission	500K bytes/min. direct mode (115K bauds) 140K bytes/min. with modem at 14.4 K bauds 240K bystes/min. with modem at 28.8K bauds
Synchron pulse input	Vih: see table of event channels Twidth: 5ms min.

Power supply

Standard power supply:	48, 110, 125, 220 V DC and 230 V AC
Tolerance on input voltage	±20%
Inrush current	35A max.
Common mode isolation	2.5kV RMS (50Hz) 2.5kV (1MHz according to IEC255-4)
Differential isolation	1.0kV (1MHz according to IEC255-4)
Surge withstand capability	3kV (CM, DM IEC1000-4-5)
Fast transient capability	2kV DM (IEC1000-4-4) 4kV CM (IEC-4-4)

Environmental

Operating	0 to 50 degrees C (IEC68-2)
Storage	-10 to 60 degrees C (IEC68-2)
Humidity	10-80% non condesing

External Graphic printer

Weight	7.6 kg
Operating	5 to 40 degrees C
Humidity	35-85% non condensing

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