Broken Rail Detection System

ENEKOM

Energy Ecology Informatics and Engineering Limited Company

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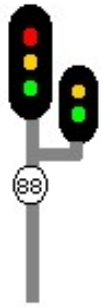
1. RAILWAYS - FOR A SAFER FUTURE

Rail System Solutions, around the world, have an increasing consideration among the transportation strategies for the reason of their being rapid, cost effective, eco-friendly and reliable.



The most important feature of a Railway System is its feature of being a highly secure system, in comparison to alternative transportation systems. So, the systems which maintain a high security standard like the railways, have to be supported by a well-conceived, straight and systematic maintenance, monitoring and check system which is particularly essential for the continuity of their safety level.

On the other hand, it may not always be a satisfactory answer to appeal only to human observation and perception in security systems which have an important role in this field that requires high security.

Substantial physical integration of the track leads the parameters which directly and basically affect the safety in railway transportation. In this sense, identifying or finding a broken or damaged rail segment on the track beforehand has also a great importance.

✖ Currently, the most commonly used broken rail sensing method is the track circuit that work with the basic principle of electrical continuity of the rails. However, this method mostly may induce misdetection in consequence of using the track as a line of return current flow concurrently.

✖ Axle counters which are commonly used at most railway systems anyway are not sufficient for sensing the rail breakages or damages reliably.

✓ **RailAcoustic** model **Broken Rail Detection System** which has been developed by Enekom is working on the basis of sensing the acoustic signals on the rail created by resonance with a significant frequency generated on track from a point at a far position.

✓ With this recent and unique system which the application for 2 patents have also been done and all the performance tests on a high-speed railway line (Ankara-Konya) are already accomplished, a breakage or a damage on the rail section lying between the acoustic signal application point and the detector at a far position (2Km apart) can easily be perceived and

this information is conveyed to control and data centre via a fiber optic communication line.

✖ Breakages or physical damages on high speed railway tracks happen every now and then. Currently, continuous daily visual inspections overcome a major accident on these lines but what if these inspections fail to spot a breakage one day?

2. ADVANTAGES OF ENEKOM BROKEN RAIL SENSING SYSTEM

Broken Rail Detection System - RailAcoustic of ENEKOM is a dynamic system working with electromechanical methods thoroughly. While vibration is injecting to rail on one point, vibration is read from another point simultaneously. The difference between vibration signal levels transferred between these two points in the healthy rail and in the rail having a breakage or a physical damage at a certain level as well as the signal returned after reflected from the failed zone are received by a highly sensitive sensing electronics circuit of the system and processed and the result is transmitted to control center through fiber-optic communication network.

✓ The sensor is in the state of listening to the line continuously. The noise existing in background is monitored continuously. Synchronization signal transmitted over the rails ensures that the noise is filtered from data obtained and the information about the rail within line block measured is obtained in a clean manner.

✖ As an alternative technology, track circuits apply an electrical signal to a certain rail block and check the continuity of the signal. However, this signal, since the rails are also a return current circuit, causes wrong results in many times.

✖ Apart from these methods, there are rail breakage sensing/analyzing processes made via ultrasonic sensors placed on a vehicle moving for testing purposes on the line. However, since these systems keep the line occupied and are not suitable for continuous measurement, cannot present the flexibility and safety presented by RailAcoustic. On the other hand, it has also been known that ultrasonic rail breakage sensing systems mounted on the tracks cannot perform properly as well, due to various technical disadvantages based on the nature of that technology.

✓ 10 to 60 minutes duration between the consecutive tests of RailAcoustic system in most of the high-speed railway applications would be enough. This duration may be decreased to seconds level and also be increased to hours or even days level. Under normal conditions, this kind of parameters are designed by the railway maintenance operator of the line according to the train traffic frequency of the line where the system is used. Programming all timing parameters can be made from operator's console in central control room.

✓ The computer within central control room gives command of starting the test to the sensing units installed on the track and exhibits test result data coming from these units on operator console audio-visually. Test result data for rails within the block being tested is produced by sensor modules fitted on the track and transmitted to the computer in central control room over the communication network. Collected data is stored in a permanent storage unit of central computer and may be reused in the future if required.

✓ Each field unit performs self-diagnostic tests with very short intervals and saves this status information in its memory for transmitting it to central control computer afterwards.

All components of the system are checked automatically by operator control computer in center continuously. The computer in center sends a question per second to these units about their situation and checks whether they are in operating state or not. This information belongs to operating status of both fiber-optic communication network and vibration applying and vibration sensing modules and consequently, it is definite data showing whether each point of entire system from start to end runs correctly or not.

3. WORKING PRINCIPLES OF ENEKOM'S BROKEN RAIL DETECTION SYSTEM

RailAcoustic which is fully designed and manufactured by Enekom, apart from all other broken rail sensing methods, works on the principle of applying a specific resonance frequency of vibration at a certain point of the track and then sensing this vibration both from a sensor located near to the signal injection point and from another sensor which is located at a faraway point.

Basic characteristics of the **RailAcoustic** are as follows;

✓ It can be used satisfactorily at the rail systems which are rendered continuous mechanically and electrically by a welded joint,

✓ It can work independently from the ballast resistor value,

✓ The system works completely isolated from the electrical properties of the track and it can sense the broken segments on any AC, DC or un-electrified tracks,

✓ It doesn't interfere with any other railway signaling equipment connected to the track,

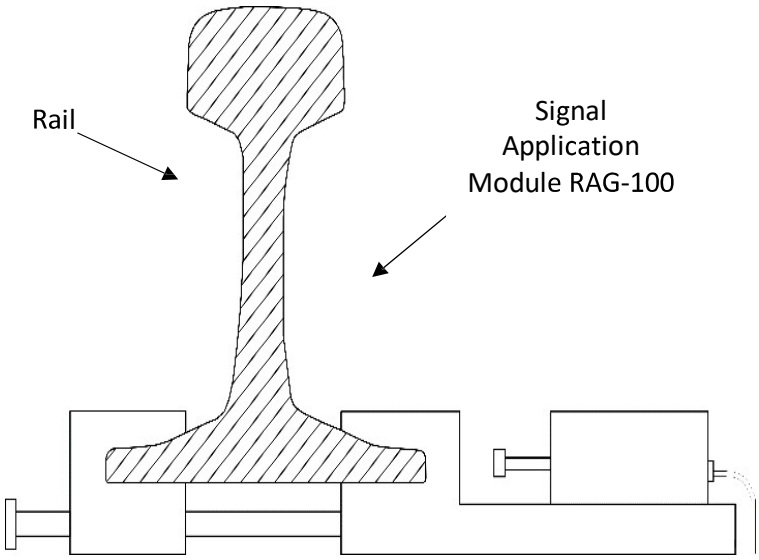
✓ The system modules can be easily installed or dismantled without any damage to the rails,

✓ Performance testing has been done satisfactorily on Konya-Ankara high-speed railway track which is in compliance with UIC60 standards,

✓ It works reliably and responsively under all weather conditions, with proven operating history since the installation of the system in mid 2018.

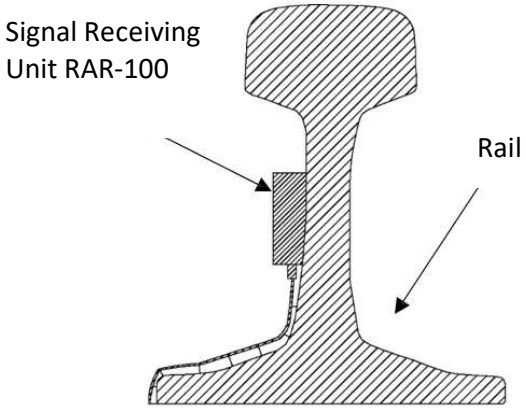
RailAcoustic Enekom's broken rail detection system consist of 5 different components; **RAG-100** signal application module, **RAR-100** signal sensing module, a track-side control cabin with a number of electronic Boards in it for driving RAG-100 and RAR-100 modules, an **IP based fiber optic communication system** for the connection of these electronic Boards and all related modules to **the computer** located in the railway command center and **MKY-100** central control software module running in this computer.

On the field, one **RAG-100,** the signal application unit and one **RAR-100,** the signal sensing unit are mounted on to the exterior surface of the track on approximately every 2 kilometers.



RAG-100 is designed as to be easily installed and demounted on the track mechanically. Both the installation and the longterm usage of this module does not require any mechanical intervention such as punching or welding and also a damage on the static structure of the track with long-term use can not be discussed.

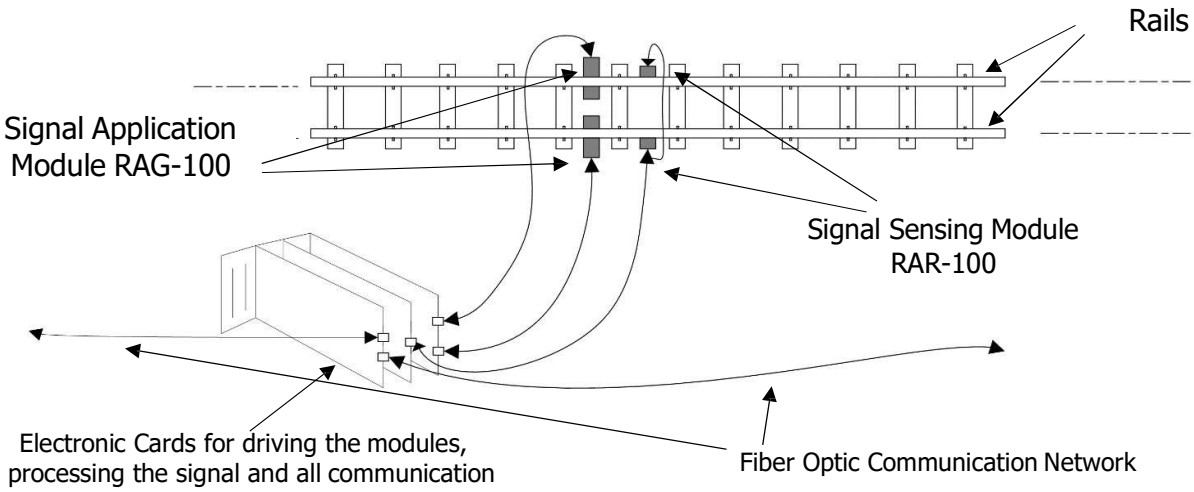
The sensor RAR-100 is installed on track as to be at a distance of 1 meter to each RAG-100, the signal application unit, and as to be connected on the same electronic control cabinet.



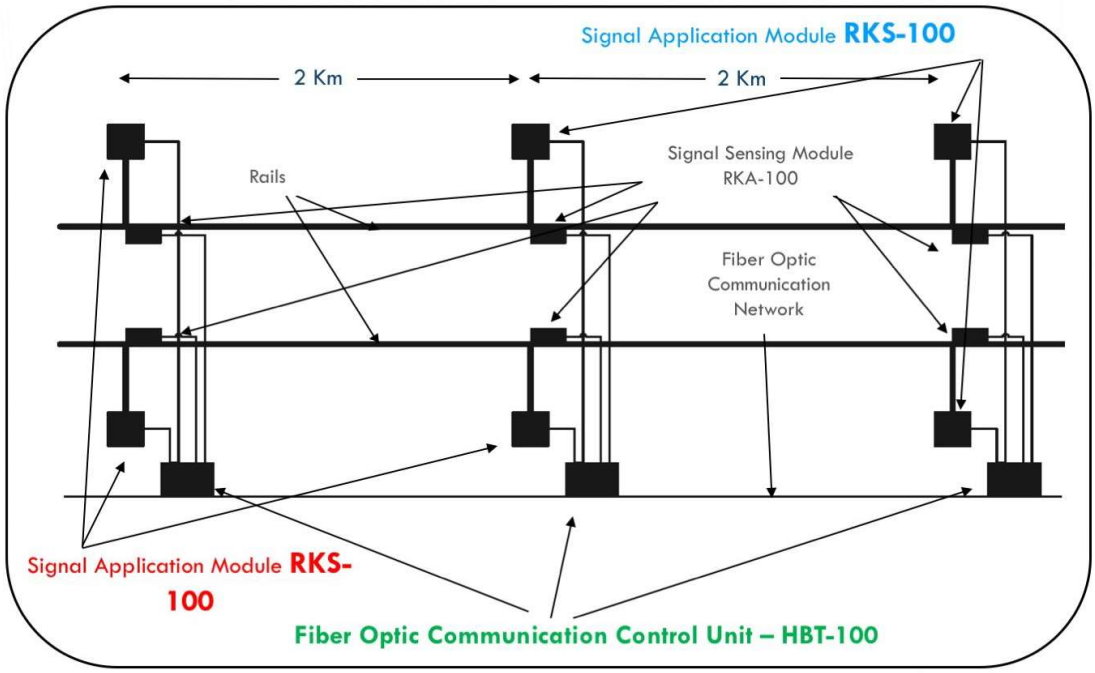
On the rail equipped with these modules, the signal of resonation is applied at a certain point on the rail is immediately measured by the sensor which is just next to the signal application unit. If the signal is at the reference level and if this is perceived by the system, then the relevant system board in the control cabinet conveys this respecting

information to the sensors which are positioned at 2 kilometres on the right and on the left of the signal application point through the fiber optical network communication system.

Two neighbouring sensors, which retrieve the information regarding the applied signal and the exact application time via the fiber optic networking system and which are at a distance of 2 kilometres, then start to work for signal processing. The detectors which obtain the signals at the predicted time frame decide if there is a damage on the route by comparing the related signal information with the reference level and transmit the consequent information to host computer of the central control station again through the same fiber optic network.



Right along with the perception, by detecting the difference in signal level, the sensing element which is located just next to the signal application point senses the vibration on the rail, first decides if the signal level is at the reference level and if the signal is effective then it starts to work for signal processing in order to sense the returned signals which will be received from defective rail blocks that are at a distance of 1 Km on the right and left of the route. With the perceived signal after this process, as it covers the reflected signals coming from the damaged sections of the rail, the track damage/output information in addition with the signal level results received from the right and left detectors at a distance of 2 kilometers are generated and this information is transferred to host computer of the central control station through the fiber optic communication line.



4. COMPLETED PROJECTS – RAILACOUSTIC

RailAcoustic® Broken Rail Detection System has been applied at a 90 km section on Konya-Ankara High Speed Train Line (Double Line) and 4 km section of conventional rail line in Ankara. The contractual acceptance of the RailAcoustic System has been granted on 30 November 2018 and the management signatures were completed until 31 December 2018. **The Final Acceptance Test of the system has been accomplished on 31 January 2019,** with a track cutting activity at a random point along the 90 km RailAcoustic equipped double track section. 2 months of trial operation was carried out between 02 December 2018 and 31 January 2019. The operation of the RailAcoustic system shall be carried out by the Railways Authority with the support of Enekom to achieve improvement targets such as land slide detection and animal access detection on the lines during the 2 years warranty period.

SITE INSTALLATION DETAILS FOR 90 KM DOUBE TRACK HIGH SPEED LINE:

In total 69 Sets Of (i) Track Side System Process Panel+ (ii) Signal Receiver (for Each Rail) + (iii) Acoustic Signal Generator (for each rail) have been assembled at 90 Km Site which is at one edge adjacent to the Konya City Center Rail Station. The site installations cover both straight tracks and switch sections.

CONTROL CENTER INSTALLATION DETAILS:

- Control Center location have been chosen by the Railways Authority depending on the existing network infrastructure (i.e. Ankara Eryaman High Speed Train Station which is 100 km far from the RailAcoustic equipped section of rail line).
- Fiber optical cable line along the tracks was already owned by the Railways Authority which is fundamentally used for data

communication (the alternative is radio frequency).

- The Control Center consist of a computer set and the control software of RailAcoustic System.
- The Control Center is capable of communicating the aforementioned 69 sets of site devices separately or entirely on an IP based network communication line.
- The Control Software performs the broken rail detection tests in an automatic manner at the pre-set time periods, or manually by the control center operators.

5. MODULES AND COMPONENTS OF RAILACOUSTIC SYSTEM

Enekom RailAcoustic Broken Rail Detection System is an integrated system comprising of **RAG- 100** the signal application module, **RAR-100** the sensing module, **HBT-100** the fiber optic network communication module and **MKY-100** the central control software module.

The components, lying through an elongated railway track and which the system's main units have a distance of 2 kilometers between each other are operating as attached to a fiber optic based ring topology communication network which operates on an industrial strength IP protocol.

Central Control Software Module monitors the continuity of an uninterrupted communication between each of system components and also central control software module itself. At the same time, it activates a precise timing communication sequence between the neighbouring signal application and sensing units in accordance with a significant synchronization protocol.

The receiving and transmitting modules of each block are operated and scheduled according to the commands coming from the central command software of the central command computer and also the test results are transferred to this respective central control unit again through the same communication line.

Full information is gathered at MKY-100 module and transferred to system operator as visual and audio messages over a 3 LCD display system.

Besides, full data regarding the rail condition of all track segments are constantly recorded to the memory of the central control module for future reference.

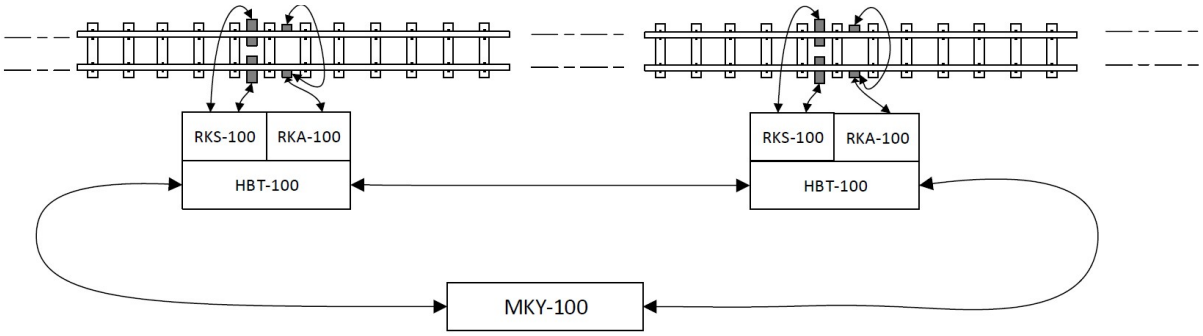
5.1 RAG-100 Vibration Signal Application Module

RAG-100, is an electronic vibration signal application unit, working in 3 second periods of time. The unit is activated by a 32-bit microprocessor, by the 'Start to Run'' command received over the Enekom **HBT-100** fiber optic communication module.

The 'Start to Run'' command is generated and transmitted from **MKY-100** central control software module to each track-side **RAG-100** module one by one. In a normal test procedure, just after 'Start to Run'' command is received from **MKY-100,** five or more vibration block signals with 3 seconds period of time between each are applied to the rail by RAG-100.

RAR-100, the signal sensing module begins to measure the applied signal's strength and conveys the information of whether the measured signal strength is in the accepted range through the fibre optic communication network to the central control software module **MKY-100** via the track-side module connection board which is in the track-side control cabin.

Each **RAG-100** signal application module applies a vibration signal to the rail on the purpose of this rail-resonation induced signal being sensed by a neighbouring sense module **RAR-100**, positioned just 1 mt away and at the same time by two other remote sensing modules **RAR-100,** which are located at a distance of two kilometers on the right and on the left to this signal appication point.



5.2 RAR-100 Vibration Signal Sensing Module

RAR-100 measures and reviews the signal levels received from 2 **RAG-100** in different frequency and time segments which are located on both sides of the attachment point and produces information of wheather a broken rail segment on each block are sensed or not. In addition, it senses whether the signal produced by a **RAG-100** unit which is positioned at a distance of approximately one meter to its attachment point are in reference signal levels or not and also this module detects the reflected signals from the defected or damaged rail segments located on both sides of the track.

RAR-100 works concurrently with the signal application modules **RAG-100,** placed at a distance of 2 kilometers on both sides and when the testing starts, it evaluates the measured signals coming from 2 kilometers on each side, together with the previously measured reference background noise levels transmitted over **HBT-100 communication** module, from the central control software module **MKY-100** and derives a clear signal by sorting out this signal from the background noise. **RAR-100** processes this signal, it produces the information of whether a breakage or a damage exists or not. At the same time, the sensing module reviews the returned reflection signals. At the end, a result information is generated by the module, belonging to both side tracks' physical properties and transferred to central control software module via **HBT-100**.

There are two electronic boards inside the module:

1- **RKS-001_V21** : Vibration signal sensing board

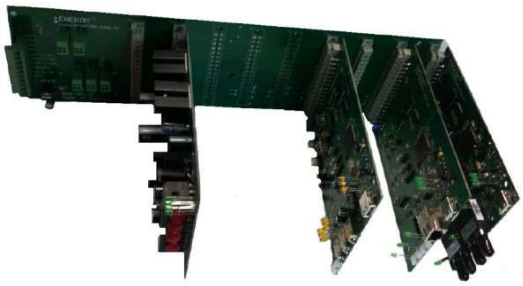
2- **SAK-001_V22** : Vibration signal processing board

The RAR-100 module is constituted by connecting RKS-001_V21 board to SAK-001_V22 board.

5.3 Control Cabin and Electronic Boards

One of the main components of **RailAcoustic** broken rail sensing system is a control cabin which is positioned alongside the track. This cabin provides a solid housing to a number of electronic Boards which are to utilised for controlling the track-side system modules, providing a communication environment in between these Boards and the MKY-100 central control software module via the fiber optic communication environment.

This metal cabin is designed each time in a flexible manner according to the general technical specifications of the railway project in which it is used. In general, it is designed and manufactured in order to protect the electronic system Boards from all climatic and environmental extreme conditions and maintain the system's integrity accordingly. It is supposed to be installed at least 50 cm above the ground level. This metal cabinet is mounted approximately at a distance of 3 meters next to the track.



A standard box contains 7 electronic circuit boards. And these are respectively as follows:

1- FOC-001_V1: Fiber Optic Communication Interface Board
2- RCI-001_V1 : Track Side Module Connection and Processing Board
3- HBT-001_V1 : Voice Communication Board (optional, for voice comm. only)
4- 4- SDI-001_V1 : Driver Board for the Signal Application Module
5- RKB-001_V1 : Enclosure Back Plane Connection Board
6- RKP-001_V1 : Power Conversion Car for the System Boards
7- RKP-002_V1 : Power Conversion Car for the Signal Application Module

5.4 MKY-100 Central Control Software Module

MKY-100 is capable of sensing any broken or damaged rail segment on every 2 kilometer blocks and submitting this information to the operator over a 3-screened computer as visual and audio messages in communication with the IP network directory of the site spread electronic modules belonging to Enekom's **RKAS –V1** Broken Rail Detection System through a track-side fiber optic communication network, named **HBT-100**.

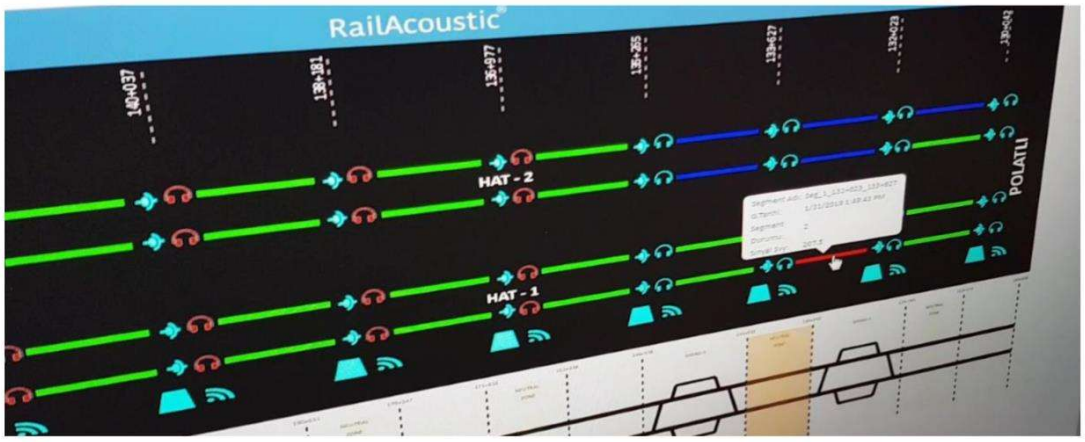
The software is written for Windows and Linux operating systems and developed by using the Java language. In order to be able to login the system or to intervene, a pre-defined encrypted password should be entered.

All the tracks through the route are monitored at the control central by the operator over a dynamic visual, extended on 3 screens enhanced diagrammatically and in visual blocks representing approximately 2 kilometers track. Trouble-free rail blocks on the screen will be represented by white in colour, blocks under test will be represented by yellow and the identified fractured rail segments, if any will be represented by red.

If any breakage is perceived in any rail block, the colour of the represented rail section will turn into red from yellow and the computer will alert out operator audio visually. The audible alarm can be silenced only by the authorized personnel and providing recording at the same time.

Yet another function of **MKY-100** is to make time dependent recording for the diagnostic information of the whole components of the system and for the test results of the rail blocks and also achieving this information when needed.

All information stored in the HDD and flash memory can be printed out by user password only.



Broken Rail Indication On The Monitoring Screen of Command Center Computer

6. ABOUT ENEKOM ENERGY ECOLOGY INFORMATICS & ENGINEERING LTD. IN BRIEF

Enekom was founded under the “Technologies for Life” slogan in 2009 and has been active in electric-electronic and machine design and manufacturing fields in the body of ODTÜ-TEKNOKENT established in the land of Middle East Technical University (METU) in Ankara.

The company has developed new technologies especially in railway and automotive sectors and put them into market successfully thanks to its highly professional personnel who are pioneer and productive in their fields.

Enekom made applications for 4 patents which shall support its unique design and manufacture understanding within these sectors in the next coming years.

There are a number of government backed research projects we continue to work on, at the moment. The company has some technology development and support agreements signed with a number of engineering companies currently.

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