Case Study – Hong Kong Rail

Began in 2007

Hong Kong Railway - Overview

Aim	To provide real-time and continuous monitoring of the structural condition of rail tracks and, using the same monitoring system, to know the location, speed and weight of passing trains.
Location	Hong Kong
System Integrator	The Hong Kong Polytechnic University, Hong Kong
End Customer	MTR Corporation, Hong Kong
Date	2007
Instrumentation	(2) Micron Optics sm130, Optical Sensing Interrogator (14) Micron Optics si425, Optical Sensing Interrogator
Sensors	FBG Strain Sensors, HKPU Design FBG Temperature Sensors, HKPU Design
Software	Customer Designed Software, LabVIEW
FBG Technology Benefit	Immunity to EMI, long life-time, and multiplexing capabilities.

Hong Kong Railway

- Motivation
  - Improve safety, reliability and efficiency
  - Transform conventional systems into *"Smart Railways"*
  - Develop *"Smart Railway Sensor Network"* by incorporating optical sensory nerves at various parts of the railway networks
- History
  - The Department of Electrical Engineering at the Hong Kong Polytechnic University has been implementing field projects at MTR Corporation employing FBG sensor arrays for temperature and strain measurements on rail tracks, train wagons and bogies.
  - FBG sensors have been monitored using FBG interrogators developed and manufactured by Micron Optics.

Hong Kong Railway

- The FBG sensors are used to monitor many important railway sub-systems such as:
  - Axle counters
  - Anti-derailment monitor
  - Train load detectors
  - Continuous rail crack detectors
  - and to monitor the instantaneous vibration signatures of passing trains at selected locations.
- Allows maxim network capacity, optimization of electricity utilization and effective detection of potential operational hazards to enhance overall service safety and quality
- The real-time monitoring system is fully operational and currently in service and provides information on:
  - Stresses experienced during service, both static and dynamic, under different operational conditions.
  - The loading and traffic status of the passenger cars.
  - Temperature-induced stresses and deformations on rails and carriages.
  - Temperatures in and around axles and wheel brakes.
  - Dynamic axle vibrations due to corrosion and bearing wear .
  - Also, other parameters relevant to railroad health monitoring.

Hong Kong Railway

- All FBG sensors are connected to Micron Optics FBG interrogators. One such location is in the MTR depot at Ho Tun Lau (HTL).

Axial counting & Derailment prevention

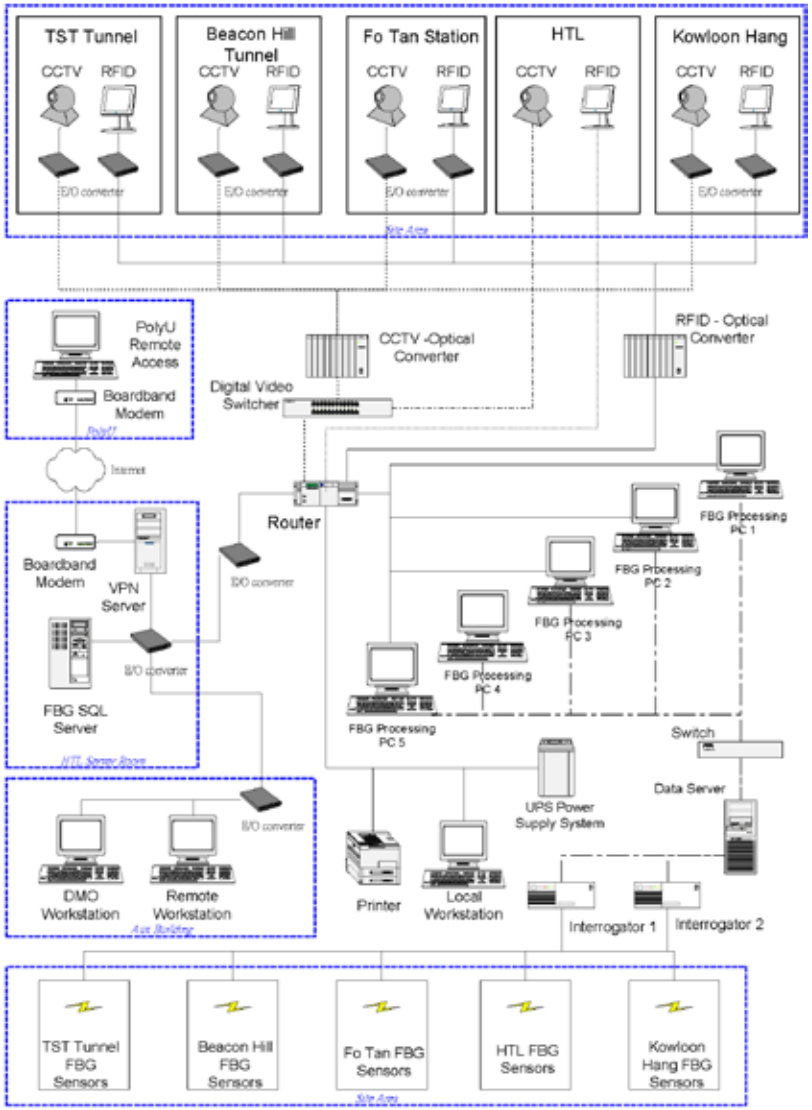
- Axial counting to ensure the same number of cars entering and leaving tunnels.
- Wheel weighing system to flag unbalanced load which may cause train damage or even derailment.

Train Identification & Scheduling

- To identify different types of trains on the railway system by recognizing their unique signature classes.
- To monitor variations in the response of trains for maintenance scheduling.

FBG Sensing System for Health Monitoring Railway Application

- Schematic diagram indicating a train monitoring system installed on five sites along the Hong Kong East Rail. The East Rail is about 36 km long and runs from Tsim Sha Tsui station to Lo Wo station.
- Each site uses approximately 10 FBG sensors on the rail tracks to measure the strain induced on the tracks when a train passes over them. These are traced back to the wagons by their IDs.
- Dynamic data collected at 1KHz is processed and evaluated to determine whether key parameters monitored by the railway engineers fall within acceptable ranges.
- The system uses a rugged system and redundant backup to ensure continuous availability of data.



- FBG sensors can be readily installed on the left and right rails (for the two wheels of the same axle) at a low cost to measure important parameters. Railway engineers monitoring the anti-derailment ratio of passing trains are able to detect imbalances on the two sides of rail wheels.
- The FBG sensors are epoxied on the rail tracks and are connected by armored optical cables to an optical fiber backbone that runs along the entire route of the East Rail.

FBG strain sensor installed on the track.

FBG Sensing System for Health Monitoring Railway Application

- Cable junction box used for splicing sensor fiber cables to the backbone fiber trunk running along the rail tracks.

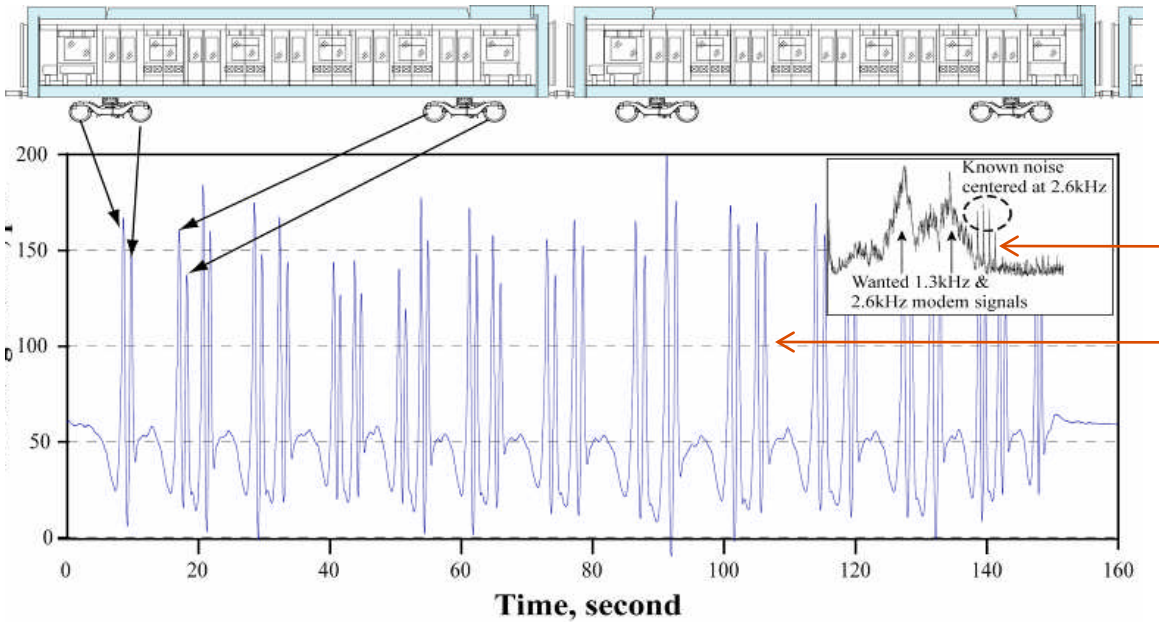
- When closed, the junction box protects splices and/or optical connectors from the external environment

- Installed junction box is secured to the rail track utility area.

- Enclosed junction box with FBG cables running to the tracks.

FBG Sensing System for Health Monitoring Railway Application

- A typical measured result of an FBG installed on a MTR rail track. Each individual wheel passing through the FBG sensor is clearly identifiable.
- Since the distances between the wheels are known, train speed is easily computed by using the data from even just one FBG sensor.
- The wavelength shift, i.e., the amplitude of the peaks shown in the figure below is related to the force applied to the sensor by the wheel passing over it.
- FBG sensors on rail tracks are also used as axle counters and at the same time provide important information for speed and weight measurements.



Noise from Electrical Sensors

Clean FBG signal response

Results & Acknowledgements

- Results
  - The field measurement results together with the experiences gained from these projects demonstrated that distributed use of Fiber Bragg Grating Sensors represents an excellent solution for the realization of smart condition monitoring systems for the railway industry.
  - Rail track monitoring systems (for the detection of wheel/rail interface response) are now used by the railway industry.
  - The Hong Kong Polytechnic University is sharing local experiences within Hong Kong as a reference to promote the Optical Monitoring Systems for broad deployment by railway operators/consultants in other parts of the world.
- Acknowledgements

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