White Paper

Wireless Magnetic Vehicle Detection System: ClairGeo-M

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TraffiClair Technology Co., Ltd.

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1. Overview

The wireless magnetic vehicle detection system, as an advanced traffic information detection method, is capable of monitoring data such as traffic volume, speed, average speed, occupancy time, vehicle length, queue length, etc. It is an innovative product in the field of traffic flow detection, widely used in the transportation development of many cities in China and has gained industry recognition. Wireless magnetic vehicle detection technology has become an essential foundational application in the development of intelligent urban transportation. It can play a crucial role in the following aspects:

- Macroscopic monitoring of the overall traffic conditions on urban roads enables timely understanding of traffic flow at different times throughout the city. This allows for a macro-level assessment of the city's traffic situation and a micro-level analysis of real-time traffic flow on individual road segments.
- Automatic detection of traffic congestion and other events allows for alerting the command center, enabling dispatchers to allocate law enforcement resources effectively and alleviate traffic congestion.
- Providing vehicle detection data to traffic signal controllers enables the implementation of signal sensing, adaptive control, and single-point optimization. Through regional linkage, further coordination control is achieved. This dynamic adjustment optimizes traffic light cycles, reduces waiting time at intersections, and improves the efficiency of vehicle passage on urban roads.
- Supplying traffic flow data for traffic guidance systems enhances the capabilities of these systems.
- Offering essential design criteria for urban traffic organization optimization and traffic infrastructure planning and construction.

2. Detection Principle

Between the Earth's North and South Poles, the Earth's magnetic field is distributed. When vehicles on the road pass through the detection area of the magnetic sensor, the ferromagnetic materials inside the vehicles disturb the Earth's magnetic field. This disturbance results in a change in the distribution of the Earth's magnetic field in that area (as illustrated in the diagram below).

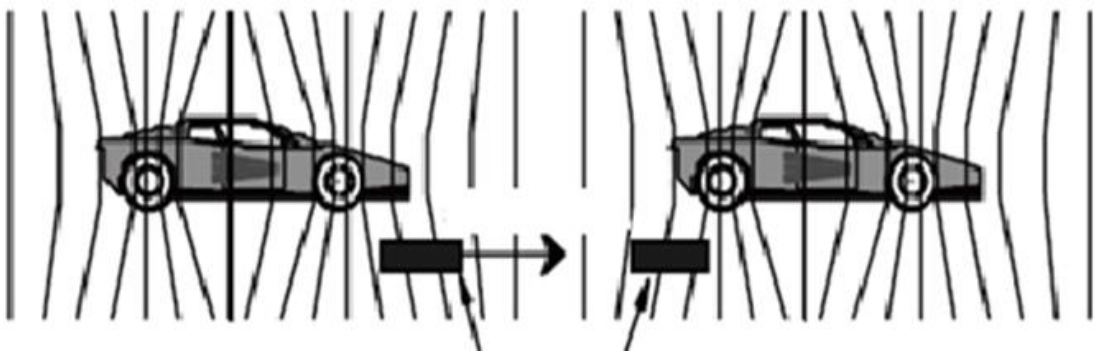
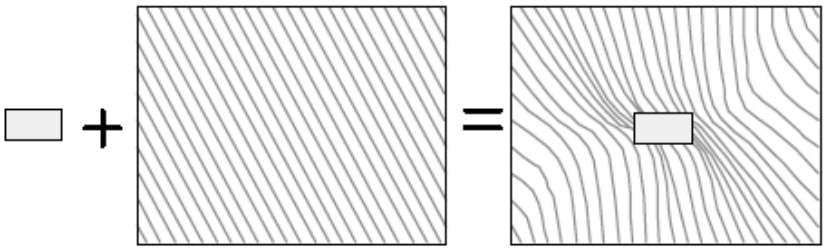


Diagram of Vehicle Disturbing the Earth's Magnetic Field

The magnetic reluctance sensor inside the magnetic detector can sensitively capture this magnetic field variation and convert it into an electrical signal. Subsequently, through the processing capabilities of the miniature computer within the magnetic detector, accurate information about the passage of vehicles is generated.

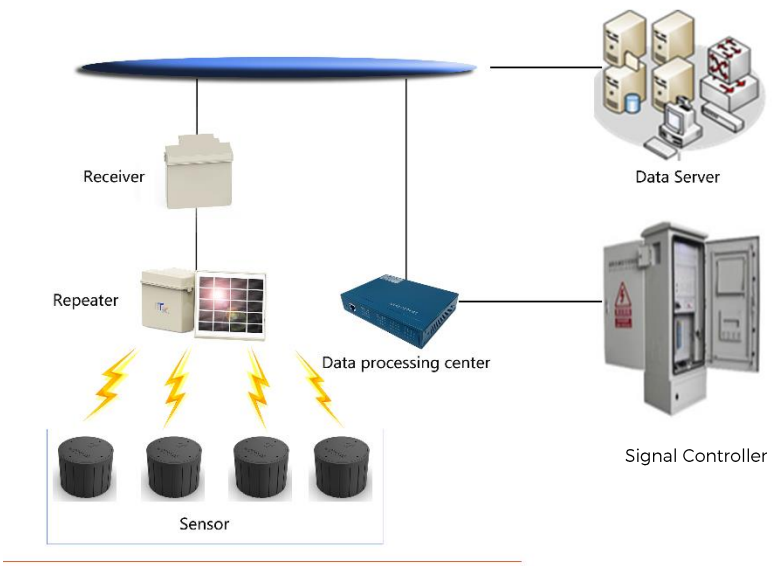


Iron-containing object + Balanced magnetic field = Magnetic disturbance

A schematic representation of the distortion caused by a ferromagnetic object in a uniform magnetic field.

3. The physical structure of the system

The magnetic detection system consists of several magnetic detectors, a receiver (referred to as AP), and a data processor for converting data. The wireless sensor network employed by the system is based on ZigBee technology, following the IEEE 802.15.4 standard. To ensure the quality of the wireless communication network, several communication repeaters (referred to as RP) may be included. The magnetic detectors, receiver, repeaters, and data processor together form a complete wireless magnetic vehicle detection system.



A schematic diagram of the system's physical structure

The functions of each component in the system are as follows:

- **Detectors**: Used for data collection, typically installed within lanes to detect the presence of vehicles and their passage.
- **Receiver (AP):** Responsible for receiving detection data from the detectors, processing the data, and transmitting it upstream.
- **Repeater (RP):** Employed to support detectors located outside the wireless range of the receiver.
- **Data Processing Center:** Receives detection data from the receiver, processes it using specific algorithms, and provides the processed data to the traffic signal controller via IO. Simultaneously, it performs local storage of relevant traffic data and can periodically upload detection data to the data server at the traffic control center.

Typical device configuration methods are as follows:

Detector Configuration Method:
- Configuration depends on the specific conditions of each location.
- Install one detector per lane, and for speed measurement, install two detectors per lane.

Repeater (RP) Configuration Method:

- Used for intersection signal control.
- Configure one repeater per direction.

Receiver (AP) Configuration Method:
- Configure one receiver per intersection.

Data Processing Center Configuration Method:
- Configure one data processing center per intersection.

4. Data Flow

Magnetic detection primarily collects data such as traffic flow, occupancy time, speed, and time parameters. This data is transmitted via a network to the platform data processing center. The common method involves transferring the signal switch quantity from the detection system to the intersection's signal controller, facilitating signal induction control, and other related functionalities.

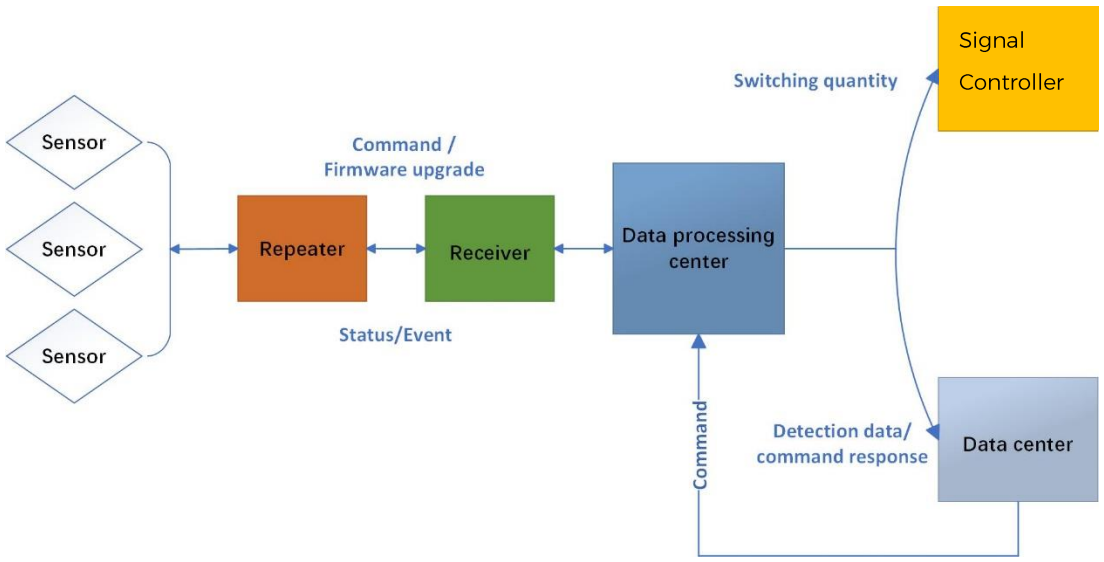


Diagram of Data Flow



Diagram of System Structure

5. ClairGeo-M Product Advantages

The ClairGeo-MDET is a wireless anti-interference vehicle detection system with strong anti-interference capabilities, suitable for various complex signal environments in urban road networks, ensuring higher accuracy in detection data. Enhanced by the outstanding waterproof performance of the detectors, the entire system can maintain a stable and reliable operational status in any harsh natural environment.

The ClairGeo-MDET wireless anti-interference vehicle detection system can be applied to various scenarios, including intersections, road segments, bottleneck intersections, tunnels, elevated bridges, and other special detection situations. It facilitates the implementation of solutions such as intersection signal control, full induction control, bottleneck control, overflow control, anti-overflow control, and special requirement control.

6. Specifications

6.1 Product Specifications

- The system features three-axis (X, Y, Z) detection with a data acquisition frequency of 128Hz. The detector, installed in the guidance lane, ensures a stable detection zone that is independent of vehicle speed, mass, or model. It prevents interference signals and data from adjacent lanes, whether vehicles are moving or stationary.
- Utilizes license-free 2.4G ISM band wireless transmission with encrypted data.
- Meets all-weather operational requirements, capable of functioning in adverse weather conditions such as rain, snow, wind, and fog.
- Interface options include RS485/RS232, Ethernet, and IO voltage level/switch quantity. Real-time detection data is transmitted through an Ethernet port to the central system. Additionally, it can provide real-time switch quantity/voltage level data directly to on-site traffic signal controllers or other control devices via the I/O interface.
- Traffic flow accuracy not less than 99%.
- Average occupancy rate accuracy not less than 95%.
- Average vehicle speed relative error less than 2 km/h, detecting speeds in the range of 0 to 180 km/h.
- Speed detection relative error less than 2 km/h, with a detection speed range of 0 to 180 km/h.
- The detection zone has 16 levels of adjustable sensitivity, accommodating various vehicle types and road surface environments.
- Local data storage duration: greater than 180 days.
- Electromagnetic interference protection level: <IEC61000-4-2 2008> 4th level of electrostatic discharge resistance, <IEC61000-4-3 2008> 3rd level of electromagnetic radiation immunity.
- To enhance the system's resistance to interference in complex signal environments, the following measures have been implemented:
  - By increasing the signal-to-noise ratio of the equipment.
  - By improving out-of-band suppression capabilities.
  - By adding an automatic system binding function to achieve interference resistance.

  Transmission distances include:
  - Flexible Deployment of Detection Points. The position of detection points can be flexibly arranged based on owner requirements. The visual distance from the receiver to the relay point meets deployment requirements ranging from 0 to 350 meters.
  - Wireless Reception Distance - Relay to Detector. Visual distance: 60 meters.
  - Wireless Reception Distance - Receiver to Detector. Visual distance: 60 meters.
- Interference Resistance Performance in Complex Signal Environments:

Interference Resistance: When the equipment receives weak signals, even in the presence of the following interference signals, it can still ensure a frame length of 20 bytes with a frame loss rate of less than 1%. (Weak signal description: Received signal strength -78dBm)

- Out-of-Band High-Frequency Interference Signal Strength: -8dBm.
- Out-of-Band Low-Frequency Interference Signal Strength: 7dBm.
- In-Band Adjacent Frequency Interference Signal Strength: -44dBm.
- Same-Frequency WiFi Interference Signal Strength:

    - ◆ WiFi actual application protocol IEEE 802.11b/g/n: -40dBm.
    - ◆ Continuous transmission of WiFi: -80dBm.
  - ■ Same-Frequency Device Interference Signal Strength: -78dBm; Mean Time Between Failures (MTBF) > 10,000 hours.
- Average Failure-Free Rate: Not less than 10 million cycles on average.
- Detector with Automatic Power-off Restart Function
- Remote Firmware Upgrade for All System Devices
- Detector with Local Self-Calibration Function Based on Local Conditions
- No Need for Pipeline Installation for Detection Equipment
- Quick and Simple Installation, Minimal Road Occupancy Time, Easy Maintenance
- Intersection Equipment Remotely Managed via Network
- Low-Power Communication Protocol, Extended Functionality, and Interchangeability for Wireless Communication System
- Modulation Method: Utilizes Direct Sequence Spread Spectrum (Offset Quadrature Phase Shift Keying Technology).
- Surge and Electrostatic Discharge Protection: The detection system is resistant to surge (impact) and electrostatic discharge interference, preventing damage caused by surge currents and transient changes from the input, output, or main power supply line.
- Sealed Detector with Ultrasonic Welding Technology: Ensures long-term water resistance.
- Wireless Communication Rate Between Devices: 250kbps.
- Operating Environment Temperature: -45±2℃ to +85±2℃.
- Humidity: ≤95% (non-condensing).
- Power Supply: AC voltage (220V, AC, 1±10%) or DC voltage (48V±4V, DC).
- Protection Rating: Detector IP68; Relay points and receivers IP67.
- Power Consumption: Less than 5W, ensuring usability with solar power.

6.2 Traffic Flow Collection Technology

Research on traffic information collection technology has been ongoing for many years. As of today, various traffic information collection technologies have been applied in practice. The traffic information collected through these technologies mainly includes traffic volume, lane occupancy, vehicle speed, vehicle type, and headway.

The development initially started with contact-based traffic information collection technology, with representatives being piezoelectric sensors, pressure tube detection, loop coil detection, and magnetic detection. These collection devices share a common characteristic – they are buried under the road surface, and when a vehicle passes over the collection device, it induces changes in pressure, electric field, or magnetic field. Finally, the collection device converts these changes in force and field into the required traffic information. Over the years, contact-based traffic information collection technology has become mature, with high measurement accuracy and ease of control, dominating the field of traffic information collection. However, these

contact-based traffic collection devices have inevitable drawbacks. Firstly, installation and maintenance are difficult, requiring traffic interruption and road damage. Secondly, with an increase in the number of vehicles, the pressure exerted by vehicles on the road shortens the lifespan of these devices. As roads expand rapidly, the proliferation of roads in various environmental conditions, along with issues such as road subsidence, salt-alkali, and freezing, significantly affects the use of contact-based traffic information collection devices. All these factors contribute to the rising cost of their usage.

The recently developed non-contact traffic information collection devices on the road do not suffer from difficulties in installation and maintenance or short lifespans. They are mainly divided into two categories: wave frequency detection and video detection. Wave frequency detection can be further divided into microwave, ultrasonic, and infrared. Among these, only ultrasonic detection can perform single-lane traffic information collection, while the others can simultaneously collect multi-lane traffic information. Due to simple installation and maintenance, the development of non-contact road traffic information collection technology has been very rapid. Video detection utilizes the principle of changes in background grayscale caused by a vehicle entering the detection area. It is intuitive and reliable but is greatly affected by illumination and weather conditions. Wave frequency detection utilizes the change in return time or frequency of electromagnetic waves caused by a vehicle passing through the detection area. Infrared detection provides clear vehicle type resolution but is greatly affected by weather conditions, while ultrasonic detection accurately determines vehicle speed and type but is limited to top-down forward installation, collecting information for only one lane. However, microwave detection has low accuracy when vehicles are traveling at low speeds.

Wireless sensor networks are a new technology that integrates short-range wireless communication technology, microelectronic sensors, and embedded systems. It is gradually being used in related fields that require data collection and detection, such as intelligent transportation systems.

6.3 Comparison of Several Main Traffic Flow Detection Methods

	Wireless Magnetic Vehicle Detection	Inductive Loops	Video Detector	Microwave Radar
Installation	The installation process only requires digging a 102mm diameter hole with a depth of 80mm, causing minimal disruption to the	The installation process involves cutting the road surface, causing severe damage and impacting the road's lifespan.	It requires the use of poles, either with assistance or as standalone structures, and wiring must be threaded through.	Poles are required, especially for forward-facing installations, where gantry structures or L-shaped poles are needed.

	road surface. It does not require wiring, making the construction process convenient. Additionally, the construction process has a short impact on road occupancy time.	Wiring is required for each loop coil, making the construction process cumbersome. The construction process also occupies the road for an extended period. Additionally, special road sections such as bridges and tunnels pose challenges for installation.		
Use	The deformation or unevenness of the road surface does not affect the measurement effectiveness, reducing maintenance workload. For reasons such as road maintenance, the equipment can be removed and reused. There are no feedline issues. In the case of road realignment, only the original equipment needs to be removed and reinstalled for continued use.	Deformation or unevenness of the road surface caused by factors such as the passage of heavy vehicles, road maintenance, thawing in high latitudes, and summer conditions in low latitudes can affect the detection effectiveness, increasing maintenance workload. The equipment cannot be reused. Feedline damage affects usability. For road realignment, recutting and reinstalling are required.	Video detection has high illumination requirements, and adverse weather conditions such as wind, rain, snow, and fog, as well as backlighting, can affect detection accuracy.	It cannot detect vehicle speeds below 20 kilometers per hour.

Maintenance	The maintenance process has a short impact on road occupancy time. In the case of a single detector malfunction, it only needs to be removed for repairs, without the need for recutting the road surface, and the original installation hole can be reused.	The maintenance process has a long impact on road occupancy time. In the case of a single loop coil damage, it cannot be cut at the original location, causing damage to the road surface, affecting aesthetics and lifespan. The average maintenance frequency is high (annual average damage rate of 20%).	The maintenance process occupies the road for an extended period and requires high-altitude operations.	The need for forward-facing installation on gantry structures or L-shaped beams makes maintenance complicated.
Compatibility	It features multiple interfaces, such as RS485/RS232, Ethernet port, digital and analog inputs/outputs, meeting various traffic interface requirements and seamlessly integrating into different systems and platforms.	The compatibility of traffic information collection systems based on other technologies is relatively poor.	In addition to the RJ45 interface, it can meet the requirements of other systems, making it suitable for various road segment applications.	In addition to the RJ45 interface, it can meet the requirements of other systems, making it suitable for various road segment applications.

7. System Applications

7.1 Intersection Detection

Intersection detection is commonly used for signal induction control, adaptive control, single-point optimization, regional linkage coordination control, and intersection service level detection.

It real-time monitors the passage status of vehicles on the road, providing accurate traffic information (including traffic flow, occupancy time, pressure occupancy status, etc.) to the signal control system. This ensures that the signal control system can accurately and reasonably adjust the signal light cycle automatically, improving the efficiency of vehicle passage at traffic intersections and effectively utilizing road resources.

Traditional intersection control systems mostly adopt fixed timing cycles, configuring different green and red-light signal durations for different intersections, phases, directions, and time periods. This configuration scheme is reliable, stable, and easy to implement, but it also has issues:

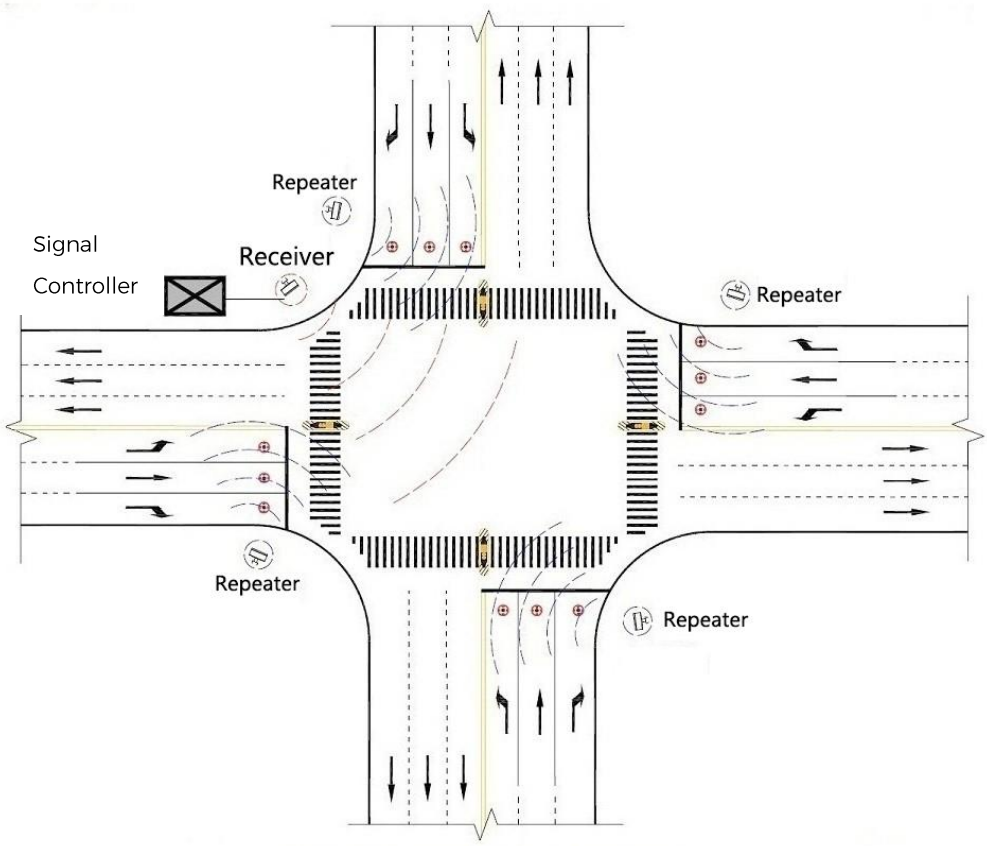
1. The durations of green and red lights for different phases heavily rely on the on-site personnel's experience and judgment, lacking accurate traffic flow data as a basis.
2. Although different durations can be configured for peak and off-peak periods, this configuration depends entirely on the linear increase or decrease of road traffic. During sudden abnormal periods, it can lead to congestion or even regional road paralysis.
3. Most fixed timing mainly focuses on relieving congestion at intersections, and during nighttime periods, it cannot achieve rapid phase changes like "green when there is a car, red when there is none."
4. Under fixed configurations, in the case of abnormal road traffic causing widespread congestion, it cannot be detected early, leading to delayed coordination of law enforcement.
5. At the decision-making level, due to a lack of a clear concept and accurate data support for urban road traffic conditions, it is not easy to improve the traffic environment and optimize traffic control strategies.

With the rise of intelligent traffic control, in recent years, the use of real-time control of signal red-green cycles based on traffic detection methods to maximize traffic efficiency has become mature and widely adopted. It has received consistent praise from customers. The effectiveness of dynamic configuration of traffic lights based on detection methods, especially in the field of induction control, is particularly prominent.

The buried positions of the wireless detectors are specified based on the requirements of different signal controller manufacturers (as shown below), generally one for each lane. For precise speed measurement, two detectors can be buried for each lane. Install one receiver near each intersection signal controller and install relays in other directions. Through the intelligent data processor, the data is accessed to the signal controller via IO signals.

Through the IO interface, necessary detection data, such as traffic flow, vehicle occupancy status, vehicle speed, and time occupancy rate, are provided to the signal control system. The real-time detection data obtained by the signal system is processed through specific algorithms to calculate the optimal phase configuration time. This, in turn, controls the red-green light cycle,

achieving the goal of "minimizing the waiting time for all vehicles at the intersection."



Due to its capability of long-range wireless communication, it can be used for special control methods at intersections and installed at specified locations according to the signal control scheme requirements. For example, burying two rows of detectors on the road segment between the upstream and downstream of the intersection can be used to judge the queue length based on the distance traveled by vehicles. The row of detectors closer to the entrance is used to determine if the traffic is moving slowly, while the row farther away is used to assess congestion. By combining these data with specific algorithms in the system, it is possible to accurately determine the congestion and service level of the intersection.

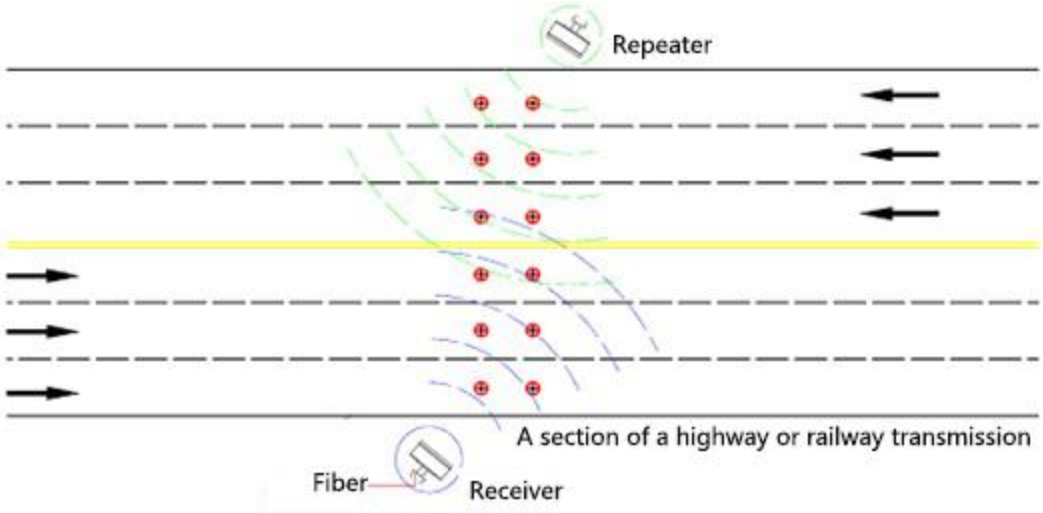


7.2 Segment Detection

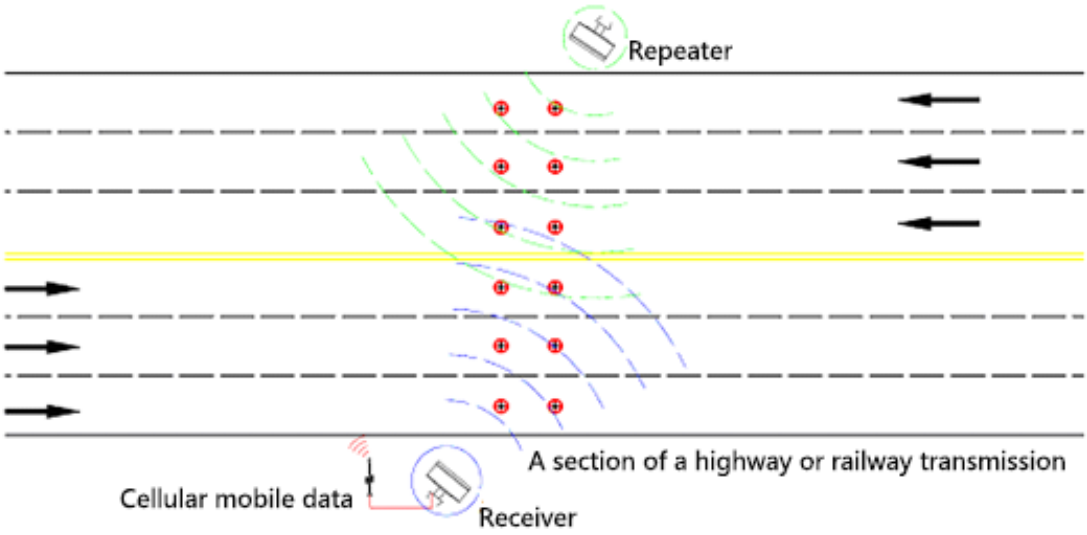
Road segment detection is commonly used for traffic flow information collection, congestion detection, traffic guidance, information dissemination, etc.

A road segment detection system provides not only traffic volume data but also parameters such as vehicle speed, occupancy rate, headway, and vehicle type classification. In cases where some road segments lack infrastructure such as power and communication, solar power and cellular mobile network communication can be employed.

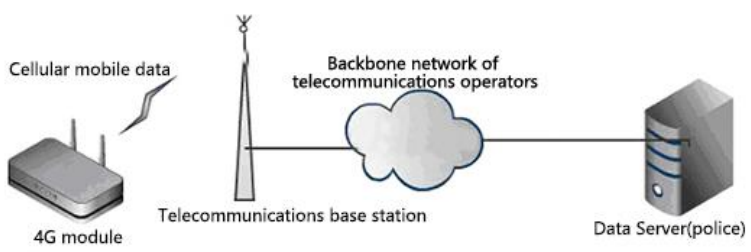
(1) Fiber network connection: Connect the receiver's Ethernet port to the optical transceiver, which is connected to the central IP network via optical fiber. The system structure is as follows:



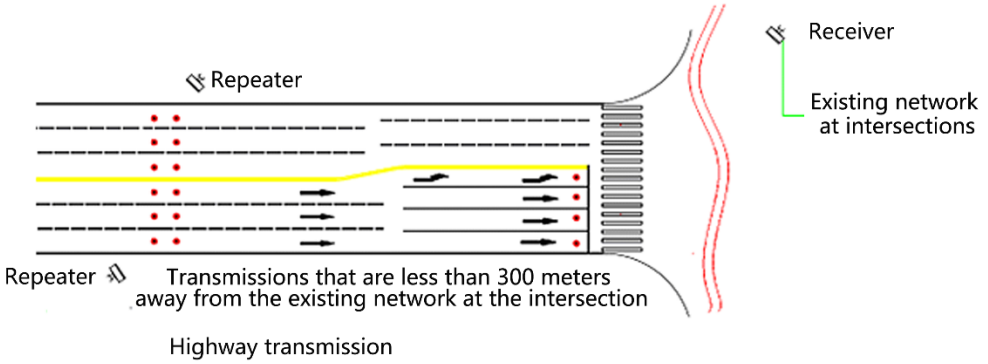
(2) Cellular mobile network connection: Connect the receiver's Ethernet port to the cellular mobile network, establishing an uplink to the central IP network. The system structure is as follows:



Transmitting data to the command center server via the cellular mobile network, the system structure is as follows:



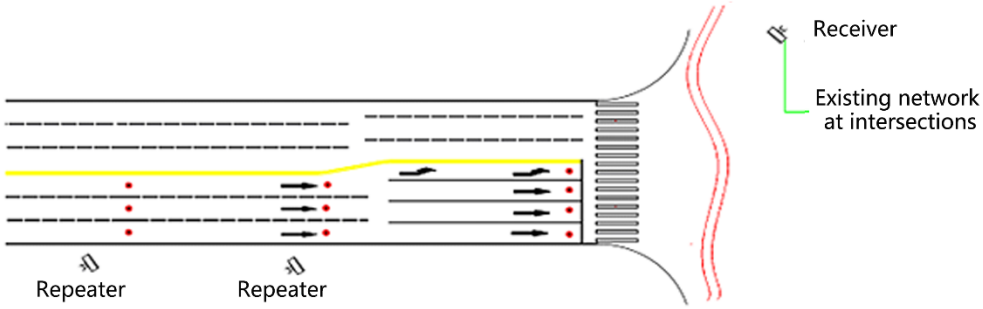
(3) Connecting to the existing network of the same section: If the section is within 300 meters of the intersection network, install the receiver at the intersection, and connect to the intersection's existing network via the receiver's Ethernet port, uplinking to the central IP network. The system structure is as follows:



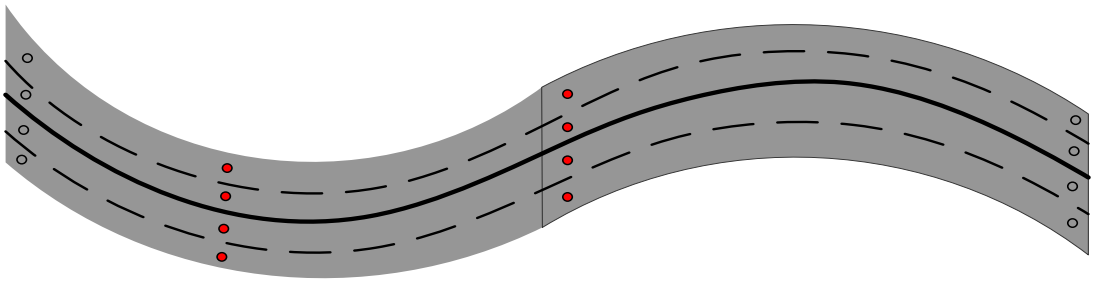
7.3 Special Applications

For some special usage requirements and specific control algorithms, it is necessary to provide special detection data or specific detection point locations. This kind of usage is often more flexible and has very noticeable effects. For example, queue length measurement, ramp (tunnel) control, variable lanes, etc.

(1) Queue Length Measurement: Install a row of detectors in the direction of the intersection's stop line, and simultaneously deploy two rows of detectors at the section location to calculate the queue length of vehicles. This information is applied in induction control, guidance systems, information dissemination, etc.

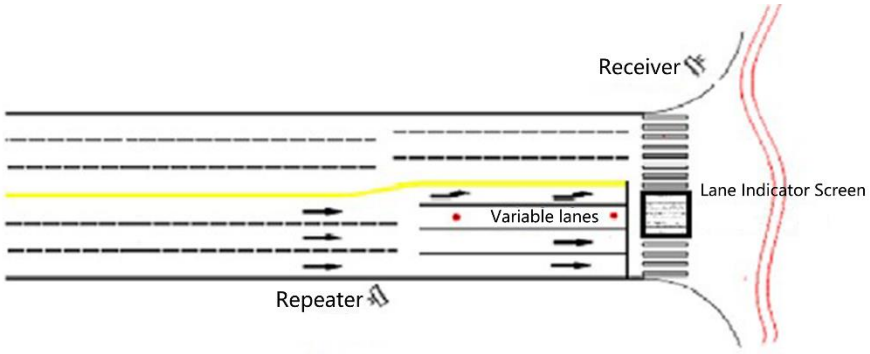


(2) Ramp (Tunnel) Control: Install detectors at the entrances and exits of ramps or tunnels. By detecting vehicles entering and exiting the ramp or tunnel, the number of vehicles in the ramp or tunnel can be calculated for a specific period. Multiple rows of detectors can be installed inside the tunnel to detect accidents and congestion conditions within the tunnel.



Tunnel Control

(3) Variable Lane: In situations where static road network resources are limited and there is a significant difference in the distribution of left-turn and through traffic during peak and off-peak hours, variable lane control can be considered to efficiently utilize limited resources. For example, when there is congestion in the left-turn lane but smooth flow in the through lane, the lane closest to the left-turn can be changed to a left-turn lane. Conversely, when there is smooth flow in the left-turn lane but congestion in the through lane, the lane closest to the left-turn can be changed to a through lane.



(4) Other Applications, such as parking lot space detection, highway speed measurement, highway intersection traffic control, enforcement, etc.

8. Main Products

8.1 Detector

The detector is used for data collection, employing highly sensitive magnetic resistance sensors to detect vehicle information by monitoring changes in the Earth's magnetic field to determine the presence or passage of a vehicle.

Each detection event recorded by the detector includes two pieces of data: vehicle entry and

vehicle exit. Each is timestamped, making data processing very convenient. A single detector can calculate metrics such as traffic flow and lane occupancy. When two detectors are paired in the same lane, they can be used to detect speed, and the paired data can exclude mismatches caused by vehicles changing lanes. Once the speed is known, it can be used to estimate vehicle length, time occupancy, and more. Detection data is transmitted via a low-power wireless communication protocol to the receiver or is relayed to the receiver by a repeater.

Components

The detector consists of the following main components: shell, battery, directional antenna, circuit board, and filling material.

Functional Features

- Vehicle Speed and Length

In typical traffic management systems, placing a detector in the middle of a lane allows for the detection of vehicles either present or passing through. For instance, installing two detectors at specific distances on the same lane and setting the precise distance between them in the software enables the measurement of vehicle speed and length.

- Quick and Easy Installation

Each detector can be installed within 5-10 minutes. During the installation process, a hole with a diameter of 102mm and a depth of 80-90mm is drilled at the designated location. The detector is then placed into the hole, appropriately adjusted to align with the traffic direction, and finally sealed with geomagnetic sealing glue.

- Self-Calibration Function

The geomagnetic detector utilizes advanced magneto resistive sensing technology to measure the Earth's magnetic field composed of X, Y, and Z axes at a frequency of 128Hz. When a vehicle is present, a noticeable change occurs in the magnetic field of the X, Y, or Z axis.

In the absence of a vehicle, each detector continuously measures the background magnetic field, estimating a reference value. Each detector automatically calibrates based on the magnetic field at its installation location and any long-term changes in the local magnetic field, causing the reference value to change over time.

By detecting the passage and presence of vehicles, both detection and non-detection thresholds are configurable relative reference values. When an event occurs, such as the absolute value of the measured magnetic field exceeding the detection threshold or falling below the threshold at the end of the event, reports are transmitted to the repeater and receiver.

The precision signal processing algorithms within each detector provide highly accurate vehicle detection and the ability to distinguish between vehicles in adjacent lanes or closely spaced

vehicles in the same lane. Each sensor can adjust detection and non-detection thresholds to avoid potential duplicate calculations.

- Configurable Detection Area and Sensitivity

Vehicle detection at intersections can have various requirements, including detecting bicycles, motorcycles, cars, trucks, and even light rail trains. The wireless sensor offers 16 different modes that can be configured, providing varying magnetic field sensitivities and settings for the vehicle detection zone.

- Remote Firmware Updates

Through the management center and wireless network, firmware updates can be performed on the front-end detectors. This allows for timely updates to the front-end detectors when new firmware versions are released, ensuring the system remains up-to-date.

- Long Detector Lifespan

If there is no vehicle detection data, the communication module enters a sleep mode (i.e., low-power mode). To distinguish whether there are no vehicles or if the detector itself is malfunctioning, communication with the upper end is maintained within a specified time, even if there is no vehicle detection data. The default value is 30 seconds.

The detector has a small footprint, buried in the middle of the lane, capable of withstanding temperature environments ranging from -40°C to +85°C. Additionally, it employs power-saving technologies in its design, uses long-life batteries, and offers flexible settings. The remote firmware update feature allows new firmware to be downloaded from the center after the detector is installed.

Technical parameters

Brand: TraffiClair

Model: ClairGeo-MDET



- Appearance and Dimensions: 94mm x 64.5mm
- Wireless Channel: 2.4GHz.
- Channel Bandwidth: 2MHz.
- Channels: 16.
- Reception/Transmission Rate: 250kbps.
- Antenna Type: Patch Microstrip Antenna.
- Antenna Range: 120° (±60°).
- Reception Sensitivity: -100dBm.

- Detection Mode: Presence/Pass-through.
- Detection Sensitivity: 0 to 15 levels.
- Background Magnetic Field Range: ±6Gs.
- Detection Method: Earth's Magnetic Field Three-axis Detection, Adjustable Threshold, Automatic Calibration of Background Magnetic Field Changes.
- Detection Range: Adjustable from 0 to 3 meters.
- Types of Detected Vehicles: Iron Three-wheelers, Trucks, Trailers, Buses, Cars, and other common vehicle types.
- Frequency: 25MHz.
- Flash Memory: 128KB.
- Random Access Memory (RAM): 16KB.
- Wake-up Time: 3.5μS.
- Flow Accuracy Rate ≥99%.
- Speed Accuracy Rate: ≥98%.
- Occupancy Time Accuracy Rate: ≥98%.
- Headway Time Accuracy Rate: ≥98%.
- Speed Detection Range: 0 to 180km/h.
- Speed Relative Error: ±2km/h.
- Average Power Consumption: Less than 10dBm.
- Lifespan: Calculated for 20,000 passes per day on a single lane, continuous operation for 5 years.
- Power Supply: Li-SOCl2 3.6V Battery, 18Ah.
- Protection Level: IP68.
- Protection Structure Design: Double-layer Shell Structure Design, Dual Impact Resistance.
- Protection Sealing Technology: Double-layer Ultrasonic Welding Sealing, Double-layer Waterproofing.
- Environmental Temperature: -45±2℃ to +85±2℃.
- Humidity: ≤95% non-condensing.
- Detector Sealing Method: The detector adopts integrated sealing without screws or threads to ensure long-term waterproofing.
- Installation Method: Installed using geomagnetic adhesive sleeves, with the detector's upper surface flush with the road surface; the drilling diameter is 102mm, with a depth of 70-80mm.

Installation Configuration

1) Configuration Method:

- When installed at intersections for signal control, typically one detector is installed per lane, with the detector's burial position determined according to the requirements of the signal control system. For speed detection on road segments, two detectors are installed per lane, with a spacing of 4 meters between paired detectors.

2) Installation Method:

- Begin by using a water drill to create installation holes at marked positions, with a depth of 70-80mm and a diameter of 102mm. Ensure thorough cleaning of the holes.

- Level the bottom of the installation holes and ensure the detectors are placed horizontally, with the top of the detector flush with the ground surface.

- Install the detectors into the installation holes and record the detector's ID number and installation location.

- Fill the gaps around the installation holes with geomagnetic sealing adhesive, ensuring they are fully sealed. Verify that the surface of the sealed detectors is flush with the road surface and wait for 2-5 minutes for the adhesive to cure.

8.2 Repeater

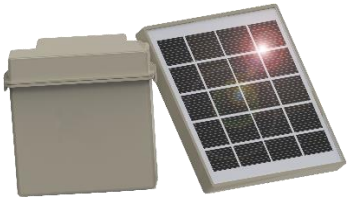
When the detector is positioned beyond the receiver's reception range, a repeater can be employed to extend the transmission distance, facilitating bidirectional data transfer between the detector and the receiver. The repeater is battery-powered and does not require an external power source.

Components:
The main components of the repeater include: the shell, battery, directional antenna, integrated circuit board, and connectors.

Features:

- Expanded Range and Coverage: A repeater can amplify the signal amplitude and extend the coverage range of a receiver unit. The installation position of the repeater must allow it to support the detectors or daisy-chained repeaters or receivers within its field of view and range. The maximum distance between the repeater and the receiver or another repeater is 310 meters, thus significantly extending the coverage range of a receiver.
- Bidirectional Wireless Communication: Enables bidirectional communication between detectors and repeaters, repeaters and receivers, and repeaters and other repeaters.
- Battery Powered: Operates on low-power consumption modes for energy efficiency.
- Wireless Firmware Upgrade via Access Points.
- Remote Firmware Upgrades.
- Simple Installation: Can be installed at any location that provides good signal coverage to the receiver or connected repeaters.
- No Adjustment or Calibration Required.

Technical parameters
Brand: TraffiClair
Model: ClairGeo-MRPT



- Wireless Channel: 2.4GHz.
- Channel Bandwidth: 2MHz.
- Channels: 16.
- Reception/Transmission Rate: 250kbps.
- Antenna Type: Patch Microstrip Antenna.
- Antenna Range: 120° (±60°).
- Reception Sensitivity: -100dBm.
- Power Source: Li-SOCl2 3.6V rechargeable battery, equipped with a solar panel.
- Battery Lifespan: Over 5 years.
- Protection Level: IP67.
- Environmental Temperature: -45±2℃ to +85±2℃.
- Humidity: ≤95% non-condensing.

Installation Configuration:

1) Configuration Method:

- For signal control at intersections, it's typically necessary to install one repeater in each direction. For traffic flow detection on road segments, generally, one repeater installation is sufficient.

2) Installation Method:

- Repeater units are usually installed at a height of 4 meters or higher on lamp posts at intersections or mounted on overpasses or other structures, simplifying the installation process significantly.

- The installation direction should be positioned between the detectors being received and the receiver (or another repeater). Secure the repeater to the designated location using clamps, adjust the direction, and ensure proper communication.

8.3 Receiver

The receiver is utilized to receive detection data from detectors. It maintains bidirectional wireless connections with detectors and repeaters, establishes time synchronization, sends configuration commands and acknowledgment messages, and receives aggregated data from detectors. The data is then transmitted via the 422 bus to the data processor, where it undergoes processing before being delivered to nearby traffic signal controllers, remote servers, traffic management systems, or other devices.

Components:

- Shell
- Directional Antenna
- Integrated Circuit Board
- Connectors
- Universal Joint

The receiver primarily relies on an external power source input. Typically, power is supplied by a nearby POE (Power over Ethernet) source or solar panel. Alternatively, it can utilize a standalone power source rated at 48V DC.

Features:

- Interface: 422 Bus
- Data Processing: Capable of processing detector data to generate different data formats to meet the needs of various devices
- Synchronization of all connected devices below
- Wireless signal quality detection: Capable of detecting signal strength and link connection quality of the wireless network
- Remote firmware upgrades
- Simple installation
- No adjustment or calibration required

Technical parameters
Brand: TraffiClair
Model: ClairGeo-MRCV



- Wireless Channel: 2.4GHz
- Channel Bandwidth: 2MHz
- Channels: 16
- Reception/Transmission Rate: 250kbps
- Antenna Type: Patch Microstrip Antenna
- Antenna Range: 120° (±60°)

- Reception Sensitivity: -100dBm
- Wireless Reception Distance: Line-of-sight distance of 350 meters
- Power Supply: 48V DC
- Protection Level: IP67
- Environmental Temperature: -45±2℃ to +85±2℃
- Humidity: ≤95% non-condensing

Installation Configuration:

1) Configuration Method:

One receiver is required for each intersection.

2) Installation Method:

The receiver can be installed at any position along the roadside, providing sufficient signal coverage to nearby detectors and repeaters. The receiver should be mounted at a height of 4-6 meters above the ground, secured to a pole with clamps. Insert the network cable, tighten the aviation connector, adjust the direction to ensure coverage within a 120-degree range in front of the receiver, covering all devices communicating directly with the receiver. Before installing the receiver, ensure that the communication network cable has been properly routed.

8.4 Data Processing Center

The Data Processing Center is designed to receive detection data from the receiver, process it through specific algorithms to generate detection data, and transmit scheduled and real-time data to the central platform server. It can locally store detection data for historical queries when needed and can also utilize network communication to send data to the traffic platform. Additionally, it provides signal switch quantities to the intersection's signal controller for functions such as signal induction control.

Components:

- Shell
- Integrated Circuit Board
- Big Data Storage Unit
- Communication Unit
- Interface Accessories

Features:

- Interfaces: Ethernet port supporting IP protocol, IO (switching quantity / voltage level), RS232/RS485;
- Data Processing: Connects to the receiver for front-end data acquisition and storage, and

transmits or copies data to central devices.

Technical parameters
Brand: TraffiClair
Model: ClairGeo-MDPC



- Storage Type: SD card, default capacity of 8GB, expandable to 16GB.
- Local Data Storage Duration: Greater than 5 years.
- Local Data: Traffic flow, average speed, occupancy rate, maximum speed, minimum speed, headway time, spacing between vehicles, average vehicle length.
- Interfaces: RS232, RS485 (with additional conversion interface), Ethernet port, IO (switching quantity / voltage level).
- Output Detection Mode: Presence/Pass-through.
- I/O Output Channels: 24 channels, expandable through cascading.
- Power Supply: 48V DC/220V AC.
- Environmental Temperature: -45±2℃ to +85±2℃.
- Power Consumption: <5W.
- Humidity: ≤95% non-condensing.
- RJ45 Output: Ethernet port output for traffic parameters such as flow, speed, occupancy rate, spacing between vehicles, etc.

Installation Configuration:

1) Configuration Method:
Each intersection requires one unit.
2) Installation Method:
- When used for signal control, the intelligent data processor is installed inside the signal control box.
- For traffic flow detection on road segments, it is installed inside the cabinet.
- A single outdoor double-sheathed Category 5e network cable is required to connect the receiver to the intelligent data processor.



Installed inside the signal controller for signal control.



Installed inside the cabinet for road segment traffic flow detection.