

# Advanced Security Control for Auto Theft Prevention System

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**Abstract:** *Modern vehicles are becoming smarter by the incorporation of higher computing power, connectivity solutions and advances in computer vision. In these vehicles automotive designs are also combined with these features. The automotive designs include remote keyless entry system and immobilizer system as the main weaponry against vehicle theft. But these systems prevent unauthorized access of the vehicle to a certain extent only. These security systems have simple and poor nature. So automotive theft has been a persisting problem around the world and it is also a greater challenge from professional thieves. This paper proposes an aim to design advanced security control for auto theft prevention system by adding significant enhancements features such as a gesture based smart gravitational lock, cryptographic keyless entry, touch screen ignition, adjustable motion alarm sensitivity. It is also combined with some modernizing security features like GPS fencing, remote fuel cut-off, car finder and a ubiquitous vehicle tracking system. These features are implemented with the help of 3-axis MEMS Accelerometer, 3-axis MEMS Magnetometer, GPS Receiver, GSM cellular modem.*

**Keywords:** Gravitational lock, Cryptographic keyless entry, MEMS Accelerometer, MEMS Magnetometer

## 1. Introduction

As vehicles become more sophisticated, vehicle security systems must be stronger than ever before. The increase in human-machine interactions in our daily lives has made user interface technology progressively more important. Physical gestures as intuitive expressions will greatly ease the interaction process and enable humans to more naturally command machines.

In this paper, a miniature MEMS accelerometer based recognition system which can recognize various hand gestures like up, down, etc., in 3-D space is built. The recognition system consists of sensor data collection, segmentation and recognition [7], [8]. The importance of accuracy in a positioning system has increasingly been stress for intelligent transport system applications based on position information, including advanced driver-assistance systems, electronic toll collection, intersection collision warnings, and traffic control. It is effective for recognizing patterns with spatial and temporal variation [9].

Nowadays, the satellite-based Global Positioning System (GPS) is widely used for such applications because the GPS receiver provides vehicle position and velocity data in global coordinates. However, a standalone GPS receiver cannot fulfil the positioning requirements of ITS applications due to the occasional temporary loss of satellite connection and signal errors. To provide continuous, accurate, and high integrity position data, the positioning system should be aided by additional sensors such as an inertial navigation system, vehicle motion sensors, digital road maps, cameras, radar. The interruptions and degradations in Global Navigation Satellite Systems-based vehicular navigation solutions in dense urban scenarios such as urban canyons and tunnels lead to the fact that these solutions have to be augmented with other systems to achieve continuous and accurate navigation [3].

A low cost navigation device for land vehicles involving a reduced number of MEMS-based inertial sensors augmented with the measurements of the vehicle odometer and integrated with GPS and map data. This solution can be used in all environments including degraded GPS environments which routinely occur in urban and rural canyons [2].

## 2. Related Works

A. N. Ndjeng et al., (2007) proposed that the Multiple Model (MM) approach assumes that the system follows one of a finite number of different models. The vehicle driving patterns are represented by a set of models and vehicle state information is obtained by combining specific model filters. The Interacting MM (IMM) estimator has high performance and low computational power and it has been used for localization and tracking problems [1].

Kichun Jo et al., (2012) implement the development of a vehicle positioning system is robust to changes in driving conditions for use in ITS applications. The experimental results showed that the estimates of the developed algorithm were accurate and reliable under the various driving conditions. The integration of the accelerometer and the wheel speed sensor in the positioning algorithm will improve the estimation of vehicle speed [3].

M.M. Atia et al., (2010) implemented in real-time performance of the Mixture PF (without map matching) on an embedded 600 MHz processor (single core used), where a speed-up was proposed that enable Mixture PF to operate at higher rates on embedded processors [4].

The integration of the Global Position System (GPS) and inertial navigation system (INS) provides a more accurate and reliable navigation system that has superior performance compared with either a GPS or a stand-alone INS. It has been commonly used for land-vehicle navigation to provide

reliable position, velocity, and attitude. The fusion of GPS data with data from INS is a common solution for positioning systems due to the complementary natures for sensors [5]-[6].

Ruize Xu et al., (2012) estimated three different gesture recognition models which are capable of recognizing seven hand gestures based on the input signals from MEMS 3-axes accelerometers. The accelerations of a hand in motion in three perpendicular directions are detected and transmitted to a PC via Bluetooth wireless protocol. The Segmentation algorithm is to identify individual gestures in a sequence. Sign Sequence is used to compress data and minimize the influence of variations. The recognition algorithm is based on sign sequence and template matching [7].

Zongwei Wu et al., (2013) describes the observability analysis and vehicle tests, the acceleration changes in the horizontal plane improve the accuracy of the yaw-angle estimation but meanwhile introduce errors to the pitch and roll-angle estimations. A Cascaded Kalman filter deal with the yaw angle separately and utilize the GPS-measured course angle to improve the accuracy of the yaw-angle estimation [10].

### 3. Existing System

#### 3.1. Remote Keyless Entry System

Remote Keyless Entry (RKE) System is refers to a lock that uses an electronic remote control as a key which is activated by a handheld device or automatically by proximity. It is also called as Keyless Entry or Remote Central Locking. It is used to unlock the doors. It includes Remote Key Ignition (RKI) System which starts the engine.

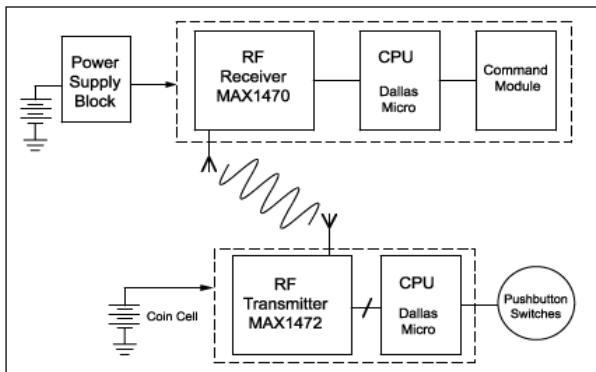


Figure 1: Remote Keyless Entry System

#### 3.2. Immobilizer System

Immobilizer is an electronic security device fitted to an automobile that prevents the engine from running unless the correct key or other token is present. This prevents the car from being "hot wired" after entry has been achieved. This system is used to remotely disable the lost vehicle.

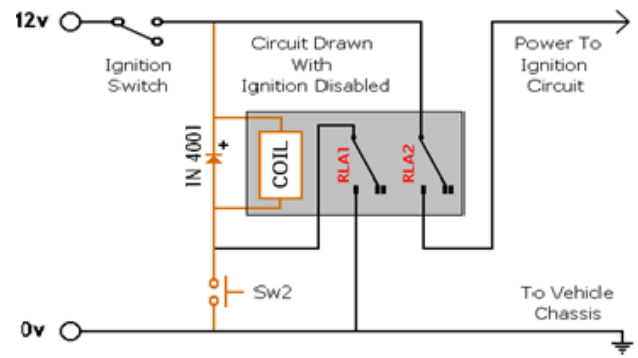


Figure 2: Automatic Immobilizer

#### 3.3. Problems Faced In Existing System

Some of the major problems with the existing auto theft prevention system are:

- It offers no protection when the key fob is stolen. So a smart key fob sold in the market is not actually smart.
- In Immobilizer System it is unable to stop professional thieves from towing the car away. The professional thieves can then dismantle the stolen vehicle and re-sell the components.
- Vehicle tracking devices will not be able to locate a vehicle in GPS denied environments such as within buildings, underground and dense city regions, resulting in the loss of vehicle.
- The currently used motion and tilt alarms will alert the owner even for an unintentional touch by a passing person or an accidental hit by a ball from a playing child.
- Limited or to be accurate no central user interface to configure and customize the vehicle security system.
- In short the existing systems are designed to give intimation to the owner only after the car had been theft.

### 4. Proposed System

The project proposed here aims to design a advanced security control for auto theft prevention system by adding significant enhancements and modernizing the existing system and thus try to overcome the above drawbacks.

It consists of two units namely,

- Smart key fob unit.
- Vehicle unit.

These units consist of the following features working's

#### 4.1. Smart Gravitational Lock

The system is armed automatically when the driver moves away from the vehicle. It is disarmed only when a specific gesture is made in the hand-held wireless key fob. The 3D gesture is made in mid-air and can be reprogrammed by the user on the fly. The air gesture is recognized using a 3-axis MEMS Accelerometer that senses the gravitational force exerted upon it. A stolen key fob thus cannot be used to enter into the vehicle without performing the secret gesture. The password is stored in an external non-volatile memory.

#### 4.2. Cryptographic Keyless Entry

If the gesture is valid the key fob transmits a unique encrypted code that changes every time when this gesture is made. RC4 Stream Cipher Cryptographic algorithm ensures the safety of the data transmitted. The key fob communicates with automotive vehicle unit using IEEE 802.15.4 wireless networking protocol. This prevents thieves from detecting the static codes which were used in older keyless entry systems.

#### 4.3. Touch Screen Ignition

A dual layer keying approach is followed during vehicle ignition process. This consists of software and hardware keys. A unique touch gesture is made on the 65k color touch screen TFT Display that acts as the software key. The system verifies this and then accepts the hardware key which is the actual key fob normally used. This feature can be temporarily disabled and enabled via SMS send by the owner. This is useful in situations such as when someone other than the owner wants to handle the vehicle and the owner does not want the other person to know the secret onscreen password.

#### 4.4. Ubiquitous Vehicle Tracking

GPS and GSM technologies enable the vehicle owners to track and monitor the vehicle with cell phone at anytime from anywhere. The important enhancement in this feature is its ability to inform the vehicle position even during a GPS outage using dead reckoning method. This is achieved with the help of inertial navigation sensors that consists of a 3-axis MEMS Magnetometer and a 3-axis MEMS Accelerometer which will act as a tilt compensated compass module.

#### 4.5. Remote Fuel Cut-Off

This feature is very useful especially in case of auto theft. If the vehicle is somehow hacked into and taken, you can send message that will slowly cut-off the fuel supply, thereby disabling the vehicle. A servo Motor controlled valve is used to cut the fuel supply.

#### 4.6. Adjustable Motion Alarm Sensitivity

The vehicle unit constantly monitors the vehicle motion after being armed (locked). The integrated motion sensing subsystem measures the vehicles three dimensional position and detects any unauthorized motion if the vehicles is moved or tilted that exceeds a threshold level. When someone tries to break into the vehicle forcibly, the alarm triggers the siren and head lamps and sends an SMS to the owner.

#### 4.7. GPS Fencing

This feature restricts the vehicle movement within a particular area. For example, if the owner wants the car to move only within a particular city, once it moves out of city borders the owner would immediately receive an SMS alert as to the current location of the vehicle. The interesting feature here is the fence radius can be programmed by the user in the touch screen display. This flexibility allows the

user to set a virtual fence that can be at building level, street level, city level or state level.

#### 4.8. Car Finder

When the owner approaches the vehicle, the system automatically verifies the code from remote key and the vehicle emits a head light flash and horn beep to show its presence. It assists the owner to locate the vehicle in a parking lot where several vehicles are parked.

#### 4.9. Advantages of Proposed System

- The proposed system offers protection even when the key fob is stolen, so it is called as real smart key fob.
- It allows us to track the vehicle even in GPS denied environments.
- Using adjustable motion alarm sensitivity feature this system eliminates tilt alarms when an unintentional touch by a passing person.
- A central user interface is used to configure and customize the vehicle security system.
- All the units are powered by a 32-bit ARM Cortex-M3 Microcontroller.
- Both the vehicle unit and the smart key fob unit use LPC1313, a 32-bit ARM Cortex-M3 microcontroller from NXP Semiconductors.

### 5. Block Diagram

The following explains about the block diagram that shows the smart key fob unit and vehicle unit. These units are implemented with Gesture Recognition System, Cryptographic Keyless Entry and Vehicle Security System.

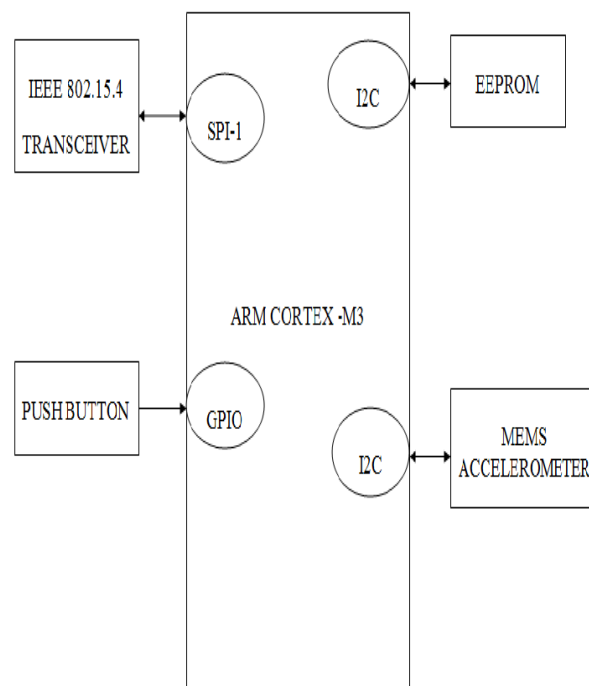


Figure 3: Smart Key fob Unit

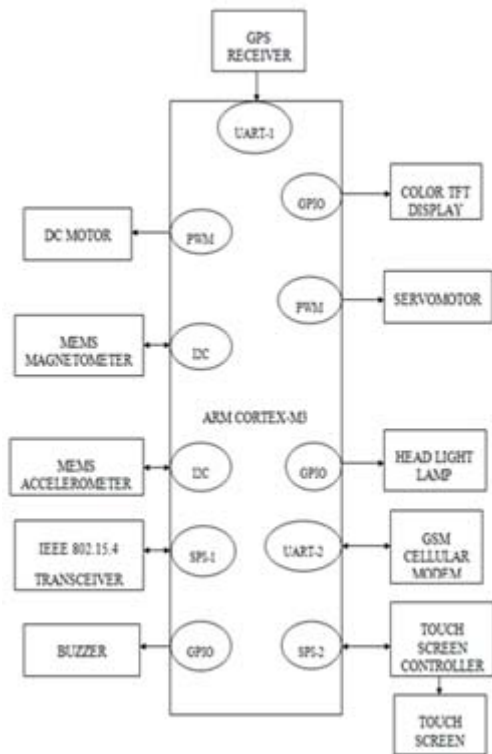


Figure 4: Vehicle Unit

## 5.1 Gesture Recognition System

### 5.1.1. MEMS Accelerometer

The MEMS Accelerometer gives the three dimensions (x, y, and z) readings of a particular object. It is a low power, low profile capacitive 3-axis accelerometer commonly called as free fall detection sensor. Because of a sleep mode pin on the accelerometer makes it ideal for the handheld battery powered electronics. The program memory of the Arm controller is coded in such a way that it recognizes the values in the tilt register of the accelerometer connected through I2C bus. So if we move the key fob in any direction then the corresponding values are noted by the accelerometer. Through embedding the MEMS Accelerometer the vehicle can be armed by gesture performance in the air.

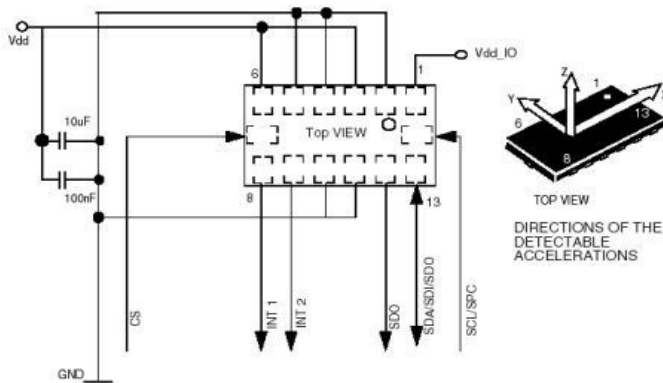


Figure 5: MEMS Accelerometer

## 5.2. Cryptographic Keyless Entry

### 5.2.1. IEEE 802.15.4

The Microchip MiWi™ P2P Wireless Protocol is a variation of IEEE 802.15.4, using Microchip's MRF24J40 2.4 GHz transceiver and any Microchip 8, 16 or 32-bit microcontroller with a Serial Peripheral Interface (SPI). The

protocol provides reliable direct wireless communication. It supports both peer-to-peer and star topologies. The total bandwidth for the IEEE 802.15.4, 2.4 GHz ISM band is, theoretically, 250 kbps. In reality, for reliable communication, the bandwidth is 20-30 kbps. The two ways to transmit a message are broadcast and unicast. RC4 is a stream cipher, symmetric key algorithm. The same algorithm is used for both encryption and decryption as the data stream is simply XORed with the generated key sequence. The key stream is completely independent of the plaintext used. It uses a variable length key from 1 to 256 bit to initialize a 256-bit state table. The algorithm can be broken into two stages: initialization, and operation.

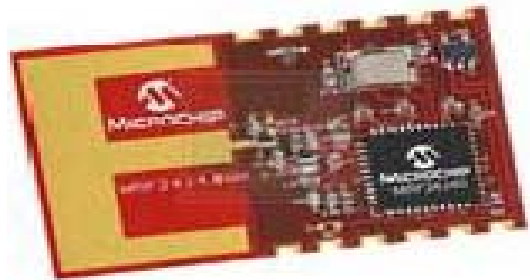


Figure 6: IEEE 802.15.4 Transceiver

## 5.3. Vehicle Security System

### 5.3.1. Global Positioning System

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver. GPS satellites are orbited high enough to avoid the problems associated with land based systems, yet can provide accurate positioning 24 hours a day, anywhere in the world. Uncorrected positions determined from GPS satellite signals produce accuracies in the range of 50 to 100 meters. GPS receiver calculates location using Triangulation method. 66 Channel GPS receiver interfaced via NMEA Protocol. When using a technique called differential correction, users can get positions accurate to within 5 meters or less. GPS receiver will automatically collect this information and store it for future reference.

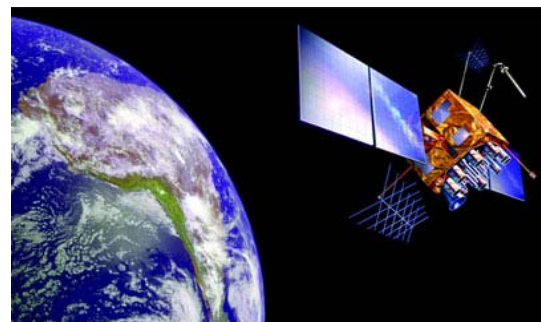


Figure 7: Global Positioning System

### 5.3.2 GSM Modem

Global system for mobile communication (GSM) is a globally accepted standard for digital cellular

communication. GSM is the name of a standardization group mobile cellular radio system operating at 900 MHz. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem while a wireless modem sends and receives data through radio waves. The working of GSM modem is based on commands; the commands always start with AT (Attentions) and finish with a <CR> character. The AT commands are given to the GSM modem with the help of PC or controller. The GSM modem is serially interfaced with the controller with the help of UART.



**Figure 8:** GSM Modem

### 5.3.3 MEMS Magnetometer

The important enhancement in this feature is its ability to inform the vehicle position even during a GPS outage using dead reckoning method. This is achieved with the help of Inertial Navigation Sensors. It is interfaced with ARM using I2C protocol.



**Figure 9:** MEMS Magnetometer

### 5.3.4. Color TFT Display

Color TFT (Thin Film Transistor) Display has TFT LCD and Touch screen.

#### i) TFT LCD

- 65K Color.
- 320 \* 240 Resolution.
- 16-bit RGB format.
- 8-bit Parallel Interface.

#### ii) Touch screen

- SPI Interface.
- Touch screen Controller.
- Digital Resistive Touch screen.
- Senses Stylus or Finger touch.



**Figure 10:** Color TFT Display

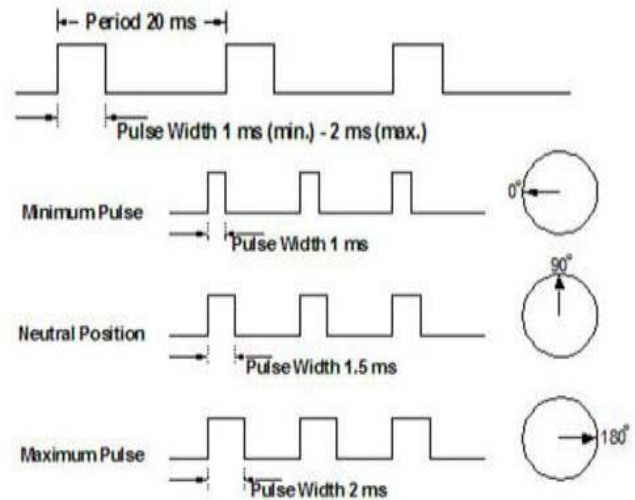
### 5.3.5. DC Servomotor

- It is used for position and speed control.
- Operated with PWM pulses at 50Hz.
- Duty cycle variation controls the desired parameter.
- Operates with low current, ideal for battery powered applications.



**Figure 11:** DC Servomotor

If the vehicle is made theft or misused by the driver or vehicle is taken to the places without the knowledge of the owned, then the owner can be able to control their car through GSM. This feature is very useful especially in case of auto theft. The control message is send to the processor by the owner. Now the processor intimates the servo motor that wills slowly cut-off the fuel supply, thereby disabling the vehicle. It uses the PWM technique to control the valve.



**Figure 12:** Servo Motor Rotation Diagram

### 5.4. ARM CORTEX-M3

- Next Generation 32-bit ARM Processor for Embedded Applications based on ARMv7-M Architecture.
- It is Harvard architecture. Separate I & D buses allow parallel instruction fetching & data storage.
- 3-stage pipeline with branch speculation. Fetch, Decode & Execute.
- Configurable nested vectored interrupt controller (NVIC).
- Advanced debug and trace components (DAP, SWV, ETM).
- Integrated bus matrix.
- Wakeup Interrupt Controller (WIC).
- Memory Protection Unit (MPU).

### 5.5. Embedded Protocols Used

- I2C.
- SPI.
- PWM.
- UART.
- NMEA 0183.
- IEEE 802.15.4.

### 5.6. Software Libraries Used

- Graphics Library for TFT LCD.
- Touch screen Controller Driver via SPI.
- Digital MEMS Magnetometer Driver via I2C.
- Digital MEMS Accelerometer Driver via I2C.
- Digital MEMS Compass Driver via I2C protocol.
- NMEA 0183 packet decoder via UART protocol.
- GSM Driver Software via UART protocol.
- Cortex-M3 Peripheral Device Driver Library.
- CMSIS from ARM.

### 5.7. Software Tools Used

- Programming Language: Embedded C.
- Development Tool: LPCXpresso (Eclipse based).

#### 5.7.1 LPCXpresso

LPCXpresso is a new, low-cost development platform available from NXP. It is a complete tool chain for LPC1000 series of Cortex-M microcontrollers. The software consists of an enhanced, Eclipse-based IDE, a GNU C compiler, linker, libraries, and an enhanced GDB debugger. The hardware consists of the LPCXpresso development board which has an LPC-Link debug interface and an NXP LPC ARM-based microcontroller target. LPCXpresso is an end-to-end solution enabling embedded engineers to develop their applications from initial evaluation to final production.

## 6. Conclusion

This paper describes an air gesture recognition system by using MEMS accelerometer. The innovative vehicle key is designed in which gesture key from key fob is compared with the stored key to secure opening of the vehicle door. This provides more protection to the vehicle even when the key fob is stolen. Secondly, a navigation device for land vehicle involves the MEMS accelerometer and magnetometer integrated with the GPS, so during GPS outage the vehicle is navigated using navigation sensor. The adjustable motion alarm is used which helpful to intimate the vehicle owner about the intentional touch given by the thief. When there is no usage of key fob, the touch screen is used to ignite the vehicle through software key that is given to the screen. GPS fencing is implemented to restrict the vehicle within the particular area by the owner. Remote fuel cut-off is used to reduce or cut the fuel when the vehicle is hacked by thief or misused by the other persons. Thus the techniques presented in this paper provide high security and reliability to the vehicle.

## 7. Future Enhancement

The demand for auto-guard systems for protecting the car from theft and loss is increasing day by day. The Proposed System will be an intellectual system to meet this demand. A stolen car can be detected and traced down to the street where it actually resides. As part of enhancement this system can be implemented not only in cars but also in other vehicles as well as in various other sectors like financial, banking, military and so on.

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