==
Engineering & Technology in India www.engineeringandtechnologyinindia.com
Vol. 1:3 April 2016
==

WIRELESS MICROSENSORS CAPSULE SYSTEM

G. Sudhanthira, M.E. (Applied Electronics)
A. Prema, M.E.
==

ABSTRACT

The interface of enabling technology with advanced product design has shown radical development in the field of intelligent sensor-embedded system design. Numerous applications are envisaged exploiting this interconnectivity, particularly, in the field of biomedical applications. A need, for example, that is of growing demand, is in the field of remote health monitoring and control of critically ill patients, with the help of networked sensors. The continuous monitoring of the health of a patient in a hospital, information fusion from multiple sensor-data as well as broadcasting the recorded data on a network for the ease of access to the clinician and implementing the decisions of clinicians through automated drug delivery units could save millions of precious lives in a country with limited medical experts. This project discribes a method for detecting human gastric-motility dysfunction using a wireless electronic capsule. The capsule's main components include three sensors (temperature, pH, and pressure), an Zigbee transceiver, and batteries. The physiological data measured by the wireless capsule within the human gastric system is transmitted to the PC. These data are continuously monitored and recorded for further medical analysis.

1. INTRODUCTION

Gastric motility is the spontaneous peristaltic movements of the stomach that aid in digestion, moving food through the mach and out through the pyloric sphincter into the duodenum. Excess gastric motility causes pain. Below normal motility is common in labor, after general anesthesia, and as side effect of some sedative hypnotics.

In some people, the rate at which their stomach empties its contents into the small intestine is not normal. This can cause feelings of Nausea, Vomiting, Bloating, etc. Few gastric motility disorders: Gastroparesis or delayed gastric emptying, Rapid gastric emptying (dumping syndrome), Idopathic vomiting, Functional dyspepsia and cyclic vomiting syndrome.

The frequency range of the EGG includes bradygastria (0.50-2.50 cpm), normal range (2.50-3.75 cpm), tachygastria (3.75-10.00 cpm), and a respiratory rate of the duodenum (10.00-15.00 cpm). Specifically, the respiratory rate must be identified before analyzing the frequency spectrum of the EGG. If not, the results may be confused with tachygastria. The studies show that patients who have idiopathic gastroparesis (IGP), functional dyspepsia (FD), or delayed gastric emptying always have an abnormal EGG .

At present, EGG cannot diagnose a specific disease, but it provides evidence for stomach motor dysfunction in various pathological conditions. Advances in very large scale integration (VLSI) architecture and system-on-chip (SoC) design have increased scholarly interest in wireless endoscopic capsules. Its major limitations being No means of lumen diameter adaptation and Lack of tissue interaction.

This led to development of the wireless electronic microsensor system in which capsule is a pill-sized sensor that is swallowed and it measures: Temperature, pH, Pressure, How quickly the stomach empties, How quickly the small intestine and colon empty. The capsule transmits these measurements to a receiver and recorder. This test records helps to diagnose conditions including gastroparesis, colonic inertia, rapid gastric emptying and constipation.

2. RELEATED WORK

` In a research paper "Wireless Telemetry for Electronic Pill Technology" Mehmet R. Yuce, Tharaka Dissanayake, Ho Chee Keong under the Australian Research Council (ARC) , research has been dedicated to the development of a high capacity radio system for a small, miniaturized electronic pill device that can be swallowable or implantable in human body in order to detect biological signals or capture images that could eventually be used for diagnostic and therapeutic purposes. In addition to reviewing and discussing the recent attempts in electronic pill technology, a wideband (UWB) telemetry system aimed for the development of an electronic pill is described in the paper.

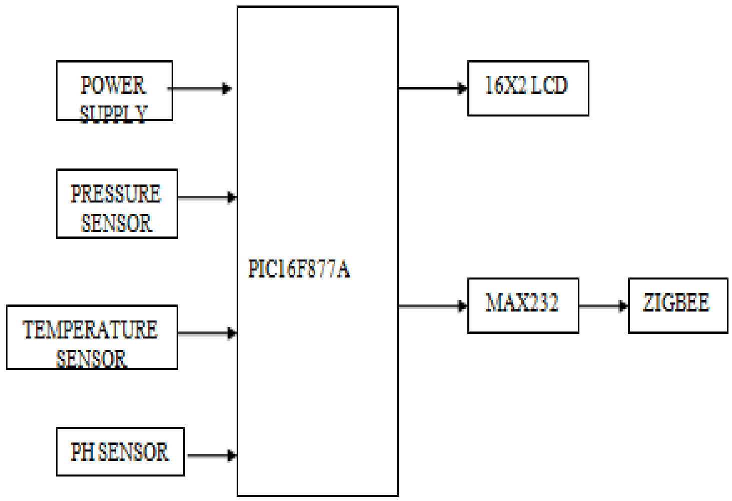
In a paper "Swallowable-Capsule Technology" by Colm Mc Caffrey, Olivier Chevalerias, Cian O'Mathuna, and Karen Twomey of Tyndall National Research Institute, the idea of exploring the human body captured the imagination was dealt with. This vision is now becoming more achievable with recent advances in electronics, microsystem fabrication, and wireless communications, and a greater understanding of human physiology. Electronic microsystems can now be ingested to explore the gastrointestinal (GI) tract and can transmit the acquired information to a base station In addition to the standard constraints in electronic design, a number of main challenges arise for systems that operate inside the human body.

"Wearable Sensors for Human Activity Monitoring: A Review" by Subhas Chandra Mukhopadhyay deals with the development of Wearable sensors detect abnormal and/or unforeseen situations by monitoring physiological parameters along with other symptoms. Therefore, necessary help can be provided in times of dire need. This paper reviews the latest reported systems on activity monitoring of humans based on wearable sensors and issues to be addressed to tackle the challenges. And reviewed the reported literature on wearable sensors and devices for monitoring human activities as well

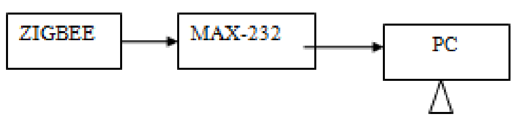
3. SYSTEM DESIGN AND ANALYSIS

The overall system architecture under discussion in presented in Fig. and is comprised of the following two functional blocks:

- A central measurement and transmitting unit
- A monitoring and receiving unit

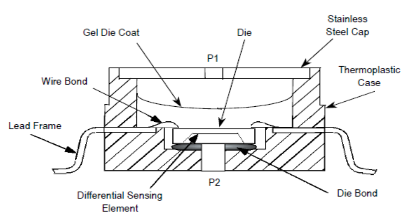


A CENTRAL MEASUREMENT AND TRANSMITTING UNIT



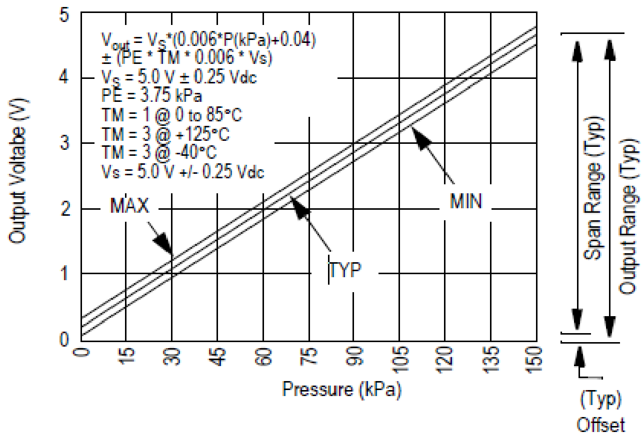
A MONITORING AND RECEIVING UNIT

PRESSURE SENSOR



PRESSURE SENSOR

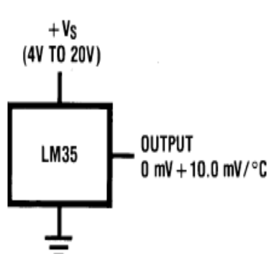
The MPVZ5150 series piezoresistive transducer is a state-of-the-art monolithic silicon pressure sensor designed for a wide range of applications, but particularly those employing a microcontroller or microprocessor with A/D inputs. This patented, single element transducer combines advanced micromachining techniques, thin-film metallization, and bipolar processing to provide an accurate, high level analog output signal that is proportional to the applied pressure.



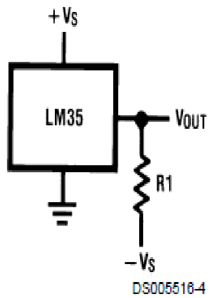
OUTOUT VOLTAGE VS PRESSURE

TEMPERATURE SENSOR

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies.

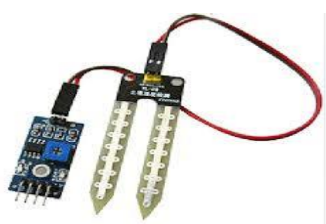


BASIC CENTEGRADE TEMPERATURE SENSOR



FULL-RANGE CENTEGRADE TEMPERATURE SENSOR

PH SENSOR

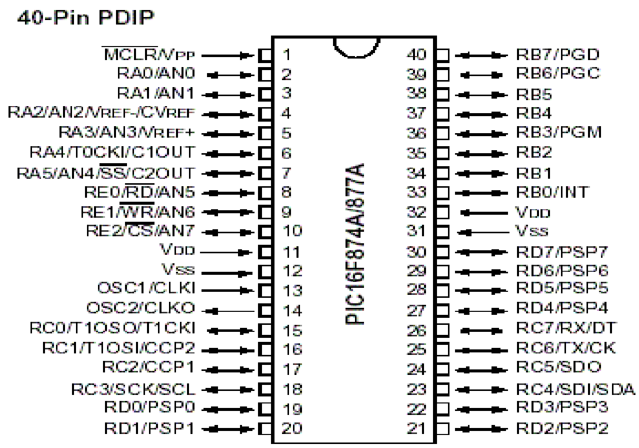


PH SENSOR

pH sensor measures the pH leve.l Basic potentiometric pH meters simply measure the voltage between two electrodes

MICROCONTROLLER - PIC16F877A

The PIC microcontroller [10] is used to interface the energy measurement unit and GSM module. The PIC microcontroller used here is PIC16F877A. .



PIN DIAGRAM OF PIC16F87/877A

UNIVERSAL SYNCHRONOUS ASYNCHRONOUS RECEIVER TRANSMITTER (USART)

The USART is two serial I/O modules. The USART can be configured as a full duplex asynchronous system that can communicate with peripheral devices or as a half duplex synchronous system in master or slave mode. Bit SPEN i.e. RCSTA and bit TRISC have to be set in order to configure pins RC6/TX/CK and RC7/RX/DT as the USART. The USART module also has a multi-processor communication capability using 9-bit address detection. The BRG support both the synchronous and asynchronous mode of the USART. It is dedicated 8-bit baud rate generator. The SPBRG register controls the period of a free running 8-bit timer. In asynchronous mode, bit BRGH controls the baud rate. In synchronous mode, bit BRGH is ignored. It is advantageous to use high baud rate for low baud clocks.

USART IN ASYNCHRONOUS MODE

In this mode the USART uses standard Non-return-to zero format. The most common data format is 8-bit. The USART transmits and receives the LSB first. The transmitter and receiver functionality are independent, but use the same data format and baud rate. This mode is selected by clearing bit SYNC (TRISA).

In transmitter the TXREG register is loaded with data. The TSR register is not loaded until the STOP bit has been transmitted from the previous load. As soon as the STOP bit is transmitted, the TSR is loaded with new data from TXREG register. Once the TXREG register transfer the data to the TSR register, the TXREG register is empty and flag bit TXIF is set.

The interrupt can be enabled/ disabled by setting/clearing-enabled bit TXIE. Flag bit TXIF will be set, regardless of the state of enable bit TXIE and cannot be cleared in software. It will reset only when new data is loaded into the TXREG register. While flag bit TXIF indicates the status of the TXREG register, another bit TRMT shows the status of TSR register. The status bit TRMT is read only bit, which is set when the TSR register is empty. Setting enable bit TXEN enables the transmission. The actual transmission will not occur until the TXREG has been loaded with data and the baud rate generator (BRG) has produced a shift clock. First loading the TXREG register then setting enable bit TXEN can also start the transmission.

In reception the data is received on the RC7/RX pin and drives the data recovery block. In the receiver side the data is received serially in shift register. The main block in receiver is receiver shift register (RSR). After sampling the STOP bit, the received data in the RSR is transformed to RCREG register. If the transfer of data is completed, flag bit RCIF is set. The actual interruption can be enabled / disabled by setting/clearing enable bit RCIE. RCIF register is cleared when the RCREG has been read and is empty. RCREG is a double-buffered register. It is possible for two bytes of data to be received and transferred to RCREG FIFO and then shifted to the RSR register. On the detection of the STOP bit, if the RCREG register is still full, the overrun error bit OERR will be set. The word in the RSR will be lost. Overrun bit OERR has to be cleared in the software. This is done by setting the receive logic. If the OERR is set, transfer from the RSR register to the RCREG is inhibited, and no further data will be received. It is essential to clear OERR bit if it is set. Framing error bit is set if a stop bit is detected as a clear. Bit FERR and the 9^{th} receive bit are buffered as the same way as the receive data.

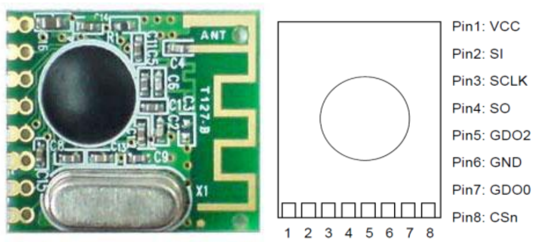
RS 232 COMMUNICATION

To allow compatibly among data communication equipment made by various manufacturers, an interfacing standard called RS232 was set by the Electronics Industries Association (EIA). It was modified and called RS232. It is most widely used for serial I/O interfacing standard. This standard is used for communicating between PIC microcontroller and GSM module. In this standard, a '1' is represented by -3 to -15V, while a '0' bit is +3 to +25V, making -3 to +3 undefined. For this reason, to connect any RS232 to a microcontroller system we must use voltage converter such as MAX 232 to convert the TTL logic levels to the RS232 voltage level, and vice versa.

ZIGBEE TRANSCEIVER

ZigBee and IEEE 802.15.4 are standards-based protocols that provide the network infrastructure required for wireless sensor network applications. 802.15.4 defines the physical and MAC layers, and ZigBee defines the network and application layers.

This is an FSK Transceiver module, which is designed using the Chipcon IC (CC2500). It is a true single-chip transceiver, It is based on 3 wire digital serial interface and an entire Phase-Locked Loop (PLL) for precise local oscillator generation .so the frequency could be setting. It can use in USART / NRZ / Manchester encoding / decoding. It is a high performance and low cost module. It gives 30 meters range with onboard antenna. In a typical system, this trans-receiver will be used together with a microcontroller. It provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication and wake on radio. It can be used in 2400-2483.5 MHz ISM/SRD band systems. For sensor network applications, key design requirements revolve around long battery life, low cost, small footprint, and mesh networking to support communication between devices in an interoperable environment.



ZIGBEE TRANSIVER BOARD & PIN CONFIGURATION

4. SOFTWARE PLATFORM DESIGN

In our proposed system we have use the Proteus software. Proteus developed by Labcenter Electronics, is a software with which you can easily generate schematic captures, develop PCB and simulate microprocessor. It has such a simple yet effective interface that it simplifies the task required to be performed. It is compatible with both 32 bit and 64 bit systems. Proteus software package splits into three parts very conveniently namely: -

- ISIS Intelligent Schematic Input System - for drawing circuit diagrams etc.
- ARES Advanced Routing and Editing Software - for producing pcb layoutbdrawings.
- LISA Labcenter Integrated Simulation Architecture - for simulation of circuit diagram. Separate handout.

Proteus VSM (Virtual System Modelling) feature allows the real time design simulation. It is armed with the mixed-mode SPICE simulation. The graphical approach also allows non-programmers to build programs by dragging and dropping virtual representations of lab equipment with which they are already familiar. The Proteus programming environment, with the included examples and documentation, makes it simple to create small applications. The back panel contains structures and functions which perform operations on controls and supply data to indicators. The structures and functions are found on the Functions palette and can be placed on the back panel. Collectively controls, indicators, structures and functions will be referred to as nodes. Nodes are connected to one another using wires – e.g. two controls and an indicator can be wired to the addition function so that the indicator displays the sum of the two controls. Thus a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the node through the connector pane. This implies each VI can be easily tested before being embedded as a subroutine into a larger program.

The graphical approach also allows non-programmers to build programs by dragging and dropping virtual representations of lab equipment with which they are already familiar. The Proteus programming environment, with the included examples and documentation, makes it simple to create small applications.

Features of Proteus:

- Below are some noticeable features.
- Easy to use tool.
- Simple but effective interface.
- Circuit designing and schematic making made easy.
- Provides a powerful working environment.
- Real time design simulation with VSM.
- Can route and edit different components using ARES feature.

Need of Proteus:

Combine the power of Proteus software with modular, reconfigurable hardware to overcome the ever-increasing complexity involved in delivering measurement and control systems on time and under budget.

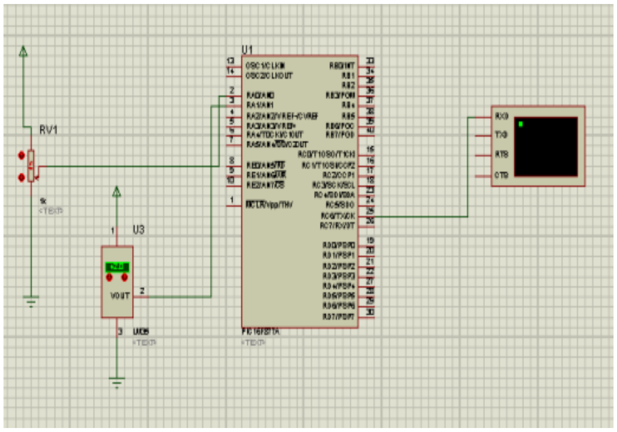
Application Areas:

- Acquiring Data and Processing Signals
- Automating Test and Validation Systems
- Academic Teaching
- Instrument Control
- Embedded Monitoring and Control Systems

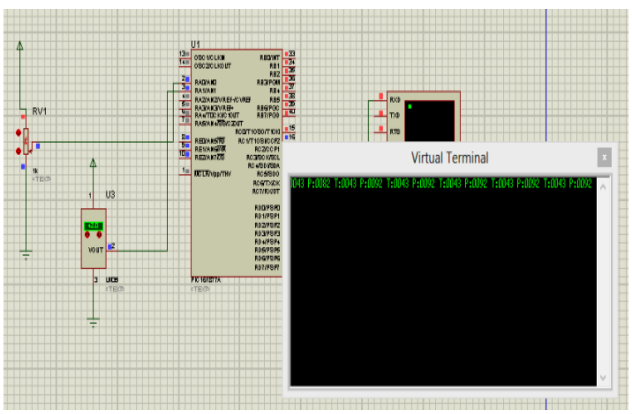
- Wireless System Prototyping

5. SOFTWARE RESULTS

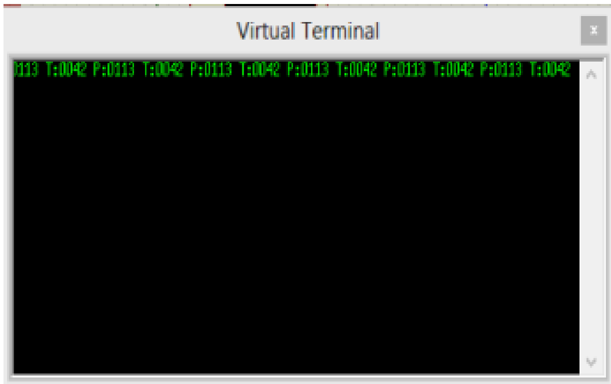
SIMULATED OUTPUT OF THE CAPSULE SYSTEM:



SIMULATED OUTPUT SHOWING VIRTUAL WINDOW:



VIRTUAL TERMINAL WINDOW SHOWING VARYING OUTPUTS OF THE SENSORS:



6. Conclusion

Techniques and methodologies have been presented in this project for the use of wideband technology in a miniaturized electronic pill to provide a high capacity wireless channel. Aprototyping system including sensors and transmitter/receiver has been developed to investigate the feasibility of a physiological data transmission for the electronic pill technology.

==

Acknowledgement

We thank the anonymous reviewers for their detailed comments and suggestions, which helped in improving the technical and editorial quality of this paper.

==

REFERENCES

1. Mehmet R. Yuce, Tharaka Dissanayake, Ho Chee Keong under the Australian Research Council (ARC) , “Wireless Telemetry for Electronic Pill Technology”

2. Colm Mc Caffrey, Olivier Chevalerias, Cian O’Mathuna, and Karen Twomey of Tyndall National Research Institute , “Swallowable-Capsule Technology” Published by the IEEE CS 2008

3. Advanced Technologies for Gastrointestinal Endoscopy Pietro Valdastri,1 Massimiliano Simi,2 and Robert J. Webster III314 May 2012

4. Subhas Chandra Mukhopadhyay, “Wearable Sensors for Human Activity Monitoring: A Review” for IEEE Sensors Journal, Vol. 15, No. 3, March 2015

5. Z. D. Goh, P. Georgiou, T. G. Constandinou, T. Prodromakis, and C. Toumazou, “A CMOS-based ISFET chemical imager with autocalibration capability,” IEEE Sensors J., vol. 11, no. 12, pp. 3253–3260, Dec. 2011.

6. N. Ollovier-Henry et al., “Design and characteristics of a multichannel front-end ASIC using current-mode CSA for small-animal PET imaging,” IEEE Trans. Biomed. Circuits Syst., vol. 5, no. 1, pp. 90–99, Feb. 2011.

7. X. Zhang, H. Jiang, L. Zhang, C. Zhang, Z. Wang, and X. Chen, “An energy-efficient ASIC for wireless body sensor networks in medical applications,” IEEE Trans. Biomed. Circuits Syst., vol. 4, no. 1, pp. 11–18, Feb. 2010.

8. L. Wang et al., “A wireless biomedical signal interface system-on-chip for body sensor networks,” IEEE Trans. Biomed. Circuits Syst., vol. 4, no. 2, pp. 112–117, Apr. 2010.

9. Varadarajulu S, Banerjee S, Barth BA, Desilets DJ, Kaul V, et al. 2011. GI endoscopes. Gastrointest. Endosc.

10. Rodriguez S, Banerjee S, Desilets D, Diehl DL, Farraye FA, et al. 2010. Ultrathin endoscopes. Gastrointest.Endosc. 71:893–98

11. Gonzalez S, Yu WM, Smith MS, Slack KN, Rotterdam H, et al. 2010. Randomized comparison of 3 different-sized biopsy forceps for quality of sampling in Barrett’s esophagus. Gastrointest. Endosc.

12. T. Dissanayake, M. R. Yuce and Ho C. K. "Design and evaluation of a compact antenna for implant-to-air UWB communication," IEEE Antennas and Wireless Prop. Letters, vol. 8, Page(s):153 - 156, 2009.

13. N. Aydin, T. Arslan, and D. R. S. Cumming, "Design and implementation of a spread spectrum based communication system for an ingestible capsule," IEEE Trans. Information Technology in Biomedicine, Vol.9, March 2005.

14. T. Dissanayake, M. R. Yuce and Ho C. K. "Design and evaluation of a compact antenna for implant-to-air UWB communication," *IEEE Antennas and Wireless Prop. Letters*, vol. 8, Page(s):153 - 156, 2009.

==

G. Sudhanthira, M.E (Applied Electronics)
Department of Electronics and Communication
Veerammal College of Engineering
PVP Nagar
Dindigul - Batlagundu Highways
K. Singarakottai
Dindigul 624708
Tamil Nadu
India

A. Prema, M.E. Assistant Professor
Department of Electronics and Communication
Veerammal College of Engineering
PVP Nagar
Dindigul - Batlagundu Highways
K.Singarakottai
Dindigul 624708
Tamil Nadu
India