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# Emenu Solutions using ARM Architecture for Next-Generation Dining Experience

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## ABSTRACT

We propose, 'E la carte', an eMenu solutions employing ARM architecture is proposed for next generation dining experience. eMenu is an efficient way of catering patrons thus enriching their dining experience. The implemented design results in a decrease in the customer service time of 44% and the customer downtime by 64% .A helical antenna of gain approx 7 db is designed to provide wireless transmission of menu coded as an innovatively designed tag. An eco-friendly illumination mechanism implemented for light intensity control reduces the power consumption by 25%.

## Keywords

**eMenu, ARM architecture, RF transmitter and receiver, helical antennas**

## 1. INTRODUCTION

Eating out at restaurants and café's these days' turns out to be a very expensive proposition. In spite of the increased price that people pay to satisfy their palate, the hospitality industry fails to provide the average customer an enhanced dining experience [1-4,11].

We propose a state of the art eMenu solutions developed on ARM architecture which replaces the traditional menu in eateries – entire family catered at a single touch. This innovation in hospitality solutions leads to improved operations, lower costs, more footfalls and ultimately an increase in the revenue.

The digitized menu provides customized image descriptions provides personalized service and thus strengthens the brand identity and loyalty. The one time implemented system considerably reduces the waiting time, increases the average order total per customer while human efforts and resources are greatly reduced. E la carte as it is termed is friendly, an intuitive interface which enables quick ordering, billing and payment collection.

## 2. PROPOSED SYSTEM ARCHITECTURE

The architecture designed as a real time application is customized and scalable. The module consists on an arm processor (version 9) with an interactive display and is adapted for a sit down dinner with 30 tables. The user friendly screen welcomes the guests and displays a variety of applications to choose from. The processor is
designed to interface with: an 'a la carte' menu, illumination regulation & control and a third for communication with housekeeping.

The signal selected by the patrons is transmitted through a serial output TTL port through the RF transmitter. The menu order to be placed is sent through this serial port as a tag. The information is wirelessly transmitted to the receiving station placed in the cooking area by means of a helical antenna. This tag is decoded by a RF receiver section and the information is passed on to the computer by using a serial communication cable. A text to speech
module is used to convert the menu into an audio output. The block diagram of the proposed system is as shown in Figure 1.

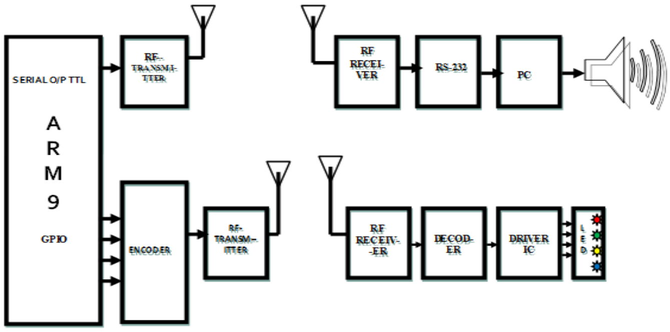


**Figure 1: Block Diagram of the Proposed System**

### 2.1 Processor Interfaces

The choice of menu generated by the customers is coded as a sequence of desired parameters which take the form of a tag. The tag consists of four essential variables as shown in Table I. The table number and item quantity use decimal data type, the variants in the menu use character data types while the item description is in binary. Since we have customized the processor for accessing four menu sections (Starters- 'S', Main Course- 'M', Deserts-'D' and Cocktails-'C') the binary representation aids in reducing the memory and increasing the speed of operation.

**Table 1: Coding Tag for menu Transmission with their equivalent data formats**

| TAG | TABLE NUMBER | TYPE OF ITEM | ITEM DESCRIPTION | ITEM QUANTITY |
|---|---|---|---|---|
| Data Format | T Decimal | Character | Binary | Decimal |

In order to distinguish between two consecutive codes sent, the alphabet 'T' is used in the beginning of each code. The order from individual table is send to the kitchen by using text to audio converter. The billing desk is the master ARM processor which is simultaneously fed with the information tag. The order from the individual tables is sent to the kitchen by using a text to audio converter. A speaker is installed in the kitchen where the menu which is ordered is announced. The illumination of the table can be controlled by the patrons. The variations in the illumination control in real time are sent from the arm processor module to an encoder. The information is coded and sent through an RF transmitter. The RF receiver section receives this information and decodes it and amplifies it to run the LED lighting system. The service interface of the arm is used for basic utilities such as housekeeping, bill payment or if you want an interaction with the maître d'.

## 2.2 Processor Design

ARM 9 is used because of it has 5 stages of pipelining which improves the speed, Harvard memory organization with clock rate of 200 MHz [5,14,15,16].

### *2.2.1 Transmitter*

The block diagram of the transmitter section is shown in Figure 2.

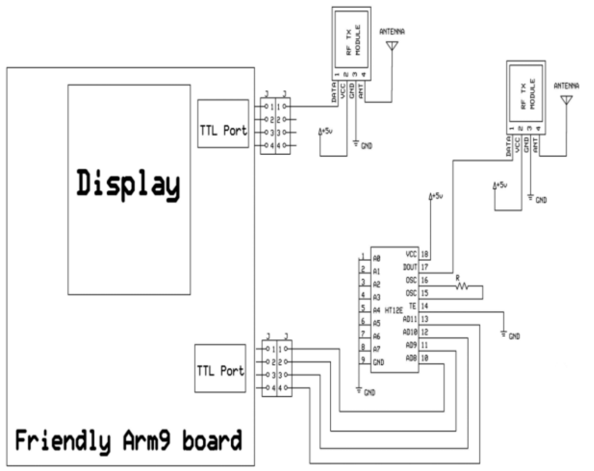


**Figure 2: RF Transmitter with Helical Antenna**

The heart of the RF transmitter is the helical antenna which forms the mode of transmission between the customer and the kitchen. The helical antenna with 4 turns is ASK [6] modulated and resonates at 833 MHz frequency. ASK modulation is the simplest of all the modulation techniques and it also satisfies the requirements of the design as it provides a range of 100 to 300 sqft.

HT12E [7] encodes the 10 bit parallel data into serial for transmission through the RF transmitter. The menu information is stored in the General Purpose Input Output (GPIO) registers. RF transmitter gets the encoded information through the encoder and transmits it through the antenna.

### *2.2.2 Illumination Control*

To control the lighting system, the information is sent from the module to the RF transmitter section by using GPIO provided in the module. With power for commercial establishments coming at a premium, we have employed an eco friendly lighting system as shown in Figure 3. The encoded lighting control information is transmitted serially by the arm module is received by the RF receiver by using an antenna. A four bit decoder IC HT12D is used. The four pair darlington configuration is used to boost the signal power to drive the LED lighting system. Depending on the intensity of the lighting selected by the costumer, the number of LEDs glowing can be varied. For example if the dim mode is selected then only two LEDs of the first row would glow.

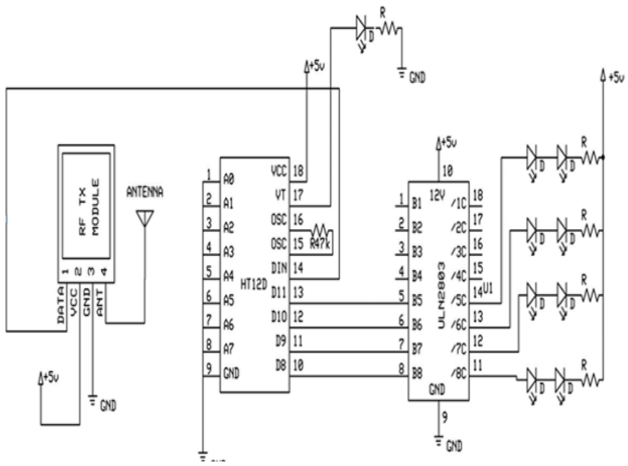


**Figure 3: Illumination control circuit**

### *2.2.3 Receiver*

The RF signal transmitted by the is received by a helical antenna tuned to the receiver section

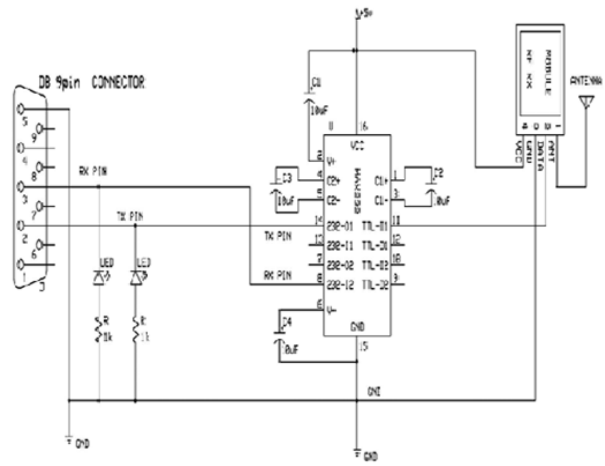


**Figure 4: RF Receiver with Coded Menu Signal from Antenna**

The receiver design employs a helical antenna [8] with similar parameters. This received signal obeys the TTL logic and is thus interfaced with the computer using RS232 communication protocol. Four capacitors each of 10 µF are deployed to boost the signal to -/+ 10 volts. The signal is fed at the receiver (Pin 2 of DB-9 connector). The receiver gives good operating characteristics when placed in the range of 100 to 300 sq ft area from the transmitter.

## 2.3 Algorithm

ARM touch screen module is loaded with Window C operating system. VB6 studio software is used to program ARM touch module. VB.net frame work is used to for designing of front end of the system.

*Algorithm:*
*Initialize → counters and reset flags*
*Define → variables*
*Initialize → port for serial communication*
*Data polling*
*Observe data for placed order or call of service.*

*If* $b_0 \rightarrow 'T'$ *then order*
$b_1 \rightarrow 'table\ number'$
$b_2 \rightarrow ' character(type\ of\ item)'$
$b_3 b_4 b_5 b_6 \rightarrow '\ dish\ number\ corresponding\ to\ menu\ type'$
$b_7 \rightarrow$ *'quantity of selected items'*
*Else*
*Call of service*
*Reset flags*
*Server updated at billing desk*

The data transmission is carried out in between a pair of identically designed transmitter-receiver antennas.

## 2.4 Antenna Parameters

A pair of matching helical antennas is designed, fabricated and is described in detail in the following section[12,13]. The circularly polarized 4 turn helical antenna resonating at 833 MHz receives the coded signal. The receiving antenna operated in the axial mode circumscribes 35 cm by (1).

$$D = \frac{\lambda}{\pi} \tag{1}$$

The condition (2) is satisfied for the transceiver which associates with the optimum performance of the helix [9] [10].

$$3\lambda/4 < C < 4\lambda/3 \tag{2}$$

The empirical equations for antenna gain (G), characteristic impedance (Z) and Half Power Beam Width (HPBW) are obtained from (3), (4) and (5) respectively.

$$G = 10.8 + 10\ \log_{10}[\left(\frac{C}{\lambda}\right) * 2N * \left(\frac{S}{\lambda}\right) \tag{3}$$

$$Z = \frac{150}{\sqrt{C/_{\lambda}}}\ \Omega \tag{4}$$

$$BW = \frac{52}{\left[\left(\frac{c}{\lambda}\right)\sqrt{N\left(\frac{S}{\lambda}\right)}\right]} \tag{5}$$

Where N represents the number of turns, S is the vertical spacing between the turns, C is the circumference of a helical turn and λ is the wavelength corresponding to the resonant frequency.

**Table 2: Antenna Parameters for a 4 turn helical antenna operating at a frequency of 833 MHz**

| Helical Antenna Parameters | Experimental Results |
|---|---|
| Relative Antenna Gain (G) | 6.82 dBi |
| Characteristic Impedance (H) | 150 Ω |
| Diameter (D) | 11.5 cm |
| Spacing between coils (S) | 3.6 cm |
| Length of wire (L) | 149 cm |
| Half Power Beam Width (HPBW) | $82.2^{\circ}$ |
| BW first nulls (BWFN ) | $182^{\circ}$ |
| Effective Aperture (Ae) | $0.0496 m^2$ |

# 3. EXPERIMENTAL VALIDATION & RESULTS

An archetype of the eMenu system is installed and adapted in a sports bar due to its restricted menu and limited seating arrangement. A server at the billing desk controls the client architecture at an alcove having a capacity of two diners while the remaining alcove is serviced by the maitre d'. The receiver is installed in a small kitchenette at a distance of approximately 50 ft. The performance of the sports bar is evaluated by distinguishing between the customers hold time, the service time of the diners and the billing wait time between the two alcoves. Figure 5 charts the average comparison of Customer Service Time (CST), Customer Down Time (CDT) and Billing Time (BT) between the automated and traditional service at the sports bar over a six hour rush hour in the evening. The aforementioned parameters are stipulated as in (6), (7) and (8) as time interval between

$$\text{CST} = \text{ Order placed and received} \tag{6}$$

$$\text{CDT} = \text{ Patron arrived and seated in alcove} \tag{7}$$

$$\text{BT} = \text{ Order placed and received} \tag{8}$$

The figures obtained as above are then averaged over the six hour period by normalizing with the number of times the alcove was occupied during that interval.

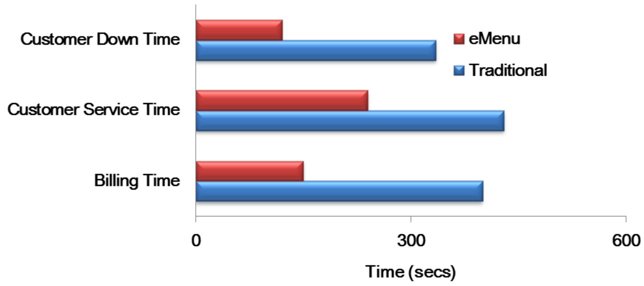


**Figure 5: Reduction in billing time, customer down time and customer service time in eMenu scenarios.**

As observed from the time analysis in Figure 5, on an average a 62% reduction in billing time and 44% decrease in the customer service time is observed in the alcove served with electronic menu. It cuts approximately three minutes off the average diner's stay. Consequently this results in a 64% reduction in the customer down time.

The distinctive feature of the system is the power saving circuitry due to which illumination control can be exercised. The two alcoves are fitted with CFL's and fluorescent lights of the similar wattage. Figure 6 provides the comparison between the powers scavenged by the traditional setup with non-variable illumination control as opposed to the eMenu driven illumination control.

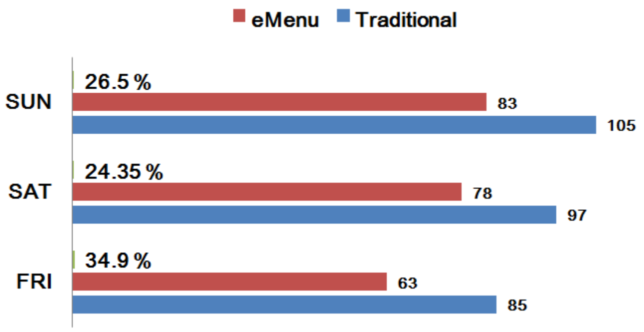


**Figure 6: Scavenged Power (Wh) comparison using proposed illumination control.**

The statistics mentioned in the aforementioned figure are averaged in a 6 hour period over the weekend. The power is calculated in terms of Watt hr and is indicated to the right of the statistical bars in Figure 6. Due to the system performance there is an average reduction of 25% in power consumption per day.

## 4. CONCLUSIONS

eMenu processor is implemented as a real time efficient and effective system which streamline the service and controls the kitchen. The intended functions of this device are to take orders from the customer electronically, transmit orders to the kitchen, and maintain record of orders in PC memory.

The system results in fewer errors on the order by eliminating and providing effective communication between customer and kitchen. eMenu allows the user to build an additional source of income through the advertising of banner ads in the empty spaces within the screen and thus offers far more than the standard cardboard menu.

The designed processor is power efficient as eco friendly high efficient lighting system is implemented which consumes 25% less power. The implementation is performed for a single table. When multiple alcoves are used, eMenu can be used by employing Bluetooth or zigbee communication.

The system however replaces the highly personalized hospitability services and thwarts the indulgencies which most patrons enjoy.

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