

Special Edition on ITS

# An RF Module for Use in ETC Vehicle On-board Equipment

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## Abstract

ETC (Electronic Toll Collection) systems automatically collect tolls, exchanging information by wireless between a base station installed at the toll gate and on-board equipment.<sup>1</sup> Our company is involved in the developing and putting into actual use both base stations and on-board equipment. In this paper, we discuss the specifications and performance of a radio frequency (RF) module which is now in mass production for ETC on-board use. We also discuss a next model which will be smaller and lower in cost and which is now under development with the intent of starting mass production in business year 2001.

## An Outline of the RF Module

The special features of the RF module required for an ETC system are:

- ① communication using high frequency waves in the 5.8GHz band
- ② high speed communication in a narrow area just surrounding the toll gate,
- ③ stable communication under severe environmental conditions (especially, a broad range of operating temperatures), since the units are mounted on automobile dashboards.

The functions required of a RF module are shown in Table 1.

Frequency	5.8GHz band
Communication method	Semi-duplex operation
Antenna	Right-turning circularly polarized wave type
Modulation method	ASK
Modulation speed	2048kbaud, split phase code
Operating temperature range	-30 ~ +85°C
Storage temperature range	-40 ~ 105°C

Table 1: Functionality of the RF module<sup>2</sup>

Frequency deviation	±100ppm or less
Antenna power	10mW or less
Deviation of antenna power	±50% or less
Permitted value of occupied bandwidth	8MHz or less
Power leaked to adjacent channel	-40dB or less
Strength of spurious emissions	25μW or less
Modulation index	0.75 ~ 1
Power leaked during carrier off	2.5μW or less
Strength of secondarily generated waves	2.5μW or less
Reception sensitivity	-60dBm or less
Antenna gain	10dBi or less

Table 2: Electrical specifications of RF module<sup>2</sup>

(Vcc = 5V, Ta = 25°C)

Satisfying these requirements by applying advanced high-frequency wireless technology, temperature compensation technology, and packaging technology, we succeeded in making a viable RF module. The electrical specifications of the RF module are shown in Table 2. The RF module is configured of a transmitter which includes a 5.8GHz modulator and a receiver which converts received signals into intermediate frequencies and detects them. Figure 1 shows a block diagram, while Photo 1 shows an exterior view.

## Planning the Next Model

In order to promote wider use of ETC on-board equipment, additional miniaturization and cost reduction of RF modules is needed. To do that, we applied the 5.8GHz band design techniques which we gained in developing the current model (LX3438) and set as our objective for the next models (LX3445 and LX3446) thorough cost-reduction and full-fledged size reduction. Photo 2 shows the appearance of the insides of the sealed case of the RF module.

In order to carry out the cost reduction plan, we implemented the following three improvements:

- ① parts for the RF block were changed from MMIC (Monolithic Microwave Integrated Circuits) to general-purpose transistors which are lower in price,

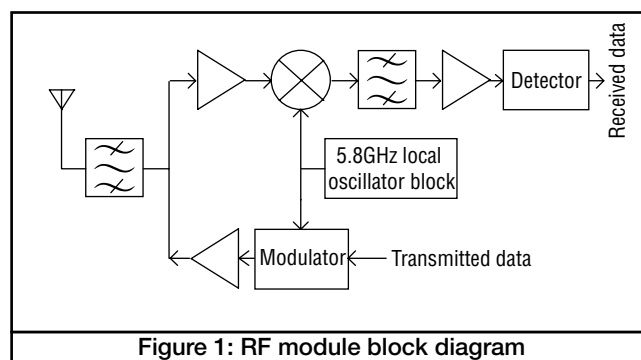


Figure 1: RF module block diagram

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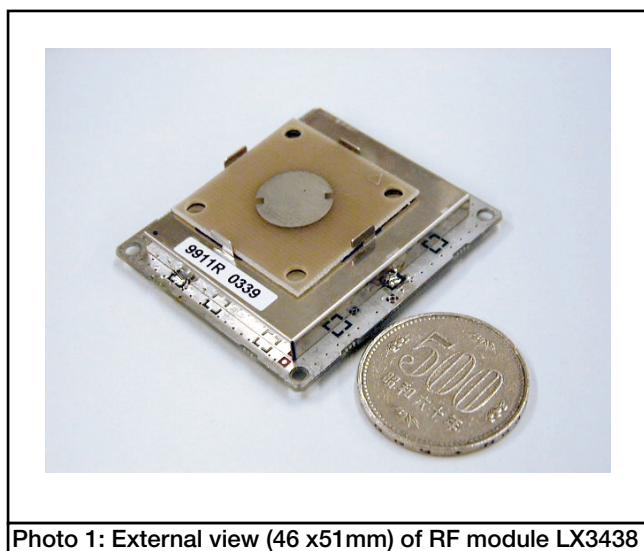


Photo 1: External view (46 x51mm) of RF module LX3438

- ② hybrid IC's which were purchased from external sources and included in the product were replaced with our company's own circuitry, and
- ③ utilization of a distribution factor circuit.

To achieve reduction in size, we implemented the following two improvements:

- ① increase in the level of integration through changes in the receiving circuit, and
- ② high density wiring of the high frequency patterns.

As a result, in the prototype, while maintaining the functionality of the existing model, we achieved a 50% reduction in base cost and a 35% reduction in board area, compared to the current model. In addition, we accomplished a 55% reduction in power consumption compared to the current model.

The next generation models LX 3445 and LX3446 are configured on the same board. Their applications are separated according to the type of antenna connection: LX3445 is made for mounting on on-board equipment with an integral antenna, while LX 3446 mounts on on-board equipment with separate antennas. Each is designed to be adaptable to the specs of the on-board equipment to which it is mounted. The external appearance of both RF modules is as shown in Photo 3.

## Conclusion

Here we have reported on an RF module for use in on-board equipment used in ETC systems. However, the 5.8GHz "Dedicated Short Range Communication" (DSRC) system used in ETC is gathering attention as a communication system which is expected to develop further in the future. Use of the system is being studied, not only for toll highways, but also for implementing other services focused on cars, such as parking lots, convenience stores, gas stations, etc.<sup>1</sup> There is a solid demand for timely and low cost provision of the RF modules which are the key to these

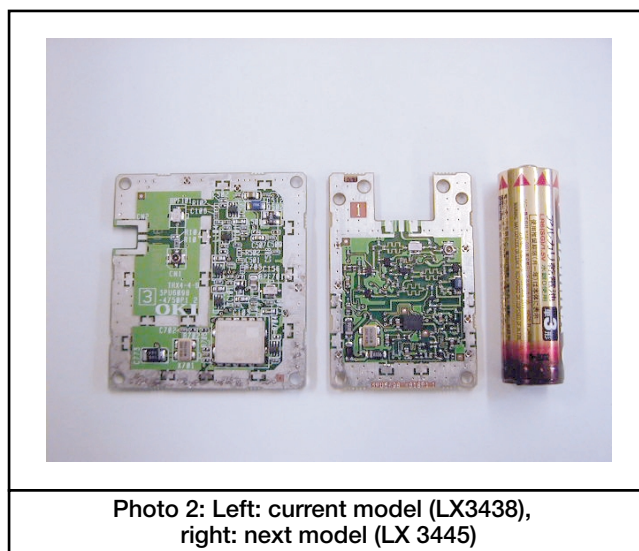


Photo 2: Left: current model (LX3438), right: next model (LX 3445)

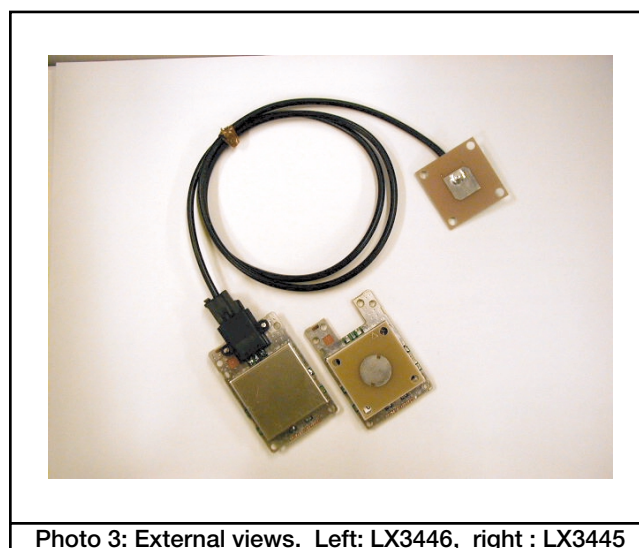


Photo 3: External views. Left: LX3446, right : LX3445

DSRC systems. Also, there is a strong demand for achieving total systems with optimized specifications and formats in order to implement a variety of systems in the limited space inside an automobile.

Our company plans to contribute to advances in ITS by developing and putting into practical use the RF modules for DSRC systems. These modules are a key component of ITS.

## References:

1. DSRC System Research Committee, ITS Information Shower, First Edition, Create Cruise, Inc., published December, 2000.
2. Dedicated Short Range Communication for Transport Information and Control Systems ARIB Standard, ARIB STD-T55, published by Association of Radio Industries and Businesses (ARIB).