

The Anti-RFI Design of Intelligent Electric Energy Meters with UHF RFID

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Abstract: In order to solve the existing artificial meter reading watt-hour meter industry is still slow and inventory of common problems, using the uhf radio frequency identification (RFID) technology and intelligent watt-hour meter depth fusion, which has a one-time read multiple tags, identification distance, high transmission rate, high reliability, etc, while retaining the original asset management functions, in order to ensure the uhf RFID and minimum impact on the operation of the intelligent watt-hour meter, proposed to improve the stability of the electric meter system while working at the same time, this paper designs the uhf RFID intelligent watt-hour meter radio frequency interference resistance, put forward to improve intelligent watt-hour meter electromagnetic compatibility design train of thought, and introduced its power and the hardware circuit design of printed circuit board, etc.

1. Introduction

The micro-controller is introduced into the design of intelligent electric energy meters, which makes greater demands on the electromagnetic compatibility (EMC) of meters. The main reason is that external electromagnetic interference may result in an “uncontrollable” pointer controlled by programs, errors and losses of electric quantity data and even a chaotic system. Due to the special status of meters in the grid system, it is impossible to handle abnormal operations and even crashes by restoring to the initial state as frequently as other electronic devices. Therefore, fundamental measures are taken to improve the EMC performances of intelligent electric energy meters in order to enhance corresponding anti-interference capabilities and guarantee the normal and stable operations under the specified conditions.

As a measurement product of electric energy measurement and electricity charge settlement, intelligent electric energy meters possess not only an accurate and stable measurement performance, but also a strong capability of anti-electromagnetic interference, impact resistance and harsh environment resistance. Therefore, electricity consumption information are guaranteed to be accurate and reliable and interests of both power utilization and supply parties are guaranteed to be protected under any circumstances. As most of intelligent electric energy meters are designed on the basis of the one-chip micro-controller technology, electromagnetic interference is one major reason of failures or performance reductions of such meters. Hence, the improvement of the electromagnetic compatibility of intelligent electric energy meters is the key to improving corresponding operational reliability. The EMC has been internationally listed as an extremely important performance indicator of electrical and electronic products and corresponding laws and regulations are compulsorily implemented. In addition, China has also made clear requirements and regulations of the EMC of intelligent electric energy



meters via JB/T7566 and JB/T8382

2. The High-frequency Interference Source Analysis and Anti-interference Methods

Intelligent electric energy meters introduce the UHF RFID technology and, at the same time, the high-frequency interference source. During the RFID meter reading and asset management processes, the UHF RFID reader is launched, which puts intelligent electric energy meters in the UHF electromagnetic field and exerts a certain influence on operations of meters. An anti-interference method is designed in the high-frequency electric field to minimize the influences of UHF RFID signals on intelligent electric energy meters, which can be well solved by the electromagnetic shield theory.

The electromagnetic shield is one of the major methods to solve EMC problems. In fact, most of the EMC problems can be solved via the electromagnetic shield. The biggest advantage of solving electromagnetic interference problems via the electromagnetic shield is that no effects are exerted on the routine operations of circuits. Therefore, no modifications are made to such circuits.

3. The Common Shielding Technology

The common shielding technology involves multi-layered shielding and thin-film shielding technologies.

In order to achieve a better shielding effect, the multi-layered shielding technology is adopted to provide better protections for electric and magnetic fields, which is particularly suitable for shields focusing on reflection losses. Separated materials can form multiple reflections, which can generate better shielding effects than metal sheets with the same thickness.

The principle of the multi-layered shielding technology refers to no connection between two shielding layers. In fact, air should be isolated or other media be filled in among such layers. Otherwise, expected shielding effects may fail. Each shielding layer should adopt different materials. Magnetic permeability and saturation level should be taken into consideration. The size of the aluminum sheet in a shielding room is measured as 1,200mm x 1,200mm. Concrete shielding effects of one single layer and multi layers in an electric field refer to the following table. When the shield requires a good air permeability and ventilation, a mesh shielding with the size of 600m x 600m is adopted. Concrete shielding effects measured in the shielding room refer to Table 2. Based on the shielding effect comparison of aluminum sheets between a single layer and multi layers from Table 1, aluminum sheets are more suitable for the single-layered shielding from a medium-frequency to a high frequency. According to Table 2, the single-layered shielding effect of the metal mesh is more apparent in the medium- and high-frequency. The multi-layered shielding effect of the metal mesh is more suitable for the multi-layered shielding in the medium-frequency and demonstrates better shielding effects.

Table 1 The Electromagnetic Shielding Effect under Different Shielding Efficiency

	0dB	0~10dB	10~30dB	30~60dB	60~90dB	90dB~
Electromagnetic Shielding Effect	fail	poor	fair	average	good	excellent

Table 2 The Electromagnetic Shielding Effect of Aluminum Sheets Measured in the Shielding Room

Aluminum plate	10kHz	15kHz	10MHz	450MHz	1GHz	10GHz
Single layer shielding effect/dB	68	94	113	127	121	102
Multilayer shielding effect/dB	70	101	113	126	123	105

Table 3 The Electromagnetic Shielding Effect of Metal Meshes Measured in the Shielding Room

Wire mesh	10kHz	15kHz	10MHZ	450MHZ	1GHZ	10GHZ
Single layer shielding effect/dB	17	40	70	78	98	93
Multilayer shielding effect/dB	20	47	102	101	109	107

Table 4 Performance Features of Shielding Materials of Surface Conductive Coatings

Process method	Film thickness/um	Shielding numerical/dB
Magnetron sputtering Cu/Ni membrane	1.00~4.00	80~110
Spray metal zinc	50.80	60~120
Duplex electroless CU/NI coating.	1.27	60~120
The vacuum plating silver	0.50~1.30	50~70
Stick a metal foil	35.00	70~

Table 5 Conductive Plastics and Corresponding EMC Performance

Conductive filler	plastic	Shielding effectiveness	The manufacturer
Al	Polycarbonate、ABSmixing	45~65 (0.5~960MHz)	Mobay Chemical(USA)
Fe fiber	Nylon 6、polypropylene、PP、PC	60~80	NSK(JPN)
Stainless steel fibre	Polyvinyl chloride (PVC)	40	USA
Cu fiber	Polyvinyl chloride (PVC)	67(100MHz)	Hitachi Chemical(JPN)
Nickel-plated graphite fiber	ABS resin	80(1000MHz)	American Cyanamid
Ultrafine carbon black	PP	40(1000MHz)	Mitsubishi Rayon(JPN)

3.1 Thin-film Shielding

The thin-film shielding technology often coats a conductive thin film on intelligent electric energy meters via techniques, such as spraying, vacuum deposition and pasting, whose shielding efficiency is determined mainly by reflection losses and correction factors of multiple reflections (which will be introduced later on). When it is inconvenient to construct a shield, a thin metal coating is covered on a meter through a tinsel pasting manner or a spraying manner in order to absorb microwaves, shield electromagnetic waves and prevent radio frequency radiation.

3.2 Shielding Material

Electromagnetic waves experience reduction when passing through shields due to energy losses. Such losses can be divided into two parts: reflection loss and absorption loss. The shielding efficiency applied to the electricity field shield can be demonstrated via the following equation:

$$SE=R+A+B$$

Reflection will appear when electromagnetic waves are incident on interfaces of different media, which will also weaken the electromagnetic energy passing through interfaces. Reflection loss refers

to the electromagnetic energy loss caused by such reflection. As electromagnetic waves pass through 2 interfaces when going through one shield, two reflections will appear. Therefore, the reflection loss caused by electromagnetic waves passing through a shield is equal to the total of the reflection losses on the two interfaces.

For electric field waves, the reflection loss on the first interface is relatively big and that on the second interface is relatively small. For magnetic field waves, the reflection loss on the first interface is relatively small and that on the second interface is relatively big.

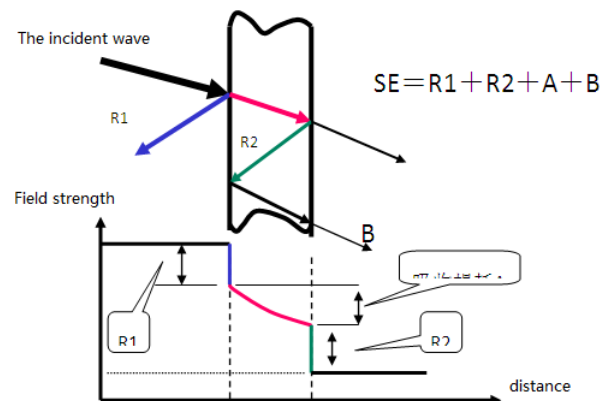


Figure 1. Anti-Interference Measures Calculated by Actual Shielding Efficiency

4. Anti-interference Design of Hardware of RFID Intelligent Meters

System failures and hardware damages are largely caused by a variety of interference, most of which originate from a power supply. The anti-interference technology of a system power supply is of greatest importance. Anti-interference measures of some power supplies are as follows:

(1) A power filter is installed at the primary of the power transformer in the series form, such as the circuit filter of a “duplex winding chock ring”. It has a high impedance against high-frequency interference signals, which generates a certain high-frequency isolation between the whole meter and the power grid and, at the same time, restrains an external high-frequency electromagnetic field interference.

The voltage changes of the power grid (such as voltage drops, surges and interruptions), frequency changes, wave form distortions of voltages or currents, continuous noises or clutters and power interference caused by transients exert an effect on the routine operations of meters mainly via power lines. Therefore, the interference and restraints of power lines become the first priority in product designs. Now, there are a variety of devices and products that can effectively restrain interference of power lines. Due to the working environment and costs of intelligent electric energy meters, the mainly selected devices include varistors, silicon Transient Voltage Suppressors (hereinafter referred to as TVS) and isolation transformers. Varistors are used to absorb transient voltages, the standard voltage (the fluctuation range of voltages should be taken into consideration) of which should be selected according to the 1.2 -1.4 times the working voltage of the circuit used. At the same time, the conversion between the effective value and the peak value should be paid attention to. TVS has an extremely rapid response time and a high surge absorption capability in order to protect circuits from static electricity, the handoff process of inductive loading and transient over-voltages caused by indirect lightning strikes. Isolation transformers can solve the interference caused by ground loop currents by implementing an electrical isolation among circuits and are particularly effective for low-frequency interference.

(2) The Design of A Printing Circuit Board

The power supply and the digital logic circuit are distributed in different areas in order to shorten the routing path of high-frequency currents on the printing board. Decoupling capacitors are used to eliminate the effects of transient processes on circuits and should be kept closely to the chip's power

pin as much as possible! The size of capacitors used should be small as much as possible and the length of the pin (wireless pin) should be shortened as much as possible. All connectors connecting with other boards and components must be close to each other as much as possible in order to prevent external currents from passing through lines on the printing circuit board.

5. The Wiring of a Printing Circuit Board

(1) Circuits transferring signals should be close to corresponding signal loops as much as possible, which can eliminate high-frequency current loops and prevent radiations caused by loop areas that are surrounded by such circuits. The power line and the ground electrode should be as close as possible. The former is arranged on the side of the printing board and the latter is arranged on the other side, which can minimize the impedance of a power supply in the form of an upper-and-down superposition. Distances among lines on the printing board are enlarged or a piece of ground electrode is consciously placed among lines, which act as an isolation between lines in order to reduce interference caused by a parallel routing.

(2) A MOV is put in parallel at the incoming line terminal of an AC power supply, the electric resistance of which reduces as the voltage at the two terminals increases. Then, a low-impedance shunt is formed when an over-voltage appears during the power supply process, which can prevent a surging increase in the voltage at the two terminals. When such voltage is restored to the normal state, the MOV will return to its high impedance.

(3) A TVS is connected in parallel in front of the three-terminal voltage stabilizer before the main controller's power supply. Due to the transient high energy impact at the two terminals, TVS can become a low-impedance device at an extremely high speed and absorb a large amount of currents in order to clamp voltages of the two terminals at a relatively low value, thus subsequent circuits being protected from damages caused by transient high voltages. This method is relatively effective for interference caused by lightning strikes and surges.

(4) The main circuit adopts an independent power supply and appropriate isolation measures (such as optocoupler) are adopted among circuit modules in order to enhance mutual interference.

The points mentioned above are the measures and techniques concerning the anti-interference design of hardware, which can effectively restrain bad effects of some interference sources on functions and performances of intelligent electric energy meters.

6. The Anti-interference of Software

The anti-interference of software mainly avoids major mistakes of intelligent electric energy meters during the working process. As a measurement and recording device of electricity consumption, an intelligent electric energy meter has extremely important materials, such as data of electricity consumption. The acquisition, transmission and storage processes of such data must be accurate and reliable. The following is a brief introduction to the guarantee of a reliability concerning E2PROM data readings.

(1) Application Software Trap. When a controller is interfered during the operational process, an "uncontrollable" program may be generated by making the PC point to the non-program area. Such "uncontrollable" program may be trapped in one certain loop and difficult to get rid of. When there is no clear watchdog instruction in the loop, the PC pointer will be reset under the given watchdog timing condition. However, when there is a clear watchdog instruction, a crash will appear. In order to deal with such condition, the program can make a large number of software traps. When entering to the non-program area, PC is possibly trapped in software traps in order to successfully reset PC. Locations of establishing software traps involve: ① An interrupt area to be used. The establishment of software traps in the interrupted service sub-program that is to be used can effectively capture the wrong interruption. ② To write software trap instructions at the space un-programmed in the processing equipment. When programs are uncontrollable and enter into such space, they can rapidly return to the normal state.

(2) A Timing Set of the I/O State. Some controllers can programme the I/O state, so the I/O state

can be changed when a micro-controller is interfered. For example, the electrical pulse input port may be interfered and changed into an output port, which may make a result that intelligent electric energy meters fail to detect electricity consumption by users. Therefore, to regularly and repetitively define the input/output states of I/O is beneficial to operations of intelligent electric energy meters under an interfered environment.

(3) Data Verification. As some data stored in intelligent electric energy meters are extremely important, no mistakes are allowed. Inputs of such data require particular and legal judgments. For example, a judgment of forms of electric quantity data is made in order to effectively avoid some mistakes and to improve corresponding anti-interference performances.

7. Conclusion

This article introduces a design of anti-RFI on intelligent electric energy meters with UHF RFID, studies the interference of UHF signals against intelligent electric energy meters, analyzes anti-interference methods of intelligent electric energy meters, searches theoretical approaches to solving problems and concludes methods to solve UHF interference problems by comparisons of various shielding materials and the optimal design of shielding structures.

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