Research on Performance of Different Hall-Effect Switch on Smart Meter

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Abstract. With the deepening application of smart meter and improvement of electricity information acquisition system, more and more problem recorded by smart meter being discovered in scene, such as constant magnetic field events, communication failure event. Some smart meter recorded tens of thousands constant magnetic field events and the reason is varied, however, the ultimate cause of the event is the hall-effect switch on smart meter. This paper just analyzed the event of constant magnetic that detected frequently by the electricity information acquisition system, and the result showed that the hall-effect switch from different manufacturers has different performance.

1. Introduction
With the popularization of smart meter and function improvement of electricity information acquisition system, the power grid is more and more intelligent. However, many problems recorded by smart meter showed up as well, such as constant magnetic field events, communication failure event and so on. These events recorded by smart meter is used for the electricity safety and electricity theft prevention, but some events are abnormal that recorded by smart meter acquired from the electricity information acquisition system. For example, the constant magnetic field event was recorded thousands of times in some smart meter, it influenced seriously the normal operation of smart meter and the basic function of electricity stealing prevention. It can know the main reason is the interference of large current nearby that created alternating magnetic field according to scene analysis, and the different hall-effect switch in smart meter that record constant magnetic field event has different performance. This paper just does the research on performance of different hall-effect switch on smart meter.

2. Principle of Hall-Effect Switch
The hall-effect switch on smart meter mainly includes AH9247, APS13221 and SGC610xC that from different manufactures, the different hall-effect switch has different working principle and different performance.

2.1 The hall-effect switch of AH9247
The AH9247 is a high sensitivity Hall-effect switch with internal pull-up resistor on the output, designed for battery-operation, handheld equipments. The functional block diagram is as figure 1. A
chopper stabilized amplifier improves stability of magnetic switch points. A sleep-awake logic controls the IC in sleep time or awake time. This function will reduce the average operating current of the IC. During the awake time, the output is changed with the magnetic flux density. During the sleep time, the output is latched in its previous state and the current consumption will reduce to some µA. The output can be switched on with either north or south pole of sufficient strength. If the magnetic flux density perpendicular to the part marking surface is larger than operating point (BOP), the output will be turned on; if it is less than releasing point (BRP), the output will be turned off.

2.2 The hall-effect switch of SGC610xC
The 3D magnetic switch chip SGC610xC is an omni-directional magnetic field detection chip developed to meet the requirements of smart meter anti-theft application in power grid. The functional block diagram is as figure 2. SGC610xC integrates anisotropic magneto resistive (AMR), comparison operational amplifier circuit, temperature compensation circuit and so on, which fully meets the requirements of omni-directional detection, high sensitivity, low power consumption and wide working range of smart meter anti-theft application.

2.3 The hall-effect switch of APS13221
The APS13221 integrated circuit is an ultrasensitive Hall effect switch with 3D omnipolar magnetic actuation. The functional block diagram is as figure 3.

The single silicon chip includes: three Hall plates, multiplexer, small signal amplifier, chopper stabilization, Schmitt trigger, and an NMOS output transistor. The device output turns on when a magnetic field of sufficient strength is applied to the sensor in any orientation. Removal of the magnetic field will turn the output off. The functional block diagram is such as figure 2. The APS13221 is offered with a combined X+Y+Z output. The low operating supply voltage, 2.5 to 5.5 V, and unique clocking algorithm assist in reducing the average power consumption, making it ideal for battery operation (e.g., the power consumption is less than 25 uW with a 2.5 V supply).
3. Experiment and Analysis

As the hall-effect switch of AH9247 is uniaxial to the constant magnetic field, only if the magnetic flux density perpendicular to the part marking surface is larger than operating point the output can be turned on, and the main hall-effect switch on smart meter is the 3D switch of SGC610xC and APS13221, so this paper just do research on the 3D hall-effect switch of SGC610xC and APS13221.

3.1 Experiment

This paper build test environment firstly, it mainly includes a cuboid magnet of 480mT magnetic field intensity, a digital gauss meter, a infrared imager, a workbench of smart meter and some smart meter from different manufactures that fitted with 3D hall-effect switch of SGC610xC and APS13221. Then let the cuboid magnet perpendicular to the smart meter and make sure if the smart meter recorded the constant magnetic field events through workbench, it can control magnetic field strength through the
distance of cuboid magnet to smart meter. To compare the performance of different hall-effect switch particularly and clarify the reason of abnormal record of constant magnetic field events in some smart meter, this paper divided the three phase smart meter into 38 regions, and then testing the maximum field strength of the meter recording constant field event in every region, the detail of the regions is such as figure 4.

To verify the reliability of hall-effect switch, this paper put the 480mT cuboid magnet to the board of the smart meter directly for one hour, and then observe the variation temperature of the board after putting the cuboid magnet through the infrared imager, the temperature distribution of the board before putting cuboid magnet is such as figure 5.

3.2 Results and analysis
The results of critical magnetic field strength of every area that can cause the record of constant field event is such as table 1. It can know that the hall-effect switch of SGC610xC and APS13221 both can cause constant field event when the magnetic field intensity is large. However, some area of the APS13221 can cause constant field event when the magnetic field strength is 14.1mT but the SGC610xC can not. As a whole, the critical magnetic field strength of the APS13221 is less than SGC610xC, so the hall-effect switch of APS13221 is more sensitive than SGC610xC.

| Area | Hall-effect Switch | Critical Magnetic Field Strength | Area | Hall-effect Switch | Critical Magnetic Field Strength |
|------|--------------------|---------------------------------|------|--------------------|---------------------------------|
| area 1 | SGC610xC | 19.5mT | area 20 | APS13221 | 37.1mT |
| area 2 | SGC610xC | 21.5mT | area 21 | APS13221 | 63.7mT |
| area 3 | APS13221 | 14.1mT | area 22 | SGC610xC | 25.2mT |
| area 4 | APS13221 | 21.1mT | area 23 | APS13221 | 37.1mT |
| area 5 | SGC610xC | 35.2mT | area 24 | APS13221 | 14.1mT |
| area 6 | APS13221 | 31.1mT | area 25 | APS13221 | 37.1mT |
| area 7 | SGC610xC | 34.7mT | area 26 | APS13221 | 31.1mT |
| area 8 | APS13221 | 30.5mT | area 27 | SGC610xC | 14.1mT |
| area 9 | SGC610xC | 51.5mT | area 28 | APS13221 | 46.7mT |
### Table

| Area   | Hall-effect Switch | Critical Magnetic Field Strength | Area   | Hall-effect Switch | Critical Magnetic Field Strength |
|--------|--------------------|-----------------------------------|--------|--------------------|-----------------------------------|
| area 10| APS13221           | 19.5mT                            | area 29| SGC610xC           | 20.2mT                            |
| area 11| SGC610xC           | 24.8mT                            | area 30| APS13221           | 46.7mT                            |
| area 12| APS13221           | 14.1mT                            | area 31| SGC610xC           | 20.2mT                            |
| area 13| SGC610xC           | 22.1mT                            | area 32| APS13221           | 37.1mT                            |
| area 14| APS13221           | 21.1mT                            | area 33| APS13221           | 44.8mT                            |
| area 15| SGC610xC           | 30.5mT                            | area 34| APS13221           | 29.6mT                            |
| area 16| APS13221           | 30.5mT                            | area 35| APS13221           | 37.1mT                            |
| area 17| SGC610xC           | 44.8mT                            | area 36| APS13221           | 14.1mT                            |
| area 18| APS13221           | 36.7mT                            | area 37| APS13221           | 36.7mT                            |
| area 19| SGC610xC           | 14.1mT                            | area 38| APS13221           | 36.7mT                            |

![Fig 6 The temperature distribution of the board after putting cuboid magnet](image)

The result of reliability of hall-effect switch is such as figure 6, it can know that the location of maximum temperature after putting cuboid magnet for an hour is changing from the power supply to the hall-effect switch and the smart meter can work normally, so the reliability of APS13221 and SGC610xC is enough.

### 4. Conclusions

This paper does the research on performance of hall-effect switch of SGC610xC and APS13221, the results show that the two switches both have enough reliability to ensure the smart meter normal working in in extreme cases, and the hall-effect switch of APS13221 is more sensitive than the SGC610xC. The result can explain the reason of the abnormal thousands records of constant field event in some smart meter, that’s because the large current nearby the smart meter produced magnetic field whose strength is larger than the critical magnetic field strength, so the smart meter records constant field event incessantly. As well as, the shortcoming of hall-effect switch urge us to research new technology of hall-effect switch to be applied to the smart meter.
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