AZD086 - ESD test guidelines for touch-sensing applications

1 Introduction

One of the biggest threats with regard to touch sensing applications is the risk of damage to the electronic equipment or components with electrostatic discharge (ESD). The testing of electrostatic discharge (ESD) immunity is usually done at expensive electromagnetic compliance (EMC) testing laboratories and the entire process can be very time consuming. This has led to a growing need for technical engineers and designers to be able to do their own pre-compliance testing.

This paper aims to explain the basic set-up, test procedures, ESD test guidelines and the specifications of the IEC61000-4-2 ESD standard for pre-compliance testing of ESD in touch sensing applications.

The IEC standard is a system level test that replicates a charged person discharging to a system in a system end user environment. The purpose of the system level test is to ensure that finished products can survive normal operation. The IEC61000-4-2 standard is commonly used to certify equipment such as mobile phones and computers and any other sensitive electronic equipment such as that used in touch sensing applications.

2 Test Bench

- The first step in the set-up is the test-bench: The drawing below is a simplified version of the test-bench set-up at Azoteq for table-top equipment.

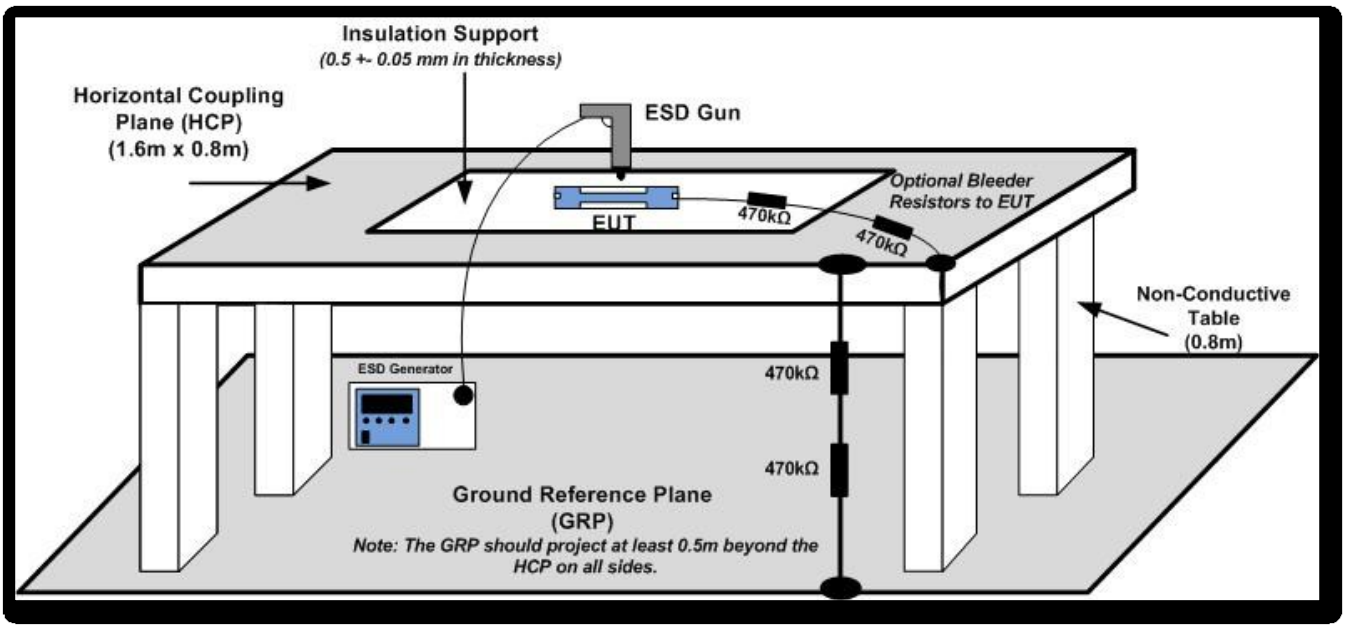

Figure 2.1 Basic set-up of test bench.

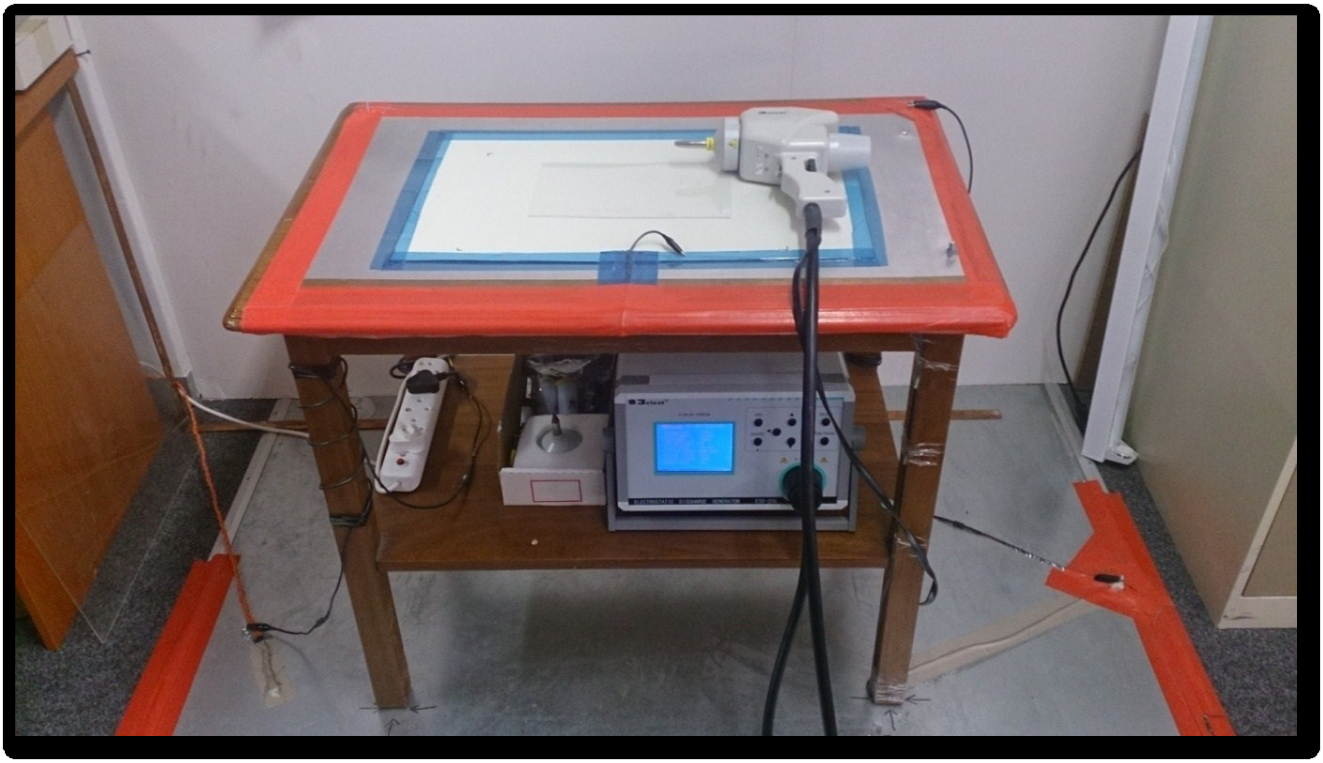

Figure 2.2 The ESD test bench at Azoteq.

3 Contact Discharge or Air Discharge

The IEC 61000-4-2 standard defines four standard levels of ESD protection, using two different testing methodologies: Contact discharge and air discharge.

These methods are often misunderstood and not performed correctly which leads to conflicting results. Below is a brief summary of the differences between the two methods:

Contact Discharge	Air Discharge
Preferred method	Use when contact discharge cannot be applied
More dedicated to conductive surfaces	More dedicated to insulating surfaces
Current levels and rise times are reproducible.	Current levels and rise times are less reproducible

- Test levels for each test method are given in Table1 below. The voltages shown are different for each method. This does not imply that the test severity is equivalent in all test methods.
- For air discharge, testing is performed sequentially at all levels up to the specified test level.
- For contact discharge, the test should be performed at the specified test level only unless otherwise specified by product committees.

Table1: IEC61000-4-2 ESD test levels

Contact Discharge		Air Discharge	
Level	Test Voltage (KV)	Level	Test Voltage (KV)
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15
X *(See Notes)*	Special	X *(See Notes)*	Special

Notes: *"X" is an open level. The level has to be specified in the dedicated equipment specification. If higher voltages than those are specified, special test equipment may be required.*

4 Air Discharge

Contact discharge might be the preferred testing method for ESD immunity testing but when it comes to testing touch sensing applications the air discharge method is used more often since most touch pads, proximity antennas, swipe switches etc. are usually covered by an insulating overlay.

The following are guidelines and notes for air discharge as per the IEC61000-4-2 standard

1. The **rounded** tip of the ESD gun is used for air discharge.
2. The ESD generator is set to the desired voltage level and then the **trigger is closed** on the ESD gun. The trigger **remains** closed and the tip of the ESD gun must approach the equipment under test (EUT) as **fast as possible** until a spark gap discharges onto the surface of the EUT electrode or until contact is made with the surface of the EUT without causing mechanical damage.
3. At higher voltage levels this discharge can occur as multiple successive discharges. A slight crackling noise can be heard.
4. After **each** discharge, the ESD gun must be **removed** from the EUT. The generator is then retriggered for a new single discharge but it is very important to allow the **EUT to discharge completely** before the next discharge from the ESD gun is applied.
5. Applying the next discharge before the EUT is fully discharged can lead to the EUT being tested at more than double the intended voltage level.
6. The **bleeder resistors** (2 x 470KΩ) can be used to ensure that the EUT is properly discharged.
7. The **"bleeder resistors cable"** can be connected between the EUT and the horizontal coupling plane (HCP). However it is stated in the IEC standard that the connected "bleeder resistors cable" can influence the test results and it therefore would be better no to connect the "bleeder resistors cable".
8. Alternatively the EUT can be swept with a **grounded carbon fibre brush** connected to bleeder resistors (2 x 470KΩ) in the grounding cable.
9. The resistors should be capable of withstanding the maximum discharge voltage applied to the EUT plane during the test.
10. A **preferred method** that is used at Azoteq is simply to "touch" the touch-sensing buttons or electrodes of the EUT as by doing so one removes the charge build-up on the surface of the device and the functionality of the device is also tested.
11. **Ten positive** and **ten negative** discharges should be applied at a specific voltage level.
12. Please note that with some sensitive touch and proximity-sensing devices a touch or proximity indication could occur as the tip of the ESD gun approaches or touches the touch pads on the EUT.
13. This can be **rectified** by simply decreasing the touch threshold during the ESD tests. As the tip of the ESD gun touches the touch pad it will not indicate a touch condition. However this lower touch threshold will still indicate a touch condition when touched with one's finger hence it still will be sufficient for testing functionality.

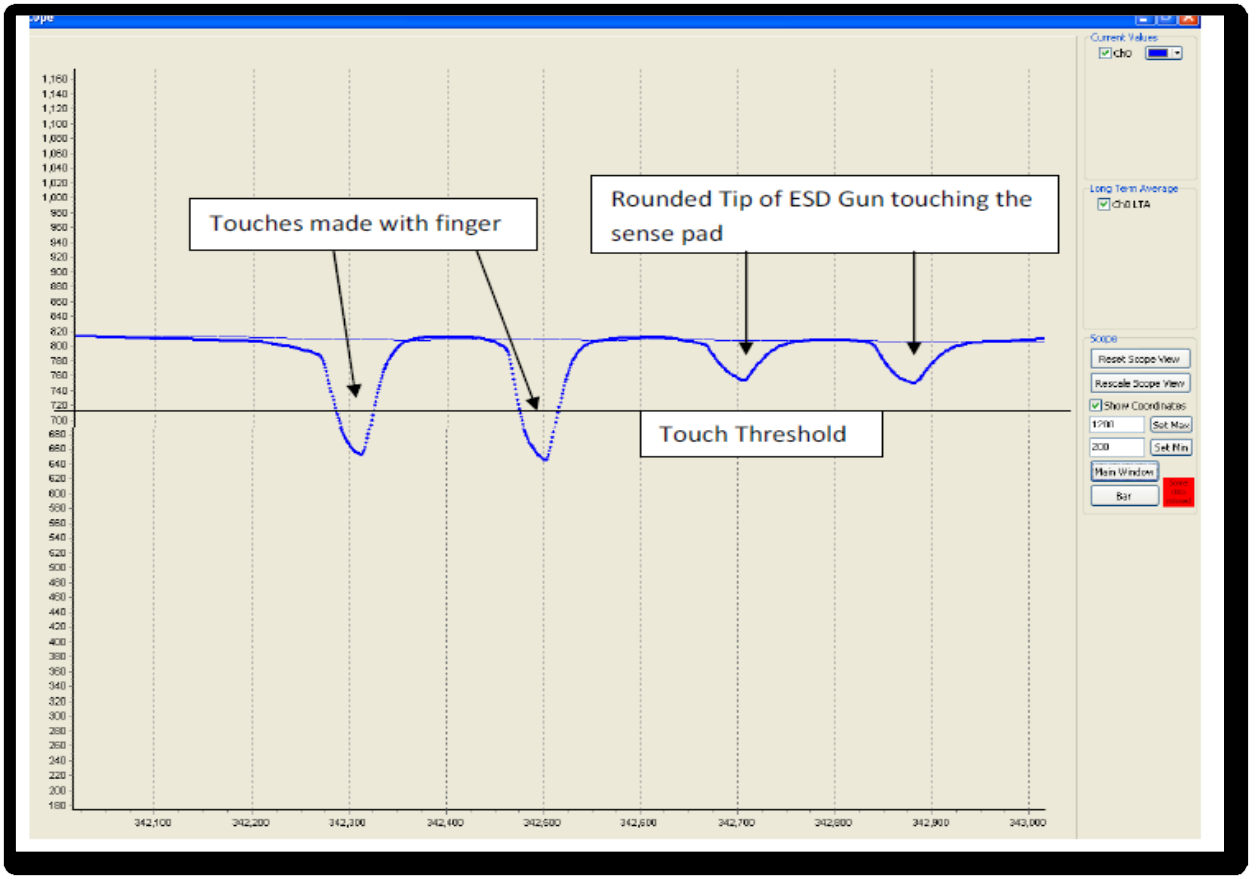

Figure 4.1 Touch-sensing device with a lower touch threshold that was used during an "in-house" ESD test.

14. The **repeatability** of the air discharge method is influenced greatly by the speed of approach of the discharge tip, humidity and the construction of the ESD generator. These all lead to great variations in the pulse rise time and the magnitude of the discharge current.
15. The **spark** is a very complicated phenomenon. It has been shown that with a moving spark gap the resulting rise time of the discharge current can vary from less than 1ns to more than 20ns just by varying the speed of the approach.
16. Keeping the **approach speed** constant does not result in constant rise time. For some voltage/speed combinations, the rise time still fluctuates by a factor of up to 30.
17. If possible the ESD gun must be held **perpendicular** to the surface of the EUT. This improves the repeatability of the test results.
18. One can also **verify the ESD test setup** by a simple discharge from the ESD gun onto the coupling plane. A small spark will be created during the air discharge at a low voltage setting while a larger spark will be created at a higher setting. It is essential to verify the ground strip connection and location prior to this verification.
19. The **climatic conditions** also play a very important role and it is essential the following parameters are met for more repeatable test results:
    - ambient temperature: 15 °C to 35 °C;

- relative humidity: 30 % to 60 %;
- atmospheric pressure: 86 kPa (860 mbar) to 106 kPa (1 060 mbar)

20. An example of how big an **influence the humidity** has on the ESD is the following: If a person walks on a regular nylon floor and the relative humidity is 20% the voltage built up can be higher than 10KV but if a person walks on that same regular nylon floor at a relative humidity of 50% the voltage built up is less than 4KV.

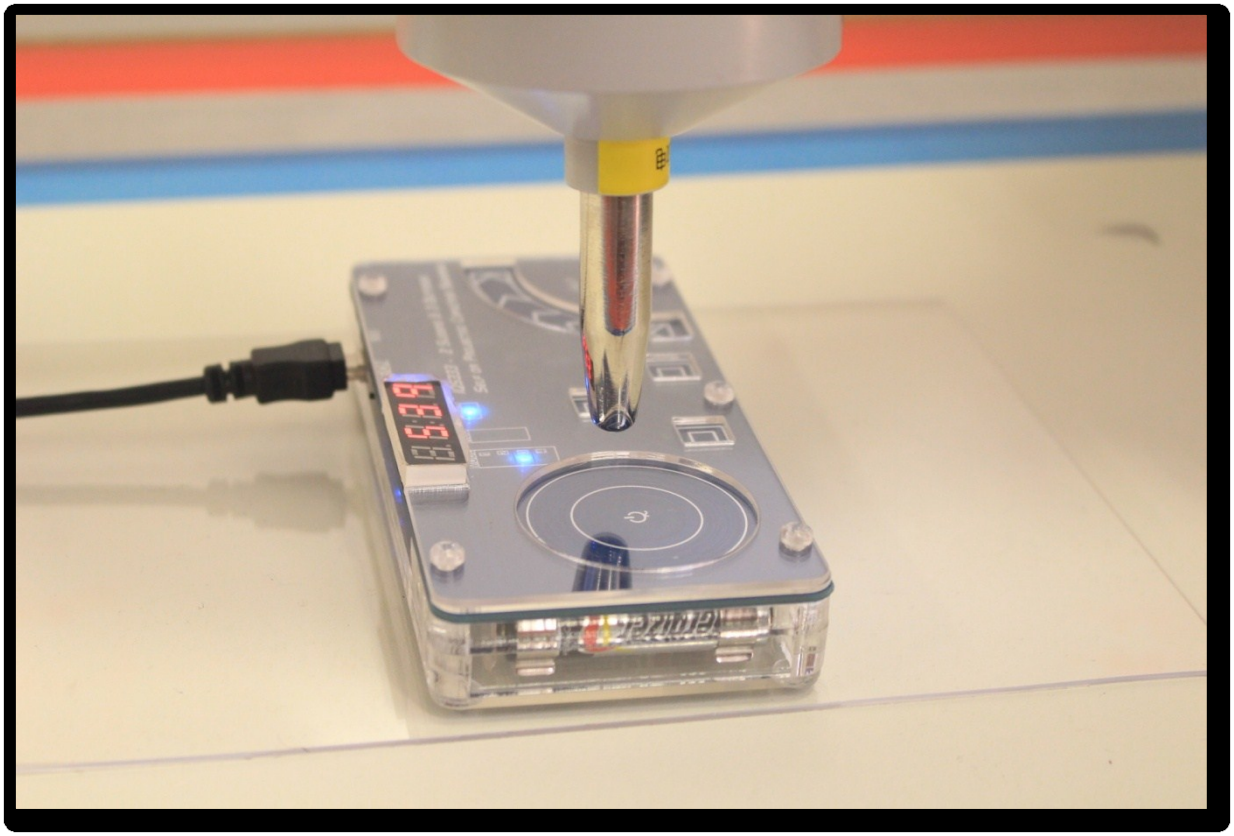

Figure 4.2 Air discharge on plastic overlay of touch and slider evaluation kit

1. Contact Discharge

The following are guidelines and notes for contact discharge as per the IEC61000-4-2 standard

1. The **sharp tip** of the ESD gun must be used for contact discharge.
2. In the case of contact discharges, the tip of the ESD gun **should touch the EUT**, before the discharge switch is operated.
3. The tip is then removed and the EUT has to discharge fully before the next discharge is applied.
4. **Ten positive** and **ten negative** discharges shall be applied at a specific voltage level.

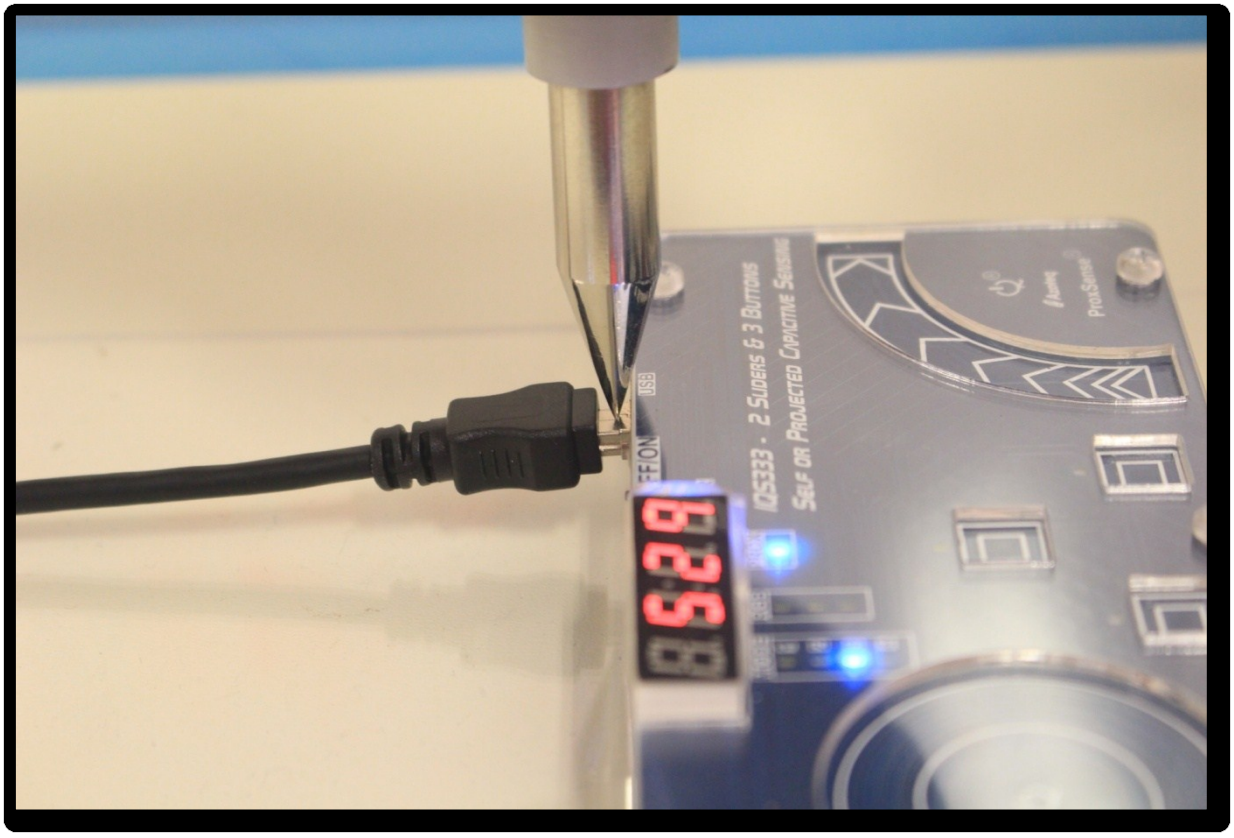

Figure 4.3 Contact discharge to USB connector on touch and slider evaluation kit

2. Common mistakes during ESD testing

The following are a few common mistakes that are made by test and technical engineers:

1) Wrong table set-up: ***(please see the proper table set-up in Figure 1)***
   - Using a fully metallic table instead of a wooden non-conductive table.
   - Connecting the HCP directly to the ground reference plane (GRP) instead of using the **"bleeder resistors cable"**
   - Placing the EUT directly on the HCP without insulating material.
   - The absence of a GRP
2) Successive discharges without allowing the EUT to discharge. ***(please see points 4 to 10 under Air Discharge)***
3) Using the wrong tip on the ESD gun ***(please see point 1 under Air Discharge and point 1 under Contact Discharge.)***
4) Trying to do an air discharge simply by closing and releasing the trigger of the ESD gun ***(please see point 2 under Air Discharge.)***
5) Performing ESD tests in adverse environmental conditions ***(please see point 19 and 20 under Air Discharge.)***

3. Conclusion

- Pre-compliance ESD testing can be a very useful tool to review a product design before the expensive and time consuming process of product qualification at an EMC test laboratory starts.
- Please refer to the application note ***AZD013 ESD Performance Overview*** which is available on the AZOTEQ website and the ***IEC61000-4-2 standard*** for a detailed description of the ESD testing procedure and other guidelines.

Appendix A. Contact Information

	USA	Asia	South Africa
Physical Address	6507 Jester Blvd Bldg 5, suite 510G Austin TX 78750 USA	Rm1725, Glittery City Shennan Rd Futian District Shenzhen, 518033 China	109 Main Street Paarl 7646 South Africa
Postal Address	6507 Jester Blvd Bldg 5, suite 510G Austin TX 78750 USA	Rm1725, Glittery City Shennan Rd Futian District Shenzhen, 518033 China	PO Box 3534 Paarl 7620 South Africa
Tel	+1 512 538 1995	+86 755 8303 5294 ext 808	+27 21 863 0033
Fax	+1 512 672 8442		+27 21 863 1512
Email	kobusm@azoteq.com	linayu@azoteq.com.cn	info@azoteq.com

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