Name：Chentian Li

Middle School：No. 1 High School of Zhuhai

Province：Guangdong

Country/Region：China

Tutor：Qinsheng Liang

Topic: Design & Implementation of Universal Power-adapting Protocol （UPP）

Design & Implementation of Universal Power-adapting Protocol (UPP)

Abstract

Two noted drawbacks can be found in nowadays' power adapting technological scheme: the first is found in both of AC & DC adapters which is that the connection between power supply and appliance is only electrical connection. Such a connection can almost do nothing against such accidents as electric shock, illegal electricity-using, and accidents resulted from overcurrent, overvoltage, overheat and/or the like; the second is mainly found in DC power adapters, which is that one power adapter can only supply power with specified electrical parameters. It means that one adapter can only power its designated electrical appliance, which will inevitably lures two issues: one is that once the electrical appliance become out of work, its power adapter would also have to be abandoned, even if it is still in good conditions, such an outcome will result in waste of resources and environmental pollution, in addition to inconvenience for users who would have to take various kinds of adapters with them during their work and life.

To solve the drawbacks above, here puts forward an adapting scheme in which electricity adapters and appliances will first conduct "communication and negotiation" prior to power delivery. The noted features of this scheme are as followings: the first, it is the first set of

protocols designed for power adaptation by which all power delivery will not be conducted only with a simple electrical connection marked as **“Contact and Power”,** but one marked as **“Agree and Power”** in which power delivery will not happen unless an “agreement” by and between the power supply and the appliance has been concluded in advance. Such an electrical adapting scheme will certainly ensure that all electrical parameters may stay within the coverage specified in the course of electrical adaptation and this would thus avoid almost all safety issues resulted from electric shock, illegal electricity-using, overcurrent, overvoltage, overheat and so on; and the second, it is first time achieving the goal of which one adapter is able to provide electricity for various kinds of appliances within the designated range automatically , i.e. the power supply will be able to provide electricity with right parameters for appliances according to their requests. Such two features above will make a way for solving issues of waste of resources, environmental pollution and inconvenience of carrying different kinds of adapters.

This scheme thus designed a protocol which has taken much effort to develop Topology, Connection Methods, Data Structures and the like and thus built up a set of standards related to communications necessarily by and between power adapter and appliance. Further, here also developed a physical device which implemented UPP, the “UPP Power Adapter”. According to the experiments and tests, the device reached all

engineering goals designed: it can supply correct electricity and provide parameter-specified safety protection according to the requests of appliances automatically within its specified range

It can be seen that UPP will soon head adapters marked as great variety and low-compatibility nowadays to unity following with more and more application of UPP in adapters just as USB had ever done on uniting computer peripherals. It will undoubtedly not only make peoples' work and life more convenient and comfortable, but also positively contribute much to reducing pollution, protecting environment and saving resources.

[Key Words]: Power Adaptation, Power Adaptation Protocol, Power Supply Device, Appliance, Electrical Connection, Digital Power Delivery, Appliances Identification, Delivering Power on Requirements, Conducting Protection Based on Actual Parameters.

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参赛团队签名： 李晨天

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Catalog

Title: Design & Implementation of Universal Power-adapting Protocol (UPP)

Text：

Why Is This Project?

I. What Is Power Adaptation: Power adaptation is one electrical conduction in which mains is inverted according to the requisites (included but not limited to current, voltage and the like) by appliances into one power with compatible specifications/parameters so as to make appliances work normally.

In our electrified times, power adaptation has become one part inevitable for our life. All appliances including those upon separated power adapters to work such as mobiles and notebooks and those upon AC power directly such as electrical fans, humidifiers and the like can work normally only through power adaptation.

Therefore, you might say that power adapters have related to our life with almost each layer, you could even further say that in such a time when electrical appliances have been so closed to us, one could do nothing if none adapter had been along with him. Adapters, however, had also brought about much trouble to us while contributed much to our life and work.

II. Issues Found in Power Adapting Relationship: Through a simple list,

we can know there are at least 3 issues found in power adaptation.

The First Is the One Related to Safety: Almost all of us had experienced such a scene in which the sockets suddenly fired while certain appliance of large watt such as an electrical kettle, electrical cooker or the like was being powered through the sockets, or a juicer stopped suddenly and sooner there was a smell of burning and you would then find the juicer had been broken, etc. These days, we had also heard of much news related to accidents in which the battery of certain appliance such as a phone burned and exploded suddenly while it was being charged, or a shock happened to one who was phoning with a phone being charged. As far as accidents resulted from water drops, metal debris or the like dropping into sockets could be found much more around us.

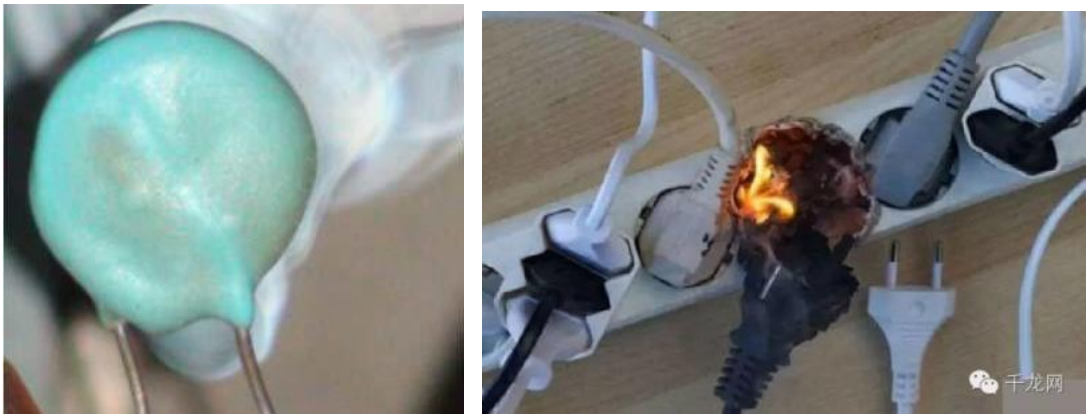


Image 1-2 Sockets Destroyed By Overload

The Second Is the One Related to Convenience of Carrying: During our journey, to make our camera, phone, notebook and the like work normally, we have to take sorts of adapters with us which would annoy us much all the time during the whole journey.

Image 3-4 Sorts of Adapters Necessary to but Troubling You

The Last Is the One Related to Waste of Resources: Maybe many people could find many sorts of adapters while they open their drawers at home. All those adapters, though could still work well, had to be abandoned because appliances using these adapters had been out of work.

Image 5 Adapters Had to Be Idled in Drawers

The issues above would not only influence our journey and work, but also even endanger our belongings and life in much occasions, which are

therefore very serious. It is thus very important to find a project which can solve or at least decrease these issues, or weaken sufferings resulted from these issues. Such a project will undoubtedly contribute much to people in increasing their safety and comfort and also to lessen waste of resources. All of those above are the reasons I selected this project.

The Main Issues & Causes of Power Adaptation

In summary, issues found in power adaptation included at least 3 sorts: the one related to safety, the one to comfort/convenience and the one to environmental protection.

To find the way to solve the issues above, let's first have a simple analysis to know **What and Why**.

I. Analysis on the Issues of Safety

To have a simple analysis on the phenomena appeared in power adaptation related to safety, it is easy to find that all issues found there are resulted from failure of the safety precautions and that the failure is further found to be close to the limitation of the safety precautions for power adaptation. .

To know what the limitations are, it might be a good idea to have a look first on the structure of the safety precautions for power adaptation.

(i) Safety Precautions for AC Adaptation First

Generally the safety precautions for AC adaptation are as the followings:

1. To estimate such power parameters as current, voltage, power consumption and so on of main bus on power requirements by appliances on largest watt, rated voltage and the like.

2. On basis of the estimated, to select wire and safety devices mainly consisting of overcurrent protectors (such as fuse/circuit breaker) and residual current circuit breaker. `

3. To create several branch lines in the main supply and to create some socket bases in branch lines.

Image 6-7 General Safety Protections of AC Power Adaptation Nowadays

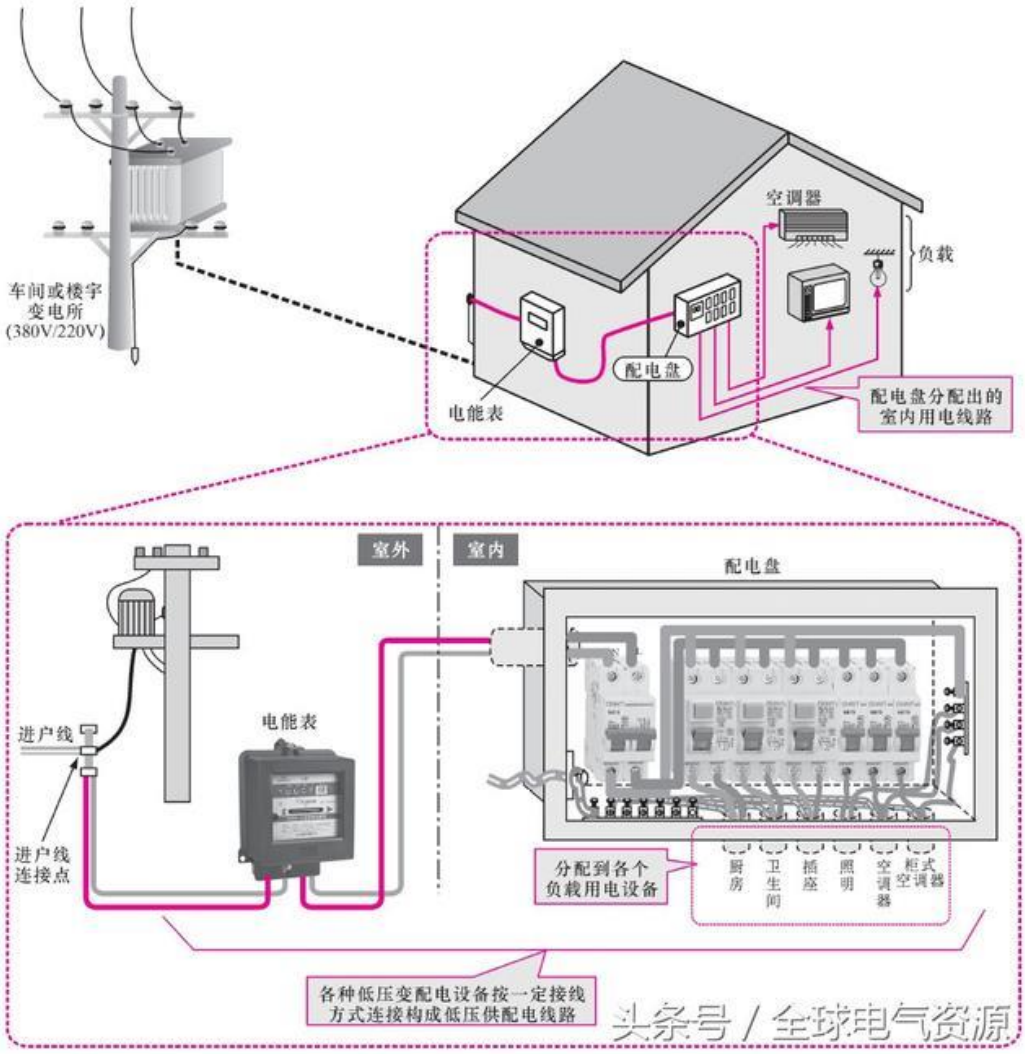


Image 8　Typical Diagrammatic of AC Power Adaptation

（ii）Limitations of Safety Precautions of Present Power Adaptation

What shown in image 8 is the most general technological project applied in safety precautions of today's AC adaptation and which would inevitably stay with following limitations:

The First Limitation Could Be Stated As "Total Control, Control Little"

As the safety precautions above paid mainly attention to the capacity of the main supply, it is thus the safety precautions would do nothing till the current of the main supply exceed the magnitude preset. The protection above is far from one being effective, because in many

occasions, a main supply may distribute many branch lines and branch lines, especially those directly connected with appliances did not have any protection separately generally. Because almost each plug base would connect with sorts of appliances which might differ much from each other on electrical parameters (for example, a household plug base might supply power for a night light of only several watts, or might supply power for a vacuum cleaner of thousands watts, it is thus almost impossible to have competent parts and units with rated electrical parameters). As the current of appliances in a branch line normally couldn't exceed the capacity of main supply but might exceed the capacity of the branch line (for example, a main supply of 60A is distributed to 6 branch lines of 10A respectively, and one of which an appliance of 15A is connected to), the safety precaution would therefore fail to work there and we would have to accept the final damaged outcome. That was why our electrical boiler might suddenly be broken while we were boiling water, because the current by the electrical boiler had exceeded the safety capacity of the branch line.

The Second Could Be Stated As "Scratch Shoes, Nothing on Itches"

The other is the safety protection model of current power adaptation. Its safety target is to protect the safety of power supply, but not the safety of appliances, which would thus do nothing on the electric abnormality by appliances, even appliances had been at risk or destroyed

unless the abnormality has been beyond the capacity of power supply. It could easily be found in the case while an electrical motor became stalled and the current was becoming larger and larger, the safety precautions still failed to work because the current, though had been becoming larger and larger, was still not large enough to trigger the protection devices.

The Third Could Be Stated As "Take Black & White as the Same, Drop into Black"

Furthermore, current project of power adaptation takes not any effort to discern whether a power request is lawful or not and it takes the physical connection between power supply and appliances as the only term for powering. Such a working mode might in many cases result in serious risk while also open a door to illegally use and/or steal electricity. For example, many accidents of kids' electric shock were resulted from such actions as holding some conductor by their hands directly into plug base. Other cases showed that some persons might steal power from the public plug cases, and so on.

Image9-10 Current Power Adaptation Project Easily Put Children into Danger

The Forth Could Be Stated As “Attention to Only One, Get Less Than One”

At last, the power adaptation project is still left with a remarkable drawback that is its safety protection basically works against only one parameter of current. Such a project against only one parameter can do nothing against accidents by factors other than current. For example, in many cases, the voltage might because of some causes become higher than normal one while the current is still right and in such a case the parameter of voltage set for starting safety protection would become meaningless.

In summary, the safety protection scheme of AC power adaptation might because of those limitations above fail to work and then result in safety issues stated above.

（iii）The Safety Precautions of DC Power Adaptation

At present, the way of DC power adaptation is mainly the one of supplying DC power through one separated or built-in DC power adapter which is connected to one AC power supplier subject to certain AC power adaptation device. The safety precautions of DC adaptation are basically those overcurrent and/or overheat protection components such as self-resettable fuses and/or thermistors fixed in relative circuits, which are so-called overcurrent and/or overheat protection told to users by sellers of adapters very much. As for the overvoltage protection many

sellers of power adapters claimed as the volumes of such parts and chips as magnetic relays, operational amplifiers, window comparators, photo couplers for voltage feedback and the like are too large to put inside the narrow space of power adapters, therefore, ordinary power adapters, especially those small-scale power adapters couldn't enjoy the protection of overvoltage at all.

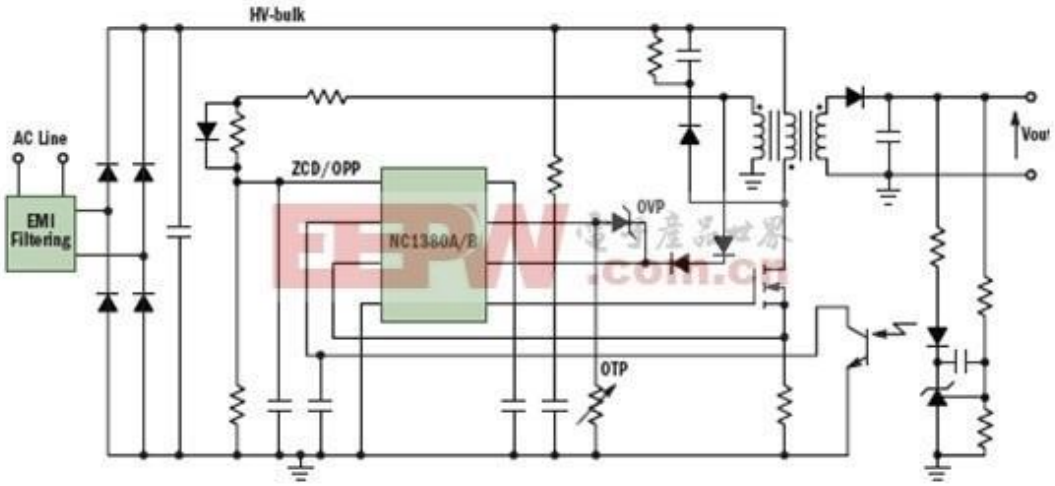


Image 11 A Typical Circuit of DC Power Adapter

Through the typical circuit of DC power adapter showed in image 11, it could be found that the ways and means of safety protection both in ordinary DC and AC power adaptation are common in which the protection mechanics are based on the parameters of power supply ends but not the actual ones of appliances and generally limited to the precautions of overcurrent and/or overheat protection. Therefore, the limitations and issues of DC power adapters today are almost the same as those found in AC adaptation.

II. Analysis on Conveniences/Comfortability

As AC adaptation systems have generally installed while buildings constructed and as specifications related to AC supply parameters are almost common, the power adaptation which might bring about troubles to people would then leave to DC adaptation.

The main inconvenience by DC power adaptation to people is great variety which are almost incompatible each other and the main cause resulted in the issue is the technological scheme of “One to One Adaptation” applied in almost all DC adaptation.

The scheme of One-to-One Adaptation is that one adapter can only supply one specified DC power with certain rated parameters. Such a scheme would inevitably result in that one appliance must be along with one specified adapter accordingly. It means that how many sorts of appliance you have, you would have to have how many kinds of adapter. Such circumstance above would of course bring about inconvenience to our life and business. More unfortunately, such inconvenience might become more and more serious following more and more DC electronic appliances come to our life and work.

III. Analysis on Issues Relative to Environmental Protection

On basis of those stated above, the issues brought about by power adaptation to environmental protection are mainly waste of resource resulted from duplicate production of adapters and pollution by electronic refuses of abandoned electric adaptation devices and both of

which are obviously from the limitations of DC power adaptation of One-to-One Adaptation model.

As each adapter can only be developed as the one supplying certain power with specified parameters, one new DC adapter would have to be developed specially for a new appliance(such as new mobile phone, notebook and so on). Then duplicate development and production become **"Certain"** which would thus result in increase of cost objectively.

Meanwhile, as each kind of power adapter can only meet the requirements by one but not more special appliance, the adapter would have to be become refuse inevitably instead of being used on for other appliances while the special appliance becomes out of work due to this or that reason. Nowadays, upgrading of IT and consumer electronic products is very speedy, and with elimination of those backward electronic products, the adapters of those products eliminated would also be eliminated as electronic rubbish which would put series of issues related to recycling and pollution of rubbish before us.

IV. Analysis on the Causes of Issues

On basis of the arguments above, the causes of those issues above shall be concluded as followings:

（i） The Causes of Safety Issues

1. Technological projects mainly based on parameters of main bus usually mismatch the actual safety requirements of appliances and the

fact would result in failure of safety protections.

2. The fact that safety protections only based on decision on threshold value don't react to the abnormal changes would result in failure of safety protections.

3. The safety precautions based on analog electronic technology, simple mechanical technology (such as bimetallic switches) and the like often result in failure of safety protections because of its inability to meet the requirements on precision, sensitiveness and speediness of safety protection of modern electronic products.

4. The technological scheme based on the tolerance of power supply and paying no attention to the parameters and tolerance of appliances often results in failure of safety protections.

5. The model of delivering power in whether physical contact is built is the only term for power deliver often results in failure of safety protections.

6. The model of starting safety protections based on the decision on only one parameter often results in failure of safety protection because of inability to decide on alteration of several parameters.

（ii）Causes of Issues of Environmental Protection

The limitation of power adaptation devices featuring One-to-One Adaptation results in duplicate development and production of adapters in addition to bring about piles of electronic refuses, waste of resources

and environmental pollution because the adapters eliminated couldn't be used again.

（iii）The Causes of Issues on Inconveniences/Comfortability

The limitation of adapters featuring One-to-One results in the necessity of a special adapter to almost each kind of appliance, which would inevitably bring about issues related to transportation, carrying and usage, especially while more and more quantity and variety of adapters come to us.

Evaluation and Design of Power Adaptation Project

I. Requirements on the Technological Project

On basis of the analysis on the causes resulted in issues, to solve the issues above effectively once for all, the technological project in the mind should contain the following elements

① **Appliances Identification:** That is power supply can tell the information of appliances which includes the identification, parameters and safety requirements of one appliance. This is something necessary to implement ② and ③.

② **Delivering Power on Requirements:** That is that one power supply might offer AC or DC power with different parameters from each other within certain range to meet the requirements by variant appliances

within the range.

③ **Conducting Protections Based on Actual Parameters:** That is that one power supply end might set the safety parameters based on both the actual circumstances of different appliances and its own capacity so as to meet the safety requirements of both power supply and appliances.

④ **Other Requisites:** At the same time, to have a technological project which can reach some norm and satisfy real requirements of nowadays people in real application, the project should include but not limit to the following terms:

①The start of safety protections shall be based on the variation trend suggested by abnormal changes of parameters within its range, but not on the preset threshold value only.

②The trigger of safety protections should meet the requirements on precision, speediness and sensitivity of safety protection of present electronic appliances, especially of appliances with low watts.

④ Able to recognize the ID and authority of appliances, and refuse or stop the illegal request for delivering power.

II. Selections & Evaluation on Technology Routes

On basis of the arguments above, here puts forward the project "Universal Power-adapting Protocol (UPP)" which is stated as following:

（i）**Overall Idea for UPP:** Set up communication between power supply and appliances which would change the pure electrical connection of

circuits into the one of **Digital-Electrical** connections.

According to the project here, power supply would be able to "understand" the requirements (include but not limited to requirements of power adaptation, safety protection and the like) by appliance(s) and then decide whether it can supply power meeting the requirements. If the judgment is yes, an agreement between power supply and appliance might conclude and power delivery begin while is no, then no power delivery will take place.

While power supply end meeting requirements by appliances and begin delivering electricity, power supply end would monitor real-time parameters dynamically and decide whether the power delivered and used normally. While it deems abnormal, it would make alarms to users or start safety protection mechanics directly.

（ii）Selection & Evaluation of the Technological Schemes for Constructing Communication by and between Power Supply and Use Ends.

1. Selection and Evaluation of Technological Schemes of Data Link for Collecting Information of Appliances.

To perform adapting power and safety protection for variety of appliances according to actual parameters, it must first to perform identification and data collection of appliances. It is therefore necessary to have a data link which can gain the information of appliances.

1.1 Selection of Methods for Getting Information

According to present technologies, there are two ways for getting information of appliances:

①**The Scheme of Active Information Tag:** to install information storage tag equipped with power (usually a small battery) in power supply end and while power supply end is connected with electrical appliance, the tag would actively “report” to and conduct communication with power supply end (like Bluetooth host discovers Bluetooth slave).

②**The Scheme of Passive Information Tag:** to install low power storage tag in electrical appliance. While the power supply end connects with electrical appliance, power supply end would deliver minor power to and get information from the tag through the lines (such as RFID coil) used for information transmitting and accessory power.

Of the schemes above, because the first one needs power to work prior to get power, accessory power like battery become necessary which would inevitably increase the cost and complexity of appliances. Further, because of live time, battery must be changed frequently and this would bring environmental damages. All of those above are the defects of this scheme.

As for the second one, because it uses passive information tag, the power unit and related device are fixed in power supply end and

electrical appliance only needs a storage chip (the one like chips with package of WSON-8 is no more than 0.1cm³)。The volume of electrical appliance would be still small. As power supply end has a ready-made power itself, the part that must add to for this scheme will then is an identification port only which would make little influence on volume. And the volume of power supply end is generally large, such increase would make not any impact on users.

On basis of the stated above, this project selected the second scheme, i.e. passive information tag scheme in which the electricity necessary for the tag to conduct Read-&-Write will supply by power supply end.

1.2 Selection of Technological Scheme of Information Tag

On basis of nowadays' electronic technology, the main ways to set up physical conditions for passive storage and identification are as followings:

① Passive RFID Tag Scheme.

② Active storage (such as SD card, EEPROM) scheme powered through port.

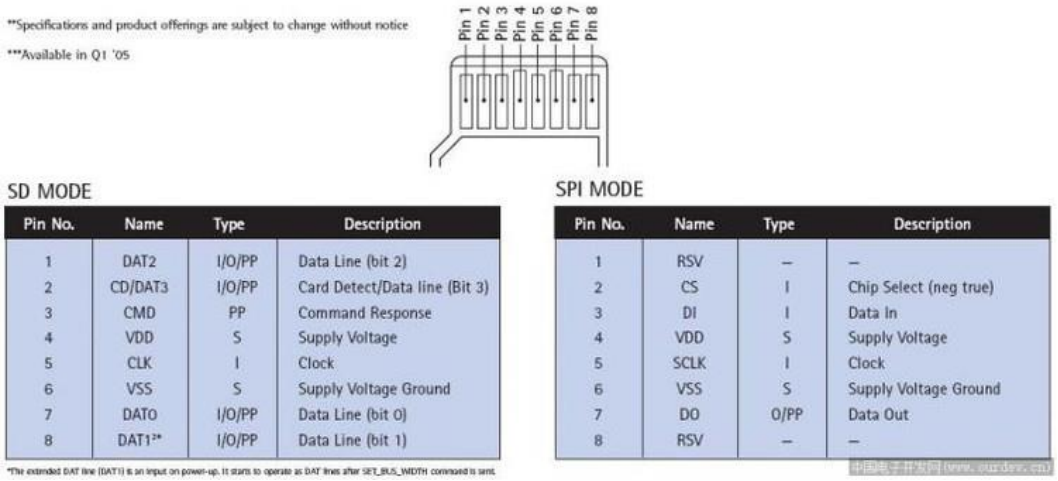
Have a look on RFID tag scheme first.

In this scheme plug base is generally used as power supply end in which one plug is often close to another (generally less than 10cm). As RFID can conduct Read-&-Write within certain distance (usually 5-10cm), it is easy to mistakenly read the information of the plug next to the right

one. It is therefore that only when the distance between two plugs is large enough this scheme can be selected.

Then let’s have a look on wired storage scheme.

Wired storage/card, though frees from interferences each other and is simpler in structure, needs many pins (as shown in image 12). Real power connectors (such as USB or DC socket) doesn’t have sufficient pins, and those with many pins can’t meet the requirements on current and voltage and people operation experiments. The one is thus not as desirable as the technological scheme of information storage and identification of appliances.



**Specifications and product offerings are subject to change without notice

***Available in Q1 '05

Pin 1 Pin 2 Pin 3 Pin 4 Pin 5 Pin 6 Pin 7 Pin 8

SD MODE

Pin No.	Name	Type	Description
1	DAT2	I/O/PP	Data Line (bit 2)
2	CD/DAT3	I/O/PP	Card Detect/Data line (Bit 3)
3	CMD	PP	Command Response
4	VDD	S	Supply Voltage
5	CLK	I	Clock
6	VSS	S	Supply Voltage Ground
7	DAT0	I/O/PP	Data Line (bit 0)
8	DAT1**	I/O/PP	Data Line (bit 1)

*The extended DAT line (DAT1) is an input on power-up. It starts to operate as DAT lines after SET_BUS_WIDTH command is sent.

SPI MODE

Pin No.	Name	Type	Description
1	RSV	–	–
2	CS	I	Chip Select (neg true)
3	DI	I	Data In
4	VDD	S	Supply Voltage
5	SCLK	I	Clock
6	VSS	S	Supply Voltage Ground
7	DO	O/PP	Data Out
8	RSV	–	–

Image 12 8 Pins Shown in the Connection Diagram of Standard SD Card

③ WID Storage Scheme

On basis of the statement above, the passive storage schemes today couldn’t meet the general requirements for real usage. To enable this project to be conducted smoothly and achieve preset norms, here developed a new wired passive storage

Shown as image 13, WID storage includes two basic parts: ① host, ② WID tag (with unique lithography 96-bits UID and other storable information). While the host tends to read WID tag, as shown in WID Protocol Timing Diagram (Image 14), the CLK/P pin of host would first send out energy-storing pulse which will be stored in capacity by the units of WID engaging in collecting and managing energy. While tag had energized, the host would then send out clock and Read-Write signals which would be converted and operated by clock distributors, logic controllers, data/address latches and address counters and in the course, the host conducts both operations of reading UID and Read-Write information of FRAM.

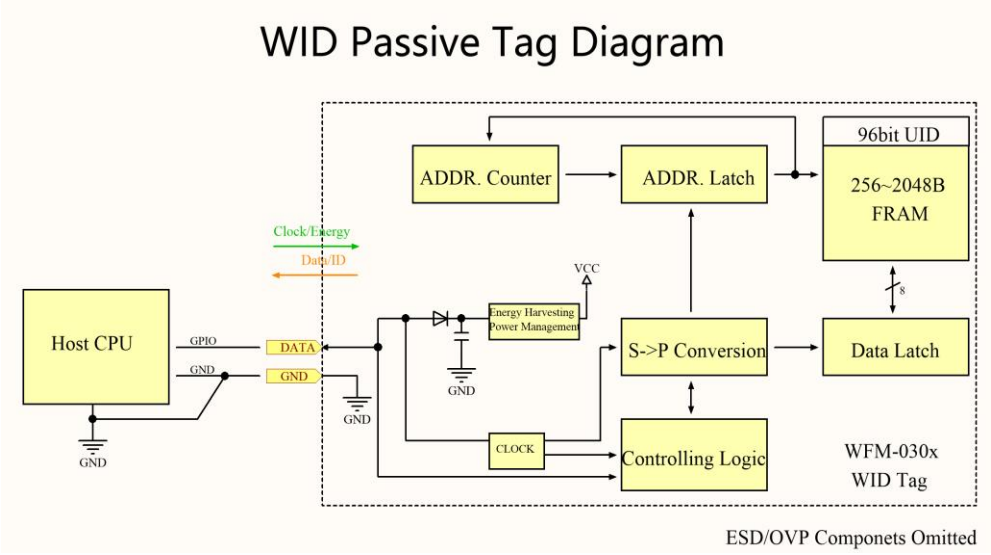


Image 13: WID Storage & Identificaiton Diagram (Direct Connection Version)

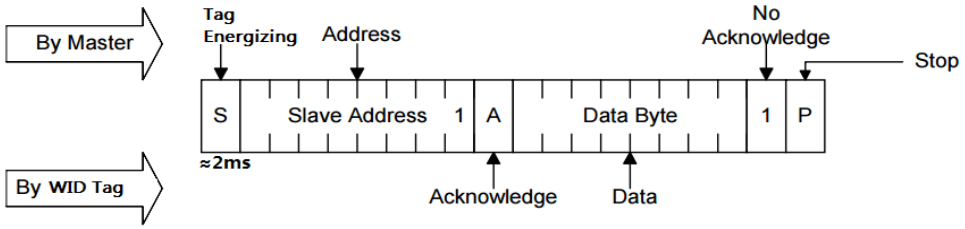


Image 14 Timing Diagram of WID Storage Identificaiton Technology

Shown as WID technological diagram (Image 13), only two pieces of data line (CLK/P line and DIO line)are necessary for connection between WID tag and host, plus a ground line, three pins are enough. Furthermore, on basis of the fact that the current necessary for WID tag to work is no more than one of μA , the pins might be decreased further through a connection of signal carrier in which the data pin is in parallel connected with the power pin of power connector by the way of capacitors of small capacitance (usually 1nF/275Vac).

According to statements above, WID overcame the issue that general passive wired identification and data storage had pins too many to be connected with usual power connector ever. WID could thus be connected with general power connectors conveniently and bring about little influence on people's operating habits and the overall construction of current connectors. Furthermore, as WID is a wired storage, it wouldn't be able to read information except there is an electric connection between reading device and tag. It can thus avoid the mistake to make wrong identification on tags in neighbor which found in RFID.

In summary, WID developed by author here can meet the real requirements of power adaptation well and may therefore be used as the scheme to construct physical conditions of collecting information of appliances.

2. Selection and Evaluation of the Technological Scheme for "Adapting Power on Requirements"

As the difference on function, design and structure of one appliance from others, requirements of appliances on specification, parameters of power would inevitably be variable. To achieve the technological destination of "One-to-Many" of "Adapting on Requirements", power supply here should have the ability to supply power adaptable to variable appliances, i.e., the ability to adapt electricity according to requirements and corresponding physical conditions.

2.1 Selection and Evaluation of the Technological Scheme for Appliances of High Voltage AC Power.

As AC appliances can work directly with high voltage AC power (115/220(230) Vac, 50/60Hz), it is generally unnecessary to regulate basic power parameters. The power adaptation would thus be right to have "On-and-Off" (deliver power while found agreed appliances and stop power while found breakdown or disagreed connection) but not regulating parameters function.

According to present electronic technology, main devices of high

voltage AC power able to conduct “On-and-Off” include:

① Electrical magnetic relays

② Magnetic latching relays

③ Triac

④ AC-MOSFET

As in adaptation of high voltage AC power, the main aim of “On” and “Off” is to deliver power on identification of loads or not, or turn off power while emergency takes place, the scheme chosen must therefore be able to handle high current (generally 5-10A), turn off power speedily (general ≤20ms), and boast of little leakage current after switch-off (according to IEC standards, no more than 5mA under 230Vac). Therefore, here would evaluate respectively on the 4 schemes and conduct selection.

① Evaluation on Relay：

Coil Parameter

Dash numbers	Coil voltage VDC		Coil resistance Ω ±10%	Pick up voltage VDC (max) (75% of rated voltage)	Release voltage VDC (min) (5% of rated voltage)	Coil power consumption W	Operate Time ms	Release Time ms
	Rated	Max						
003-200	3	3.9	45	2.25	0.15	0.20	<8	<5
005-200	5	6.5	125	3.75	0.25			
006-200	6	7.8	180	4.50	0.30			
009-200	9	11.7	405	6.75	0.45			
012-200	12	15.6	720	9.00	0.60			
018-200	18	23.4	1620	13.5	0.90			
024-200	24	31.2	2880	18.0	1.20			
003-450	3	3.9	20	2.25	0.15	0.45	<8	<5
005-450	5	6.5	56	3.75	0.25			
006-450	6	7.8	80	4.50	0.30			
009-450	9	11.7	180	6.75	0.45			
012-450	12	15.6	320	9.00	0.60			
018-450	18	23.4	720	13.5	0.90			
024-450	24	31.2	1280	18.0	1.20			

Sheet1 Parameters of JZC-32F Compact Relay

According to sheet 1, ordinary relays (such as JZC-32F model) can

meet actual requirements on current-carrying capacity, on-off speed (≤8ms shown as sheet 1), leakage current (because the contact turns off physically, leakage current might be ignored of) and the like, in addition to having had relays small enough to be fixed in socket bases of 86 model, relays suggested in magnetic relay scheme may provide the physical conditions meeting requirements. This project may thus be taken as the one to be selected for on-off control of adaptation of high voltage AC power.

② Evaluation on Latching Relay Scheme

线圈参数	
额定线圈功率	单线圈： 约400mW 双线圈： 约600mW

线圈规格表 23°C

单线圈

额定电压 VDC	动作电压 VDC	脉冲宽度ms 典型值	脉冲宽度ms 最小值	复归电压 VDC	最大电压 VDC	线圈电阻 Ω
5	≤3.5	≥50	30	≤3.5	6	62×(1±10%)
6	≤4.2	≥50	30	≤4.2	7.2	90×(1±10%)
9	≤6.3	≥50	30	≤6.3	10.8	202×(1±10%)
12	≤8.4	≥50	30	≤8.4	14.4	360×(1±10%)
24	≤16.8	≥50	30	≤16.8	28.8	1440×(1±10%)

双线圈

额定电压 VDC	动作电压 VDC	脉冲宽度ms 典型值	脉冲宽度ms 最小值	复归电压 VDC	最大电压 VDC	线圈电阻 Ω
5	≤3.5	≥50	30	≤3.5	7.5	42×(1±10%)
6	≤4.2	≥50	30	≤4.2	9	55×(1±10%)
9	≤6.3	≥50	30	≤6.3	13.5	135×(1±10%)
12	≤8.4	≥50	30	≤8.4	18	240×(1±10%)
24	≤16.8	≥50	30	≤16.8	36	886×(1±10%)

Sheet 2 Parameters of Latching Relay of HF-115 Model

According to sheet 2, because of lower speed (lowest is 30ms) and larger volume uneasily fixed inside power supply ends with limit space only, ordinary latching relays (such as HF-115 model) don’t have physical

conditions demanded, that is said, latching relay scheme is not suitable for power adaptation of high voltage AC appliances.

③ Triac Scheme

STATIC CHARACTERISTICS

T_j = 25 ˚C unless otherwise stated

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.			UNIT
		BT136-			...	...F	...G	
I_{GT}	Gate trigger current	V_D = 12 V; I_T = 0.1 A						
		T2+ G+	-	5	35	25	50	mA
		T2+ G-	-	8	35	25	50	mA
		T2- G-	-	11	35	25	50	mA
		T2- G+	-	30	70	70	100	mA
I_L	Latching current	V_D = 12 V; I_{GT} = 0.1 A						
		T2+ G+	-	7	20	20	30	mA
		T2+ G-	-	16	30	30	45	mA
		T2- G-	-	5	20	20	30	mA
		T2- G+	-	7	30	30	45	mA
I_H	Holding current	V_D = 12 V; I_{GT} = 0.1 A	-	5	15	15	30	mA
V_T	On-state voltage	I_T = 5 A	-	1.4	1.70			V
V_{GT}	Gate trigger voltage	V_D = 12 V; I_T = 0.1 A	-	0.7	1.5			V
		V_D = 400 V; I_T = 0.1 A; T_j = 125 ˚C	0.25	0.4	-			V
I_D	Off-state leakage current	V_D = $V_{DRM(max)}$; T_j = 125 ˚C	-	0.1	0.5			mA

Sheet3 Parameters of Triac of BT136 Model

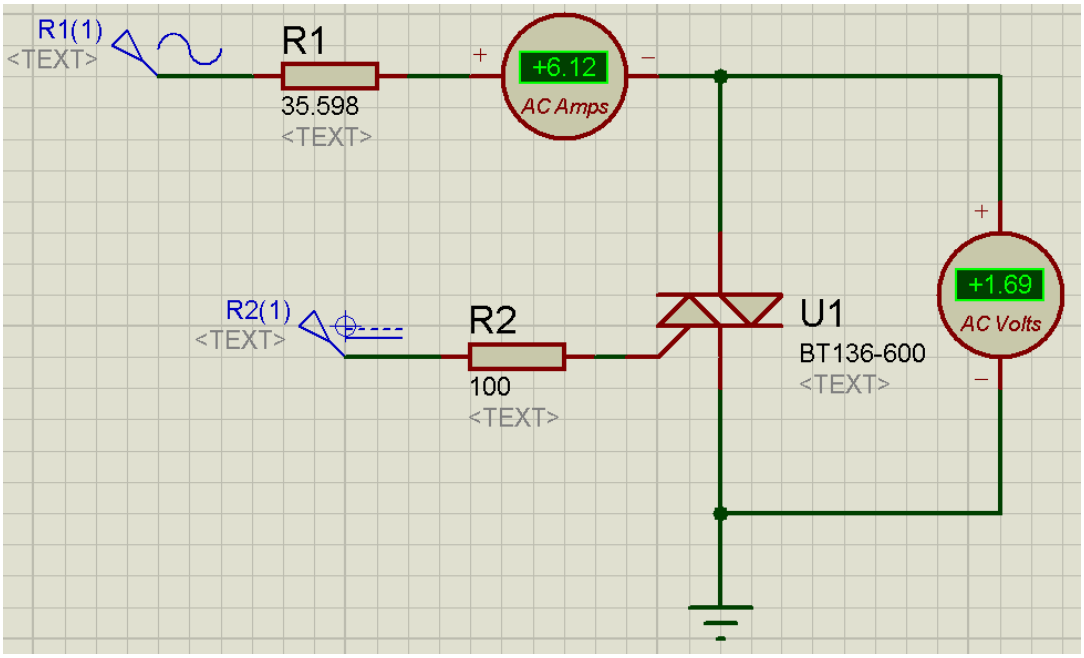


Image 15 Simulation Experiment of Triac of BE136 Model Controling 220V/1500W Resistive Load

On basis of sheet 3 and image 15, Traic (such as BT136 model) can meet the requirements for power adaptation of high voltage AC appliances on current carrying capacity, on-off speed (based on the principle that Traic would switch off while across current passes through

null line, it is about 10ms while the frequency of across current is 50Hz), and leakage current (0.1~0.5mA as shown in sheet 3), but Traic has a higher on-state voltage resulted from its structure (1.4~1.7V) which would bring about heating. Because of the space of power supply end is small, it is difficult to radiate the heat hereinabove. This would bring about risk while there is large heating.

Meanwhile, it is also not friendly for saving energy which can be proved through a simple computation and simulation: while Traic is used as unit for on-off controlling of one AC power supply end and connect with a boiler of 220V/1500W, then it can be computed as following:

$I = (P_{load} \div U) \div \cos\Phi \approx 6.82A$，$P_{disp} = I \times V_{drop}$（=1.7V）=11.594W

The value by simulation experiment shown in image 15 is almost the same as well.

This proved that waste of power in on-off device is very large and that Traic scheme is thus not suitable.

④ Evaluation of AC-MOSFET Scheme

9. Electrical Characteristics (Unless otherwise specified, T_a = 25°C)

	Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
LED	Input forward voltage	V_F		I_F = 10 mA	1.1	1.27	1.4	V
	Input reverse current	I_R		V_R = 5 V	—	—	10	μA
	Input capacitance	C_t		V = 0 V, f = 1 MHz	—	50	—	pF
Detector	OFF-state current	I_{OFF}		V_{OFF} = 60 V	—	—	1	μA
	Output capacitance	C_{OFF}		V = 0 V, f = 1 MHz	—	10	—	pF

12. Switching Characteristics (Unless otherwise specified, T_a = 25°C)

Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
Turn-on time	t_{ON}		See Fig. 12.1. R_L = 200 Ω, V_{DD} = 10 V, I_F = 2 mA	—	1	5	ms
Turn-off time	t_{OFF}			—	1	5	

Sheet 4-5 Parameters of AC-MOSFET of TLP175 Model

As shown in sheet4-5, AC-MOSFET can not only meet the requirements by power adaptation of high voltage AC power on current carrying capacity, on-off speed (1-5ms as shown) and leakage current, but also be more excellent on each norms than those of the first scheme—Relay Scheme. Additionally, because AC-MOSFET boasts of fine original isolation and lower conduction resistance (namely lower waste) which relay doesn't have, plus as minor volume as chips, AC-MOSFET scheme would be the most excellent scheme for adaptation of high voltage AC power.

In summary, both Relay and AC-MOSFET scheme can be used for adaptation of high voltage AC power because both can provide a physical condition meeting requirements of On-Off control and other relative requirements. Two schemes might thus be selected on actual requirements (generally, relay one can be selected while volume is not an important factor and cost is sensitive).

2.2 Selection & Evaluation on the Scheme of Adaptation of Low Voltage DC Power.

As appliances of low voltage DC power are so different from each other on design, circuit principle and structure that requirements by each appliance on power parameters are thus variable very much (of ordinary electronic devices, just voltage ranges from 4.5V to 24V), power supply ends must therefore quipped with ability to offer DC power consisting of any parameters (voltage, current) theoretically. According to present technology, schemes might be able to achieve the aims above mainly include:

① Machine-electronical adjustable DC power scheme.

② Digital SMPS power scheme.

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CHINA ETECH GROUPS LTD

充电器测试规范和标准

测试项目及标准				可靠性项目及标准			
测试项目		测试内容及方法		试验项目	试验内容及方法		技术要求/标准
输入特性	AC输入电压	充电器通电输入 100VAC/240VAC（国内标准），测试 DC端电压，电压应是5V±0.25V	5.0-5.4	常温老化试验	充电器通电带额定负载，在环境温度 25±5℃的条件老化6小时。	OK	满载工作6小时以后的外壳最大温升小于35摄氏度；接上匹配手机完整充电中外壳最大温升要小于30摄氏度
	电压/频率	额定输入电压为AC220V，允许输入电压范围为 100VAC/240VAC（国内标准）．频率为47HZ-63HZ	OK	高温试验	充电器通电带额定负载，储存温度为75℃±3℃，持续实验时间为12小时	未测	外观完好，电性能及安规性能合格
	输入电流（满载时）	当输入交流电压AC220V/50HZ时，最大输入电流应小于0.15A	OK	低温试验	充电器通电带额定负载，储存温度为-20℃±3℃，持续实验时间为12小时	未测	外观完好，电性能及安规性能合格
	工作效率	在输入 100VAC/240VAC（国内标准）范围内和输出500mA时，工作效率（输出功率/输入功率）≥ 60%	OK	高温贮存	实验温度 70℃±2℃，实验持续时间 48h，结束后恢复两小时后测试	OK	外观完好，电性能及安规性能合格
	浪涌电流	在冷开机的情况下，当输入220V电压后10mS内，最大浪涌电流小于25A	OK	低温贮存	实验温度-20℃±2℃，实验持续时间 48h，结束后恢复两小时后测试	OK	外观完好，电性能及安规性能合格
	输入无负载能耗	无负载能耗小于300mW	OK	恒定湿热试验	实验温度 40° C±2° C，相对湿度90-95%带电工作实验持续时间 48h	未测	外观完好，电性能及安规性能合格
输出特性	额定输出电压	DC5.0V	OK	振动试验	频率为10-55Hz，振幅为0.35mm，分别在X，Y，Z三轴的每个方向上循环振动各5次周期，实验后对外观进行检查，并进行绝缘电阻、绝缘强度和指示功能及电性能进行重新测试	OK	外观应平整无划痕、毛刺以及其他机械损伤，外露金属部分不应有锈蚀；无击穿、飞弧现象；绝缘电阻大于7MΩ；指示功能及电性能正常
	输出电压/电流范围	电压 DC5.0V±0.25V 电流：≥450mA	OK	拔插实验	将DC插头在旅行充电器的USB处进行插拔3000次。频率为200次/小时	未测	插拔结束后机械应无损坏，将连接插头从插座中完全拔出所需的力最小不得小于8N
	输出纹波	≤200mV；测试方法：任何负载正常工作下，使用示波器带宽为20MHz连接到充电器的输出端，同时输出端并连一个104pF陶瓷电容和一个10U的电解电容	OK	拉力实验	1.充电器输出插头与连接线以及充电器壳体与连接线以 10N 拉力拉动 2.插头与插座之间进行拔插，当插拔的速率不超过12.5mm/min时，将插头完全插入插座所需的力最大不超过15N，将插头从插座中完全拔出所需的力最小不得小于10N	国标USB，未与客户手机配件实测	连接可靠，无松动或脱落且功能正常

Sheet6 Trade Standards of Power Adapters for Electronical Information Products (Taking

5V/500Ma Recharger of Mobile as Instance)

As generally power supply ends take form of socket bases and most of which are often socket bases of 86 model(inside space of 86 model is often 60mm×60mm×20mm), DC power adjustor is therefore requested to have a smaller volume and more efficiency, and at the same time, as the aim of adjustment by DC power supply end is to supply power for more precise electronic DC appliances, the scheme selected shall meet the requirements on precision of voltage and ripple wave (usually according to trade standards, ripple wave ≤200mV, voltage precision ±5%$U_{rated)}$, which otherwise will influence or even destroy some appliances. According to the standards or requirements hereinabove, here makes comprehensive evaluations on the technological performances of those schemes above.

① Machine-electronic Adjustable DC Power Scheme

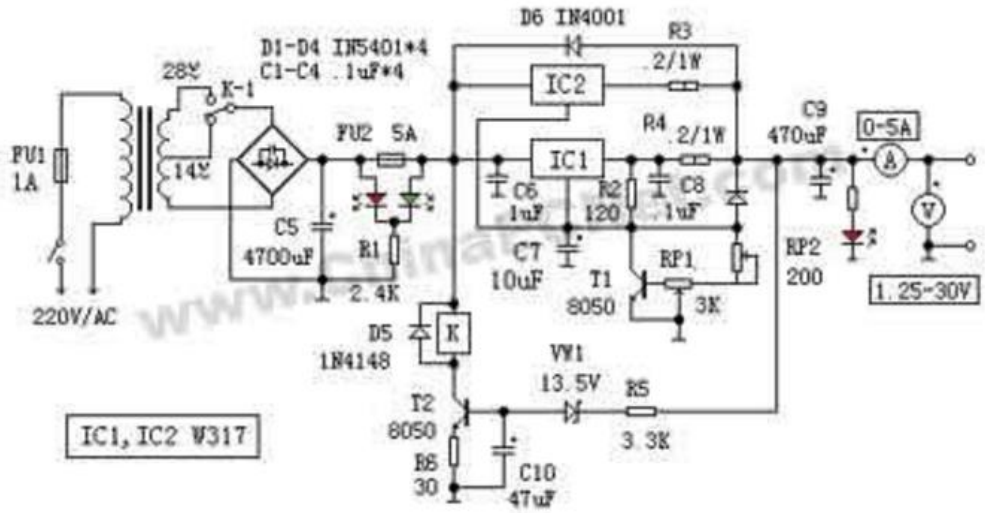


Image 16 Electrical Schematic of a Typical Machine-electronic Adjustable DC Voltage Regulator

Image 17 A Picture of Typical Machine-electronic Adjustable DC Voltage Regulator

According to Image 17, “Machine-electronic Adjustable DC Voltage Regulator Scheme” is a linear regulated power which achieve accurate adjustment and stabilization of current and voltage and power adjustment through multi-tap transformer, mechanic contacts, and power tube. Generally, ripple wave by linear regulated power source is very low (about 0.5-5Mv) which can thus completely meet the requirements of precise appliances on ripple wave. Meanwhile, as the delivered precision of linear power depends on the precision of reference voltage, through TL431A with precision of 1%, it could be seen linear regulated power source can meet the requirements of such electronic products as precise appliances on precision of output voltage, but as the volume and mass of transformers of the devices are often very large (shown as image 17), which can be seen in DC19V/90W adapter for general notebook, the volume of 100VA transformer (taking NDK-100

as instance) is as large as 103mm×87mm×99mm. Such a large volume is obviously not desirable, furthermore, it needs a device for radiating heat because of its low efficient and high heating. Additionally, such devices often need relays and potentiometers with mechanic contacts which are often short in life-time. In summary, this scheme can’t meet requirements of this project.

② Scheme of Digital SMPS DC Power

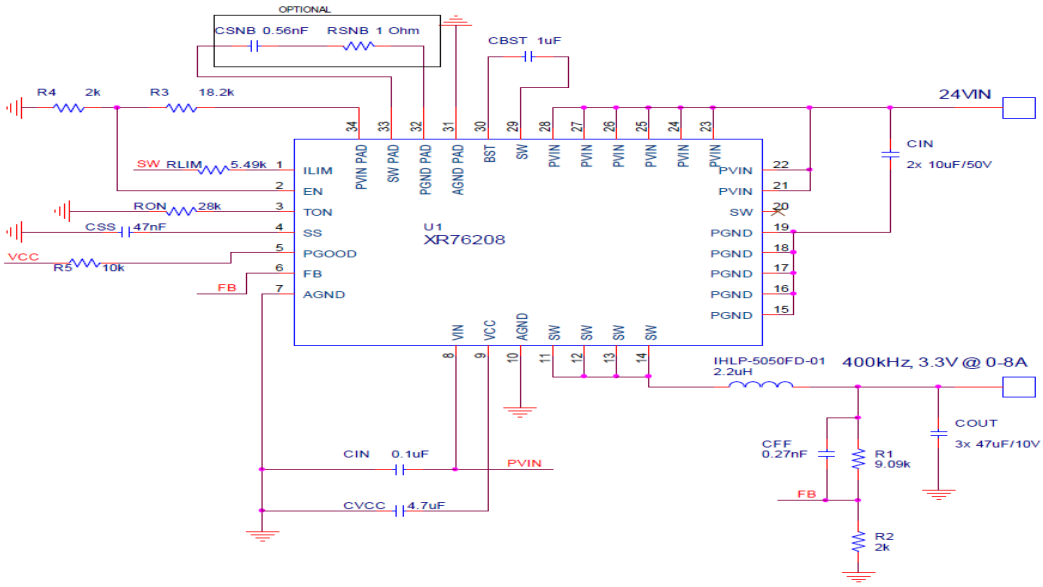


图 18 一种数控开关可调电源的电气原理图

Image18 Electrical Schematic of a Digital SMPS DC Power

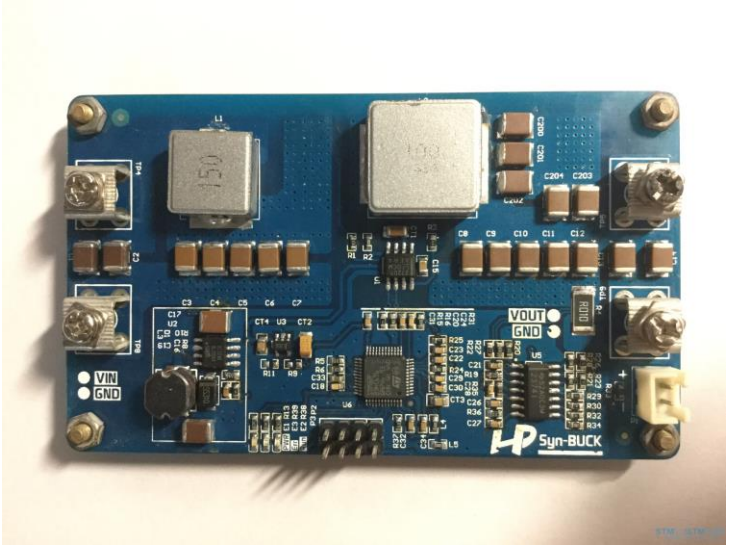


Image19　Picture of a Digital SMPS DC Power

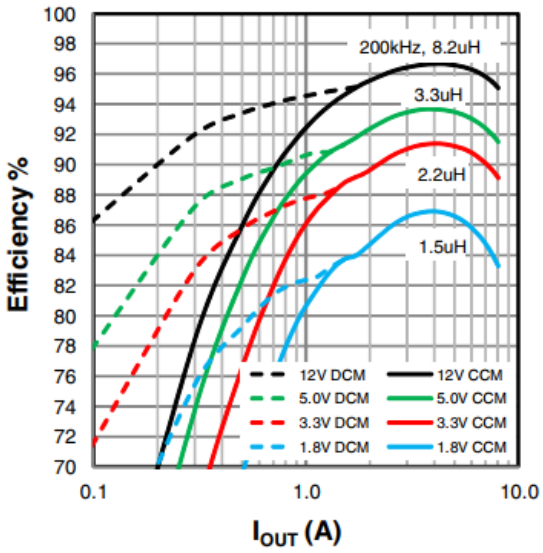


Figure 20: XR76208 efficiency, V_{IN}=24V

Sheet7 Efficient Digram of Digital SMPS
based on XR76208 (from XR76208 Data Sheet)

Digital SMPS DC Power is a power adjust device which controls duty cycle of electric-electronic components (MOSFET、IGBT and so on) with high frequency（≥30kHz）through micro-controller and external circuit according to rated and feedback parameters.

Shown as image 18, presently digital SMPS DC power are generally

constructed with some small volume components as highly integrated micro-controllers or ASIC (Application Specific Integrated Circuit) which because of no components with volume and mass as large as transformers can thus be produced with board level volume (shown as image 19) and thus meet the demand by power supply end on volume as small as a plug base of 86 model.

The efficiency of digital SMPS DC power is relatively higher. Taking the digital switch DC power based on STM32F3 series of micro-controllers as instance, its efficiency might be up to 95% which would save more energy and make less heating (shown as image19, a 240-W digital DC power can work stably only with coper foil of PCB to radiate heat) and be thus able to meet requirements on heating strictly by this project.

Through taking use of PID algorithm, dynamic data analysis, AI and the like, digital power enjoys precision much higher and ripple much lower than those by analog power (electromechanical linear power) while the tolerance of both parts and chips is the same. Presently, general digital power might have about 0.2~0.5% precision of output power parameter and ripple less than 30mV which may completely meet technological requirements of high precision and low ripple by precise appliances.

Finally, digital power also boasts of the physical conditions functioning “4 Kinds of Remote” (namely remote control, remote measure, remote alarm and remote debugging) which provide

conditions for automatic operation of power adaptation.

In summary, digital SMPS DC power shall be selected as the first scheme of low voltage DC appliances adaptation.

3. Selection and Evaluation of Technological Scheme for "Protection on Requirements".

As the difference of one appliance from another on design and structure, appliances would inevitably have different safety range (namely the highest voltage and the maximum current), to guarantee operation of power supply and appliance in safety, power supply end must have the ability to set parameters for triggering safety devices on actual conditions of variant appliances, namely to provide "Protection Based on Actual Parameters".

In view of actual condition of work and life, and the arguments above on relative issues found in present adapters, the technological scheme here should at least meet the following requirements:

① Covering variant parameters of voltage, current and power, and conducting comprehensive judgment and protection on adaptation course.

② Meeting requirements by electronic appliances, especially low power consumption appliances, on precision and sensitivity (on basis of some trade standards and data, precision shall be no less than ±5%，and sensitivity of current/power no less than 5mA/25mW) of power

adaptation and safety protection.

③ Meeting requirements on responding speed (ordinary units would demand no more than 10ms under the worst circumstance) by precise electronic appliances easy to be damaged.

④ Able to conduct trend analysis and protection, namely, able to conduct comprehensive analysis and judgment on variations and relative relations of among each power parameters within preset threshold values, so as to handle with the early abnormality and complicated circumstance (such as the danger in which the internal film of lithium battery became abnormal but short circuit still not happened during charging).

⑤ Able to set protection parameters through micro controllers for variant applications.

According to present electronic technology, the schemes which can meet the concrete requirements above mainly include followings, namely, analog-only circuit protection scheme and digital protection scheme. Analysis and evaluation on these two schemes will be conducted as following:

3.1 Evaluation on Analog-only Circuit Protection Scheme

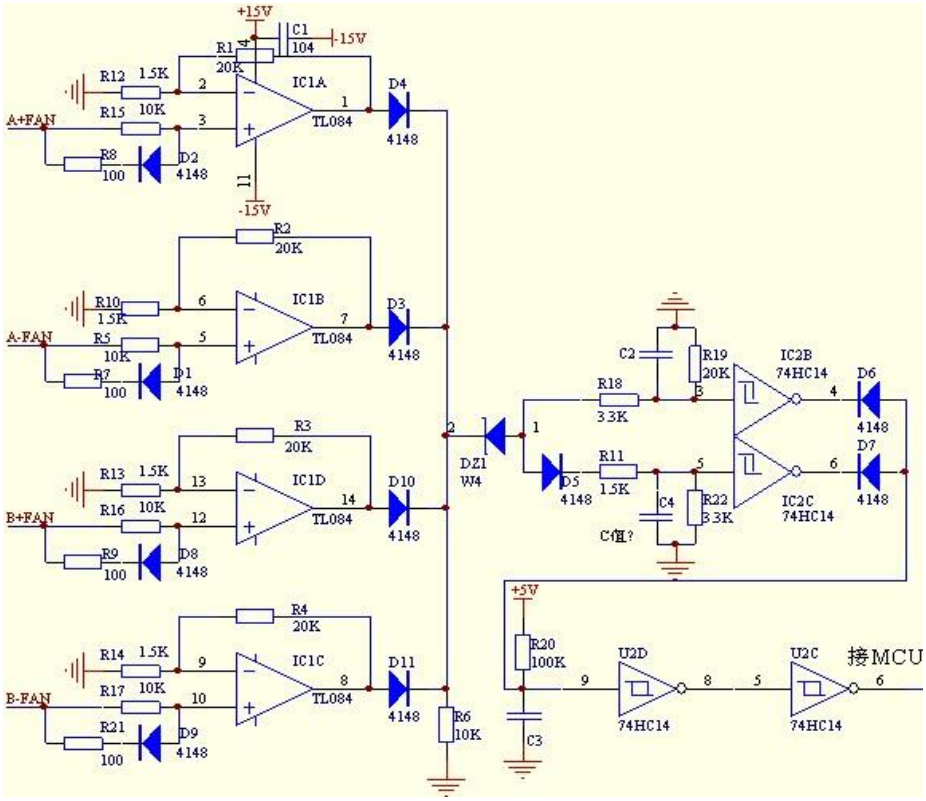


Image 21 Electrical Schematic of an Analog-only Circuit for Comprehensive Protection on both Voltage and Current Parameters

As shown in image 21, the analog-only circuit protection performs protection mainly through comparing series of signals of power parameters sent by operational amplifier and conducts logic judgment through logic parts and chips (gate circuit, relays and so on). The technological scheme features followings:

At first, analog-only circuit scheme is the one of “One Parameter, One Circuit”.

“One Parameter, One Circuit” scheme refers to that in the scheme every protection against one power parameter needs a set of independent sub-circuit (as shown in image21 there is a set of independent circuit respectively on voltage and current), therefore to

conduct comprehensive safety protection based on multiple parameters, circuits for protection would be very complicated (as shown in image 21, to have a protection against 5 parameters, the number of chips and units of the circuit will be as many as nearly 100), and large in volume which don't meet demand on volume by power supply as small as plug base.

Secondly, analog-only circuit protection scheme is the one of "Fixed Parameters"

Scheme of **"Fixed Parameters"** refers to that sorts of parameters of analog-only circuit for protection have been set while the circuits designed. It means that no parameters can be changed unless some chips and components have been altered. Though there are digital resistances and digital capacitors nowadays, they are large in volume and couldn't work unless connected with micro-controller. Obviously, it doesn't meet requirements on small volume.

Finally, complete circuit protection scheme is the one of "Mechanical Protection"

As not having functions to conduct data collection, processing and communication, it is impossible for analog-only circuit protection scheme to conduct data analysis. It means that this scheme doesn't have the ability to conduct protection on analysis of tendency (which needs integrators with complicated circuit, slope generator and the like), and it is more impossible for this scheme to complete comprehensive

conduction on more complicated circumstances. In summary, analog circuit scheme can't be used as the one for conducting **"Protection Based on Actual Parameters."**

3.2 Evaluation on Digital Protection Scheme

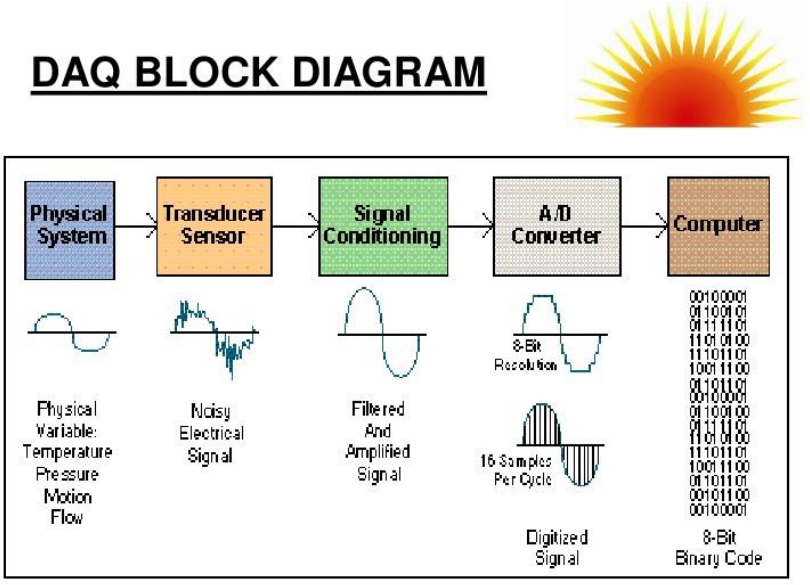


Image 22 Structure Model Diagram of Digital Protection Scheme

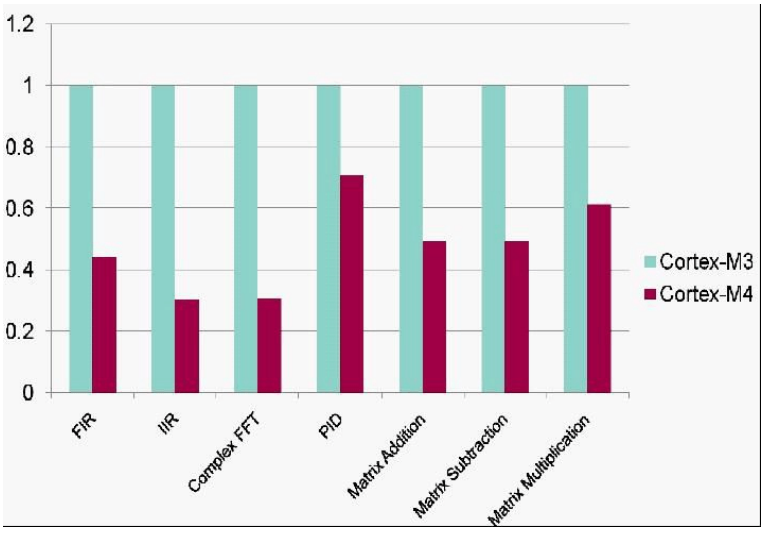


Image23 Diagram of Time-consumption of Two ARM microcontrollers, Unit Is Machine Cycle

As shown in image23, digital protection scheme is the one which takes use of ADC (analog to digital converter) device to convert the consecutive signals representing power parameters into discrete signals

which microcontrollers/computers can read and know, and then get the state of system through computer program in microcontroller/computer to conduct processing, judging and analyzing on the discrete signals and complete protection against breakdown finally. This scheme enjoys features as following:

First, digital scheme is the one featuring **“Minor”.** As ADC or micro-controllers used in almost all digital protection scheme are highly integrated SoCs (System on Chip), it is easy to have a volume as small as a board, or even a chip, which can completely satisfy the demand on volume of the protection device by this project.

Second, digital scheme is the one featuring **“Intelligent”**. As each safety protection of the total protection device is performed through soft programs and on basis of the fact that software are programmable, such a device then might adjust its protection parameters easily. Further, as the whole protection device has been developed mainly on microcontroller with ability to process data, such a device is then equipped with basic conditions for analyzing on tendency or even multiple dynamic data which might completely satisfy the requirements stated in ④ and ⑤.

Third, digital scheme is the one of identifying multiple parameters. As collection of power parameters of devices aimed to be protected in digital protection scheme is performed through ADC input, collection

and identification of multiple parameters can be performed through an ADC with multiple channels or an analog multiplexer with small volume which would thus provide physical underground for power supply end to set protection thresholds automatically on actual requirements of variant appliances, namely, offer physical conditions for conducting **“Protection Based on Actual Parameters”.**

Finally, digital scheme is the one featuring “Rapid Reaction”. With development and population of ARM, the ability to process data of micro-controllers has greatly increased, which can finish data procession relative to digital safety protection within several machine cycle (about 50—100ns). It thus completely meets requirements on respond time of this project.

On basis of those stated above, digital protection scheme is selected here as the one for **“Protection Based on Actual Parameters”.**

（iii）Design and Evaluation of Communication Protocol between Power Supply and Appliance

In view of the total design idea of this project, to achieve the three basic functions stated above, namely, Appliances Identification, Adapting Power on Requirements, Protection Based on Parameters, and any other functions, it is necessary to create a relationship of communication and identification between power supply and appliances。As such a relation is kind of electronic communication naturally, it is thus the same as

electronic communications in other occasions in which an effective communication protocol is necessary for conducting communication.

Up to now, it is time to conduct design and evaluation of such a protocol on the analysis above.

1. Selection & Evaluation on the Topological Structure of Communication Protocol between Power Supply and Appliances.

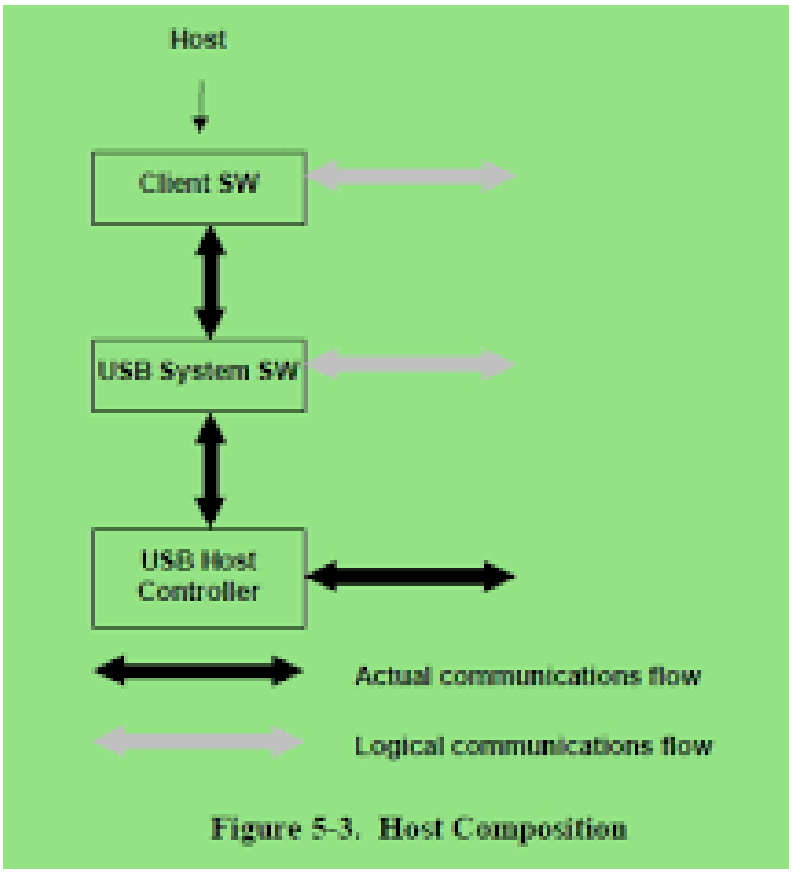


Image24 Topology of USB Communication Protocol: One Host Can Connect with Only One Slave.

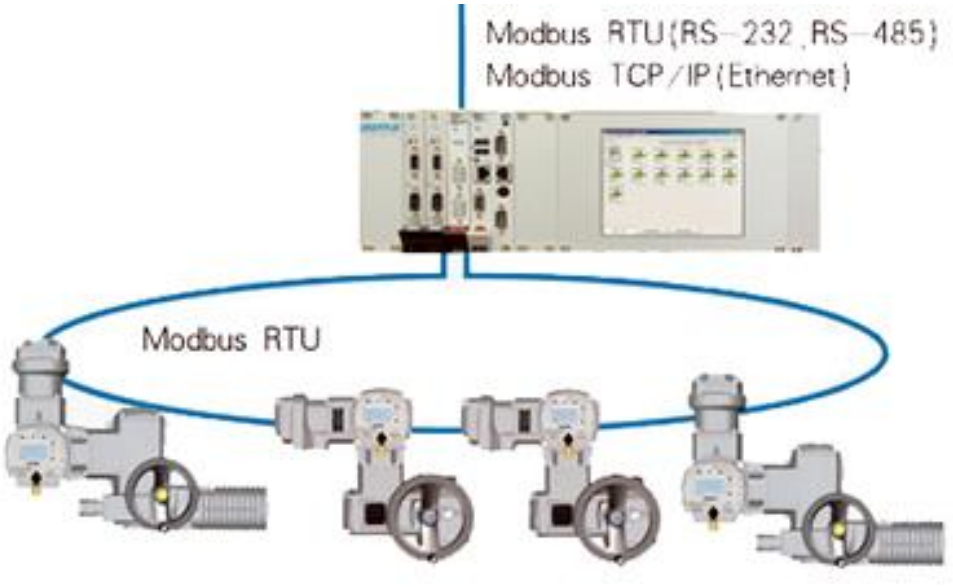


Image25 Topology of Modbus-RTU Communication: One Main Engine Can Connect with More Than One Slaves.

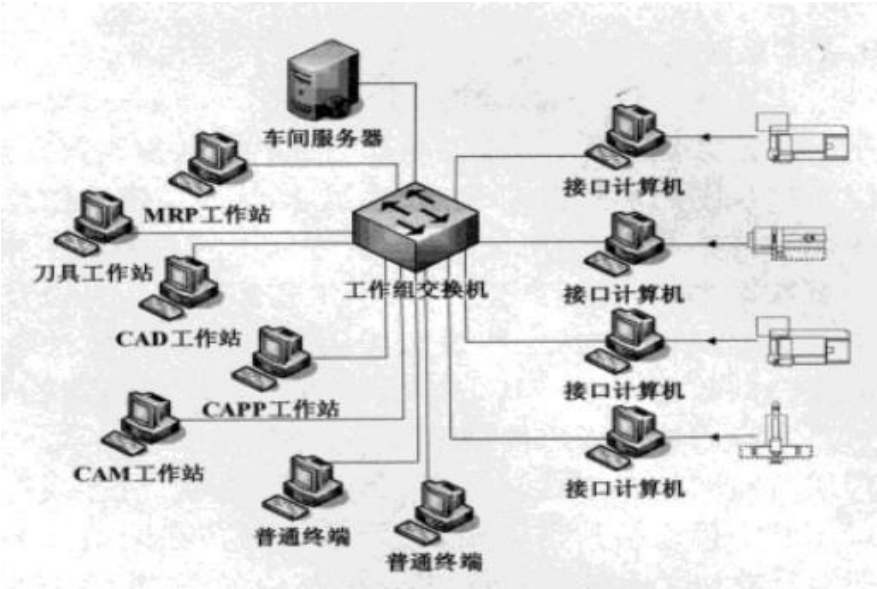


Image26 Topology of Ethernet Protocol: No Obvious Distinction between Main Machine and Slaves.

As shown in image24,25 and 26, generally, topology structures of communication protocol include such variant forms as “One Host one Slave(there are only one host and one slave in a communication net, USB protocol is of the typical)”, “One Host, Multiple Slaves(there is only one host while multiple slaves in a communication net, Modbus-RTU is of the

typical)", and "Multiple Hosts & Multiple Slaves or Main-or-Slave each other(there are more than two devices which can be the host or the slave each other, Ethernet Protocol <100BASE-T> is of the typical)".

Image27 In Power Adaptation, One Power Supply End Can Only Supply Power for only One Appliance at the Same Time

The aim of communication protocol between power supply and appliances is to have an intercommunication between power supply and appliances. On actual condition, one supply end (if there are more than one socket bases in a power supply device, such as plug board, which should be viewed as multiple power supply end) can only connect with one appliance, accordingly, the communication here would consist of two main parts only, one is power supply end and another is appliance connected with. It means that the communication here would be the one between one main machine and one slave. Therefore, topography "One Host & One Slave" is better for that of the communication protocol here in which power supply end shall be the host and the WID tag fixed within appliance be the slave.

2. Selection on Interactive Modes of Communication Protocol between Power Supply and Appliances.

General modes of communication protocol between the host and the slave include the one the slave reports actively to the host (such as most active RFID protocol, the one of peer to peer communication (such as Ethernet protocol) and the one the slave passively respond (such as most passive RFID protocol) which might be selected to use based on such factors as physical media and actual requirement of communication protocol.

On basis of the analysis above, the physical medium of communication protocol of this project---WID tag is the one of passive storage medium in which WID tag can't work before charged by the host in advance. Therefore, the communication between power supply and appliances would have to hire the mode of the slave responding passively. On sequential logic, the first is to charge the slave (WID tag) through the host, the second is the host read UID and confirm WID tag is legal, the third is reading relative information stored within WID tag, and final is the host explains power parameters of appliances on the stored information and performs variant functions.

3. Design and Evaluation of Data Contents and Formats of Communication Protocol between Power Supply and Appliances.

The aim of communication between power supply and appliances is enabling power supply end to "know" actual conditions of appliance. It is thus necessary to have a scientific and reasonable data contents,

structure, and standards for communication so as to enable variety of appliances to have a unite and easily to be explained format about their requirements on power and safety parameters. Thus power supply end can understand and use those parameters to reset electric mode of appliance and conduct safety protection and power delivery correctly. According to those above, the data contents and format of communication protocol by power supply and appliance shall include these as followings:

（1）Contents on Identification of Appliances

To perform identification and administration of power use, power supply end must be able to distinguish variant appliances from each other, even if those appliances are the same in structure as each other completely. Data must thus contain the content about identification of appliances which can have through unrepeatable UID nowadays. In view of updating speed of electric appliances, population and productivity, computing on present $6\times10^{9,}$population across the world and average 10 pieces of appliances(including those deprecated) each person , there are about 6×10^{10} pieces appliances presently. In view of the increase of appliances, the quantity of UID shall be 3 orders of magnitude larger than that of current appliances, namely, $10^{13.}$.

To have a simple design, the UID for identification of status shall take the lithography UID of 96 bits (Binary) within WID tag used as

communication medium as the UID of appliance. There thus gets a total capacity about $10^{28.8989}$ ($C=2^{96}-1\approx10^{28.8989}$) which are 15.9 orders of magnitude larger than and completely meet that of actual demand. Furthermore, as the UID of WID tag is made through lithography, it is thus almost impossible to be changed and forged and thus enjoys a higher security.

In summary, the part of identification of status of communication protocol of power supply and appliances will be the lithography UID of 96 bits within WID tag which has 96 bits in binary system, consists of 12 bytes and operates in terms of MSB first and MSBYTE first.

（2）The Part of Friendly Name of Appliances (User Interfaces)

Friendly names is one way of displays for users, naturally, it is a technological means which transforms or correlates certain information to common language expression or even images through binary information.

To enable users to conveniently operate human-machine interface (computer GUI interface/mobile devices APP/WEB website), examine and manage their appliances, and trace the history of products and other relative information, this project develops the part of friendly names for this communication protocol. The part of friendly names pay main attention to the variety of products, because generally each model needs a correlation respectively.

According to those stated above, plus some technological principles of communication medium, friendly names of appliances embrace FNID (Friendly Name Identification) of 32 binary system which has 4 bits and operate in terms of MSb first, MSB first. FIND database of ONRUN platform developed by myself in other project would provide support of correlation to product models. Theoretically, the number of product information correlation up to 2^{32}-1 and can completely meet the demand on variety of present products.

（3）The Description of Power Requirements of Appliances

As different appliances work with different power parameters, namely, different rated voltage, current and so on, appliances must have the ability to announce its own special power parameters through communication protocol to power supply end so that it can deliver competent electricity on the parameters, set parameters for safety protection and perform function of “Protection Based on Actual Parameters”.

According to knowledge and actual experiences involved of electronics, requirements by electrical appliances on power mainly include 5 parameters: ① Power Type, consisting of DC or AC with certain competent frequency; ② Power Phase; ③ Voltage, consisting of RMS value of DC or AC, an addition parameter; ④ Additional Parameters Specified Power, include, ④-1 the maximum current, consisting of the

largest RMS value of DC or AC; ④-2 the maximum power, consisting of the maximum power of DC or AC active power; ④-3 the maximum current slope; ④-4 the maximum power slope; ⑤ parameters describing course of power delivering, include, ⑤-1 the largest amount of energy for a single power delivery; ⑤-2 the longest time for a single power delivery.

This Communication Protocol Would Describe Four Basic Parameters Respectively

① Description on Types of Power

Reference to IEC60038:2002 and actual standards, the types of power used in life and work mainly include as following: DC, 50HzAC, 60HzAC, 400HzAC, 50 or 60HzAC, 45-65HzAC, and 45-440HzAC, the description on types of power is one byte of MSB first. The data contents and its corresponding power adaptation types is as shown in sheet8:

Value（HEX）	Identification	Accepted Power Types	Appliance E.g.
0x00	DC	DC	Laptops
0x01	50Hz AC	50Hz AC	50Hz Induction Motor
0x02	60Hz AC	60Hz AC	60Hz Induction Motor
0x03	400Hz AC	400Hz AC	400Hz Induction Motor
0x04	50/60Hz AC	50Hz AC or 60Hz AC	Induction Transformer
0x05	45~65Hz AC	50Hz AC, 60Hz AC, AC 47~63Hz	Tungsten Bulb, SMPS
0x06	45~440Hz AC	50Hz AC, 60Hz AC, 400Hz AC	SMPS

Sheet8 Description on Types of Power

② Description on Power Phrase:

Reference to IEC60038:2002 and actual standards, the phase of electrical appliances use now include: DC, single phase, bi-phase (often seen in 120/240Vac system), three-phrase (often seen in 220/380Vac system), and the like. As here would mainly pay attention to domestic appliances or the like with low power mainly, power phase under design will thus only include DC, single-phrase, and two-phrase. The description on types of current would be one byte of MSb first. The data contents and its corresponding power adaptation range is as shown in sheet8:

Value（HEX）	Identification	Accepted Power Phase	Appliance E.g.
0x00	DC	DC	Laptop
0x01	1-phase	1-phase AC	Desk lamp
0x02	2-phase	1-phase AC or 2-phase AC	A/C Unit, Electric Heater

Sheet9 Description on Power Phase

③ Description on Voltage

Reference to IEC60038:2002 and actual standards, the voltages of AC and DC applied in life and work are as shown in sheet10 and sheet11（the voltages of AC are RMS value of AC ）:

表 A.1 标称电压 100 V 与 1 000 V 之间的交流系统及其相关设备 单位为伏(V)

三相四线或三相三线系统		单相三线系统
标称电压		标称电压
50 Hz	60 Hz	60 Hz
—	120/208	120/240
—	240	—
230/400*	277/480	—
400/690*	480	—
—	347/600	—
1 000	600	—

Sheet10 The General Voltage of AC in IEC0038:2002, of Which Single-phrase 3-lines System Is Two-phrase system

标称值(D. C)	
优选值	增补值
	2. 4
	3
	4
	4. 5
	5
6	
	7. 5
	9
12	
	15
24	
	30
36	
	40
48	

Sheet11 Part of DC Voltage in IEC0038:2002

As the power adaptation project here is developed mainly for domestic appliances with low watt(≤230Vac) and the like related to power phases of single- or two-phases, only 4 types of voltage are designed here as AC voltage standards, including 100v, 110(120)V, 220(230)V, and 240V. The target appliances of low voltage DC adaptation are mainly such mobile DC appliances with low watts as notebooks, phones, battery chargers and the like. According to today's actual trade standards and requirements of safety on handheld devices (generally safe voltage no more than 36Vac), the voltage range of ordinary low voltage DC appliances is generally from 4.2Vdc-24Vdc, without fixed hierarchical voltages. In view of expansibility, difficulty to carry out and cost, the voltages for low voltage DC adaptation are designed as 3-30Vdc without hierarchy, and 0.1Vdc is the standard of stepper which can basically meet most of power requirements by DC appliances.

On the standards both of AC and DC voltages to design voltage

description, voltage description has 2 bytes of MSb, and The data contents and its corresponding power adaptation range is as shown in sheet12 and sheet13:

Byte Offset	Identification	Range(Hex)	Symbol
0	Voltage MSB	0x00~0xFF	UH
1	Voltage LSB	0x00~0xFF	UL
U=(UH*256+UL)*0.1,Unit is V,DC or AC RMS			

Sheet12 Description on Voltages

UH, HEX	UL, HEX	U,Vac/Vdc	Accepted Voltage/V	Tolerance
0x03	0xE8	100	100Vac	±10%
0x04	0x4C	110	110/120Vac	±10%
0x08	0x98	220	220/230Vac	±10%
0x09	0x60	240	240Vac	±10%
0xFF	0xFF	-	100/110/120/220/230/240Vac	±10%
0x00~01	0x1E~FF	3~30	3~30Vdc	±5%

Sheet13 Power Range of Adaptation by Description on Voltages

④ Description on Working Parameters

To conduct peer to peer safety Protection Based on Actual Parameters by variant appliances and refuse and stop requirements by appliances out of power range and capacity of power supply end, power supply end should get the parameters of current and watt of appliance in normal state, in addition to voltage of appliance, so as to decide the largest requirements of appliance and set safety protection parameters. Therefore, it must design description of electric parameters of appliance. The description of working parameters is as following:

④-1 Description on Maximum Current

Description on the maximum rated current is from 0mA to 16000mA

(16A), and generally no current out of that range should be used there. Description on the largest rated current has 2 bytes of MSb first. The contents are as shown in image14:

Byte Offset	Identification	Range(HEX)	Symbol
0	Current MSB	0x00~0x3E	IMH
1	Current LSB	0x00~0xFF	IML
Imax=(IMH*256+IML)*0.001,Unit is A,DC or AC RMS			

Sheet14 Description on the maximum current

④-2 Description on the Maximum Power Consumption

Description on the maximum power consumption is from 0W to 2000W, and generally no power out of that range should be used there. Description on the largest rated power has 2 bytes of MSb first. The contents are as shown in sheet15:

Byte Offset	Identification	Range(HEX)	Symbol
0	Power MSB	0x00~0x3E	PMH
1	Power LSB	0x00~0xFF	PML
Pmax=(PMH*256+PML)*0.1,Unit is W,DC or AC active power			

Sheet15 Specification of the Maximum Power Consumption

④-3 Description on the Maximum Current Slope

The maximum current slope refers to the variation of current within unit time which can also be regarded as change speed of current generally, namely, Is=ΔI/Δt, ordinarily A/S. Protection of current slope can provide safer protection on tendency for appliances (such as battery chargers) more sensitive to the speed of current variation. Description on the maximum current slope ranges from 0A/S to 655.35A/s which has 2 bytes of MSb first. The contents designed are as shown in sheet16:

Byte Offset	Identification	Range(HEX)	Symbol
0	Current Slope MSB	0x00~0xFF	ISMH
1	Current Slope LSB	0x00~0xFF	ISML
ISlopemax=(ISMH*256+ISML)*0.01,Unit is A/s			

Sheet16 Description on the Maximum current Slope of Communication Protocol

④-4 Description on the Maximum Power Consumption Slope

The maximum power consumption slope is the variation of power consumption within unit time, which can also be called as change ratio of power, namely, Ps=ΔP/Δt，ordinarily W/S. Protection of watt slope can provide a safer protection on tendency for appliances (such as precise electronic appliances) more sensitive to the speed of watt change. Description on the maximum power consumption slope ranges from 0w/S to 655.35w/s which has 2 bytes of MSb first. The contents designed are as shown in sheet17:

Byte Offset	Identification	Range(HEX)	Symbol
0	Power Consumption Slope MSB	0x00~0xFF	PSMH
1	Power Consumption Slope LSB	0x00~0xFF	PSML
PSM=(PSMH*256+PSML)*0.1,Unit is W/s			

Sheet17 Description on the Maximum Power Consumption Slope of Communication Protocol

⑤ Description on Power Delivery Process Parameters

⑤-1 Description on the Maximum Single-time Energy Delivery

The maximum single-time energy delivery is the largest one (i.e., the electricity output through power supply end) which refers to electrical appliances got within the time from connection beginning to stopping,

unit is W·h。It can provide a more effective protection on appliances of both “Energy Storage Type” (such as battery chargers) and those unable to work for a long time through stopping such potential risks as overcharging, overcharging and the like, in addition to energy conservation. Regarding to people’s habits of using power, the characteristic and power capacity of ordinary appliances, description on the maximum single-time energy delivery ranges from 0 to 6500.0W·h, which can also be unlimited. Description on the maximum single-time energy delivery once is 2 bytes of MSb first. The contents designed are as shown in sheet18:

Byte Offset	Identification	Range(HEX)	Symbol
0	Energy MSB	0x00~0xE8	SEMH
1	Energy LSB	0x00~0xFF	SEML
EDMAX=(SEMH*256+SEML)*0.1,Unit is W·h,0xFF/0xFF for unlimited energy delivery			

Sheet18 Description of Communication Protocol on the maximum single-time Electricity Delivered

⑤-2 Description on the Longest Time for a Single Power Delivery

The longest time for a single power delivery refers to the time from the moment when appliances have connected with power supply to the moment when appliances have switched off power supply, its unit is minutes. It can effectively protect appliances of both energy storage types (such as battery chargers) and those unable to work for long time (such as juicers) from potential risks by overcharging, overheating and the like, in addition to energy conservation. Regarding to people’s habits

of using power and the characteristic and power capacity of ordinary appliances, Description on the longest time for a single power delivery ranges from 0 to 6500.0min., which can also be unlimited. Description on the longest time for a single power delivery is 2 bytes of MSb first. The contents designed are as shown in sheet19:

Byte Offset	Identification	Range(HEX)	Symbol
0	Time MSB	0x00~0xE8	STMH
1	Time LSB	0x00~0xFF	STML
TPDMAX=(STMH*256+STML)*0.1,Unit is minute,0xFF/0xFF for unlimited time span			

Sheet19 Description on the Longest Time for
A Single Electricity Delivery in Communication Protocol

（4）Data Verification

As the relationship of communication and identification by and between power supply end and appliance is naturally the one of electronic communication, it would thus inevitably produce mistakes resulted from interferences by errors of software, hardware and/or other outside factors just as errors found in electronic communication used in other occasions, which might make power supply end get wrong information and then result in abnormality or even danger in course of adapting power. To assure reliability in actual application, it is then necessary to have a verification part in the protocol. There are many kinds of concrete technological schemes such as CRC32 verification, even-odd- verification, MD5 verification and so on presently which would be selected mainly on verification reliability , speed of verification

and types of error that medium used for communication might have.

Name	Uses	Polynomial representations				Parity[18]
		Normal	Reversed	Reciprocal	Reversed reciprocal	
CRC-1	most hardware; also known as *parity bit*	0x1	0x1	0x1	0x1	even
		$x+1$				
CRC-3-GSM	mobile networks[23]	0x3	0x6	0x5	0x5	odd
CRC-4-ITU	ITU-T G.704, p. 12	0x3	0xC	0x9	0x9	odd
		x^4+x+1				
CRC-5-EPC	Gen 2 RFID[24]	0x09	0x12	0x05	0x14	odd
		x^5+x^3+1				
CRC-5-ITU	ITU-T G.704, p. 9	0x15	0x15	0x0B	0x1A	even
		$x^5+x^4+x^2+1$				
CRC-5-USB	USB token packets	0x05	0x14	0x09	0x12	odd
		x^5+x^2+1				
CRC-6-CDMA2000-A	mobile networks[25]	0x27	0x39	0x33	0x33	odd
CRC-6-CDMA2000-B	mobile networks[25]	0x07	0x38	0x31	0x23	even
CRC-6-DARC	Data Radio Channel[26]	0x19	0x26	0x0D	0x2C	even
CRC-6-GSM	mobile networks[23]	0x2F	0x3D	0x3B	0x37	even
CRC-6-ITU	ITU-T G.704, p. 3	0x03	0x30	0x21	0x21	odd
		x^6+x+1				

Sheet20: Some Communications Using CRC Check Found in Wikipedia

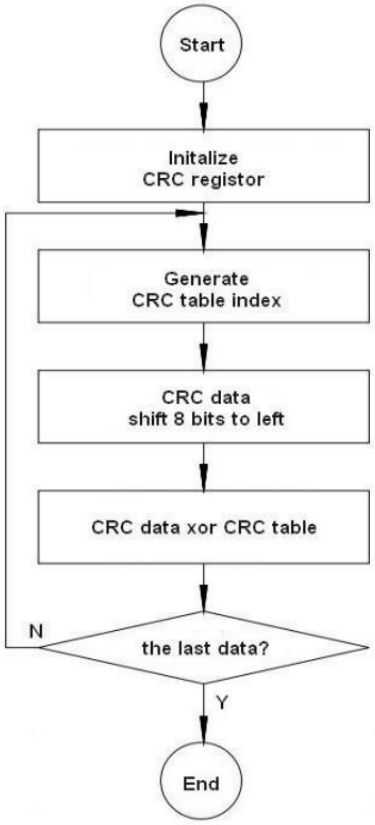


图 3-2：表查找实现

Image28 Logical Graph of Typical CRC32 Verification Algorithm

As the physical medium of identification communication protocol of appliance is WID tag and high-performance micro-controllers, WID tag

and micro-controllers of most model (such as STM32Fx Series) have hardware CRC32 verification units which can conduct check with orders programmed simply and fast. Therefore, it is desirable to select CRC32 verification algorithm for the communication protocol.

According to relative materials (MCU-AN-500032-Z-10 of FUJITSU. Pdf), the ratio of error detected by CRC32 verification algorithm reaches up to 99.9999%, and the probability of failure to detect errors is down to 0.0001% which can meet requirements on reliability by most of application. Finally, according to some documents, presently kinds of CRC checks have successfully been applied to many occasions which need examining data correctness (as shown in sheet20) and proved to be practical very much.

In view of the stated above, data check of identification communication protocol of appliances of this project embraces CRC check algorithm. Regarding to actual circumstances of micro-controllers, the algorithm and data contents designed for data check of this project are as shown in sheet21 and sheet22.

Item	Value
Polynomial Value(HEX)	0x04C11DB7
Initial Value(HEX)	0xFFFFFFFF
XOR Value(HEX)	0x00000000
Fill Value(HEX)	0xFF
Fill Method	Fill after the last byte
Data Reversal	MSB First
Result Output	MSB First

Sheet21 Parameter List of CRR32 Check Algorithm in Identification Communication Protocol of Appliances

Byte Offset	Identification	Range(HEX)
0	CRC32 Result bit 32~25	0x00~0xFF
1	CRC32 Result bit 24~17	0x00~0xFF
2	CRC32 Result bit 16~9	0x00~0xFF
3	CRC32 Result bit 8~1	0x00~0xFF

Sheet22 Specification of Data for Data Check in Identification Communication Protocol of Appliances

（5）Design of Data Pocket of Communication Protocol between Power Supply Ends and Appliances

According to the evaluation and analysis above, the format of data pocket of this project is designed as following:

Offset	Identification	Range(HEX)	Scope and use
0	Appliance UID bit 96~89	0x00~0xFF	Application IDentification
1	Appliance UID bit 88~81	0x00~0xFF	
2	Appliance UID bit 80~73	0x00~0xFF	
3	Appliance UID bit 72~65	0x00~0xFF	
4	Appliance UID bit 64~57	0x00~0xFF	
5	Appliance UID bit 56~49	0x00~0xFF	
6	Appliance UID bit 48~41	0x00~0xFF	
7	Appliance UID bit 40~33	0x00~0xFF	
8	Appliance UID bit 32~25	0x00~0xFF	
9	Appliance UID bit 24~17	0x00~0xFF	
10	Appliance UID bit 16~9	0x00~0xFF	
11	Appliance UID bit 8~1	0x00~0xFF	
12	Appliance FNID bit 32~25	0x00~0xFF	Application IDentification
13	Appliance FNID bit 24~17	0x00~0xFF	
14	Appliance FNID bit 16~9	0x00~0xFF	
15	Appliance FNID bit 8~1	0x00~0xFF	
16	Power type description	0x00~0x06	Power Requirement Description
17	Power phase description	0x00~0x02	Power Requirement Description
18	Voltage MSB	0x00~0xFF	Power Requirement Description
19	Voltage LSB	0x00~0xFF	
20	Maximum Current MSB	0x00~0x3E	Working Parameter Description
21	Maximum Current LSB	0x00~0xFF	

22	Maximum Power Consumption MSB	0x00~0x40	Working Parameter Description
23	Maximum Power Consumption LSB	0x00~0xFF	
24	Maximum Current Slope MSB	0x00~0xFF	Working Parameter Description
25	Maximum Current Slope LSB	0x00~0xFF	
26	Maximum Power Slope MSB	0x00~0xFF	Working Parameter Description
27	Maximum Power Slope LSB	0x00~0xFF	
28	Maximum Energy Delivery MSB	0x00~0xE8 /0xFF	Working Parameter Description
29	Maximum Energy Delivery LSB	0x00~0xFF /0xFF	
30	Maximum Operation Time MSB	0x00~0xE8 /0xFF	Working Parameter Description
31	Maximum Operation Time MSB	0x00~0xFF /0xFF	
32	Appliance Attached Detection	0xAA	Application IDentification
33~43	Reserved	0xFF	Reserved
44	CRC32 Result MSB	0x00~0xFF	Data Verification
45	CRC32 Result Byte 3	0x00~0xFF	
46	CRC32 Result Byte 2	0x00~0xFF	
47	CRC32 Result LSB	0x00~0xFF	

Sheet23: UPP Data Packet Byte Identification

According to the format shown in sheet23, there are 48 bytes in data packet which are all directly (not compressed) stored in the WID tag within plug. Taking ordinary WID tag chip of WFM-0304 for instance, there is a storage space of 4096 bits which can meet requirements on storage space completely.

As for the time-delay that appliances read information after plug in, as the rate for reading by WFM-0304 WID tag is 100kbps=12.500Bpms，plus 2ms for energy storage time, the time for once reading will be: $t=t_{read}+t_{energize}=(48B\div12.5Bpms)+2ms=5.84ms=5.84\times10^{-3}s$ which is a very short time and meet requirements by using habits and actual applications.

In summary, identification communication protocol of appliances of

this project can meet technological and performing requirements completely and conduct well.

Design on Physical Structure of Power Supply & Appliances

According to the technological Scheme evaluated and selected above, the physical structure of power supply and appliances of real devices is designed as following:

I. The Physical Structure of Power Supply Ends for High Voltage AC Appliances.

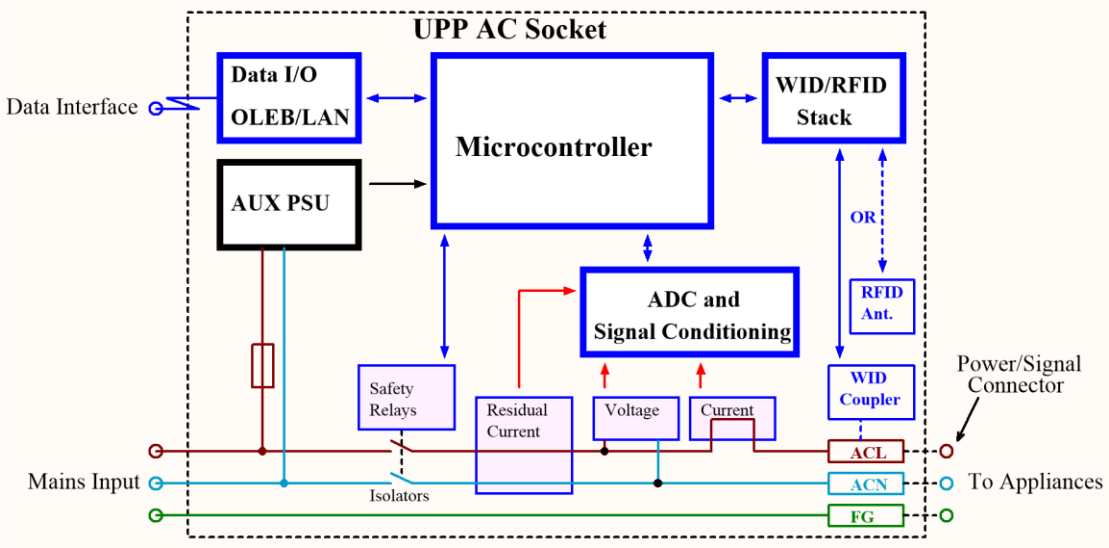


Image29 The Physical Structure Graph of Power Supply Ends for High Voltage AC Appliances

As shown in image29, power supply ends of high voltage AC consist of following basic units which will be stated as following:

① Communication Modules

Communication modules generally include wired bus or Wi-Fi modules, with which power supply ends would be able to connect with Internet and ONRUN platform or other net data platform so as to conduct integrated management and remote examination on power adaptation, in addition to offer online support for remote log-in database.

② Auxiliary Power Supply Unit

Auxiliary power supply unit are generally isolated small power switching power supply. They supply stable DC electricity for the controlling circuits of power supply and assure normal operation of each unit of power supply.

③ High Performing Microcontrollers

Generally, they are micro-controllers of ARM structure and equipped with ICOS operating system. What they do is to coordinate and control power supply ends to work well wholly and perform variety of computation and processing necessary to implement actual functions.

④ On- off Control Units of AC Power

On-off control units of AC power generally include AC-MOSFET or electromagnetic relays, plus devices detecting abnormal circumstances (such as devices detecting contactor status) which are used to assure operation reliably. The main mission of On-off control units of is to switch appliances on or off according to instructions by

micro-controllers.

⑤ Residual Current Sampling Units

Sampling units of residual current generally consist of leakage current transformers and signal conditioning circuits which are mainly used to measure residual current found during power adaptation and convey to units of ADC (Analog to Digital Converter) and parameter processor so as to conduct protection against AC leakage.

⑥ Voltage Sampling Circuits

Voltage-sampling units generally consist of AC voltage transformers and signal conditioning circuits. Their main task is to sample voltages of appliances during adaptation and convey to ADC and power parameter processors for measuring electric parameters and conducting safety protection.

⑦ Current Sampling Units

Voltage sampling units generally consist of AC current transformers and signal conditioning circuits which are used to collect and convey current found during power adaptation to ADC and power parameter processors for measuring each power parameters and conducting safety protection.

⑧ Power Parameter Preprocessor and Digital to Analog Converter

Power parameter preprocessor and ADC mainly consist of ADC conversion chips and signal conditioning circuits which are used to filter

noise from valid signals sent by each sampling circuits out and convert to discrete digital signals discernible to micro-controllers for performing measurement and collection of each power parameter.

⑨ Appliance Information Tag Reader (WID coupler or RFID antenna)

Appliance information tag reader units generally consist of WID or passive RFID protocol stacks and related coupling parts (antenna, capacitor etc.) which are mainly used to read information stored within appliance tags and convey to microcontrollers.

⑩ Appliance Signal and Power Connectors

Appliance signal and power connectors are generally pluggable socket connecters which are used to conduct connection between appliances and power supply ends as passages of conveying power and singles.

II. The Physical Structure of Appliance Ends for High Voltage AC Power Adaptation

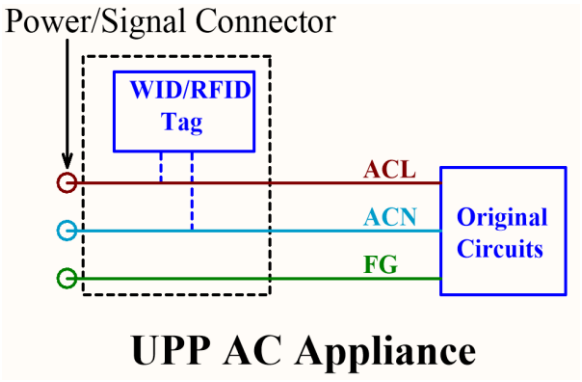


Image30 Graph of AC Power Using Ends

As shown in image30, AC electrical appliances consist of following units:

① Signal and Power Connectors

Power connectors are generally pluggable socket connectors compatible with the connectors of power supply ends which are used to conduct electric connection between power supply and appliance ends for performing power delivering and signals transmitting.

② Appliance Information Tag

Appliance information tags (including WID/RFID tag) are used to store UID and power requirements and working parameters of certain appliance according to UPP protocol.

III. The Physical Structure of Power Supply Ends for Low Voltage DC Power

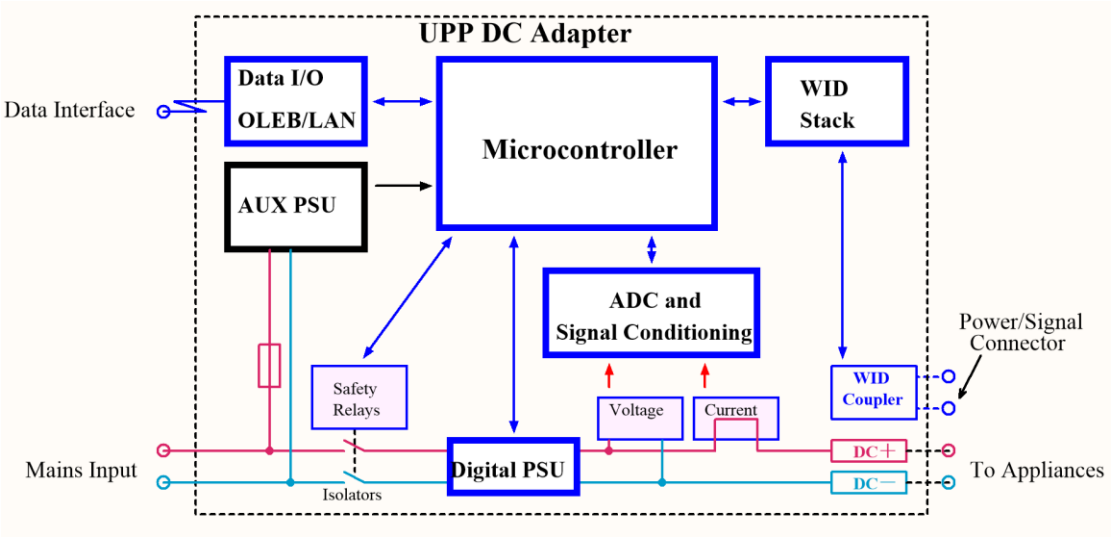


Image31: Graph of Physical Structure of Power Supply Ends for Low Voltage DC Adaptation

As shown in image31, low voltage DC power supply ends consist of following parts:

① Communication Modules

Communication modules generally include wired bus or Wi-Fi

modules, with which power supply ends would be able to connect with Internet and ONRUN platform or other net data platform so as to conduct integrated management and remote examination on power adaptation, in addition to offer online support for remote log-in database.

② Auxiliary Power Supply

Auxiliary power supply unit are generally isolated small power switching power supply. They supply stable DC electricity for the controlling circuits of power supply and assure normal operation of each unit of power supply.

③ High Performing Microcontrollers

High performing microcontrollers are core part of power supply ends. Generally, they are microcontrollers of ARM structure and equipped with ICOS operating system. What they do is to coordinate and control power supply ends to work well wholly and perform variety of computation and processing necessary to implement actual functions.

④ On-off Control parts and units of DC power

On-off control units of AC power generally include MOSFET or electromagnetic relays, plus devices detecting abnormal circumstances (such as devices detecting contactor status) which are used to assure operation reliably. The main mission of On-off control units of is to switch appliances on or off according to instructions by

micro-controllers.

⑤ Digital Power Supply

Digital adjustable powers generally consist of digital power controller chips, MOSFET, DA conversion parts and units and so on which are used to deliver stable DC power with variant parameters according to instructions by microcontrollers so as to conduct power adaptation on requirements by low voltage DC appliances.

⑥ Voltage Sampling Unit

Voltage sampling unit generally consist of hall voltage sensors or voltage divider resistance network and signal conditioning circuits which are used to sample and convey voltage during power adaptation to ADC and power parameter processors for performing measurement and comprehensive safety protection.

⑦ Current Sample Circuits

Current sample units generally consist of hall current sensors or current divider resistance network and signals processing circuits which are used to collect and convey current during power adaptation to ADC and parameter processors for performing measurement and comprehensive safety protection.

⑧ Power Parameter Preprocessor and Digital to Analog Converter

Power parameter preprocessor and ADC mainly consist of ADC conversion chips and signal conditioning circuits which are used to filter

noise from valid signals sent by each sampling circuits out and convert to discrete digital signals discernible to micro-controllers for performing measurement and collection of each power parameter.

⑨ Appliance Information Tag Reader (WID coupler or RFID antenna)

Appliance information tag reader units generally consist of WID or passive RFID protocol stacks and related coupling parts (antenna, capacitor etc.) which are mainly used to read information stored within appliance tags and convey to microcontrollers.

⑩ Signal and Power Connectors

Power connectors are generally pluggable socket connectors compatible with the connectors of power supply ends which are used to conduct electric connection between power supply and appliance ends for performing power delivering and signals transmitting.

IV. The Physical Structure of Power Using Ends of Low Voltage DC Appliances

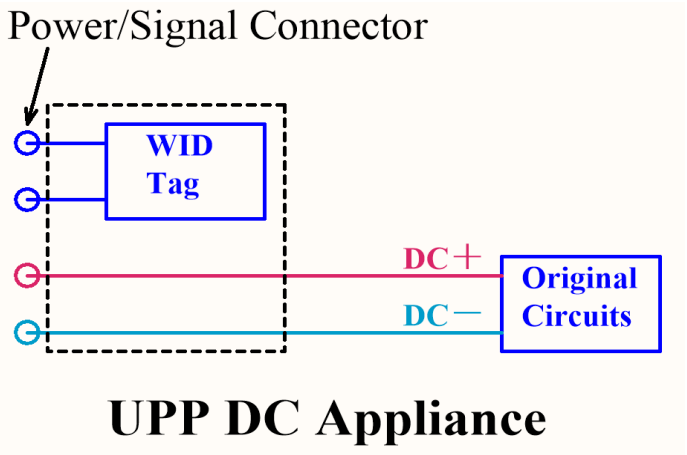


Image32 Graph of Physical Structure of Low Voltage DC Appliances

As shown in image32, the electrical appliances of low voltage DC

appliances consist of following units:

① Signal and Power Connectors

Power connectors are generally pluggable socket connectors compatible with the connectors of power supply ends which are used to conduct electric connection between power supply and appliance ends for performing power delivering and signals transmitting.

② Appliance Information Tag

Appliance information tags (WID/RFID tag) are used to store UID and power requirements and working parameters of certain appliance according to UPP protocol.

Design on Working Flow of Power Adaptation

Reasonable working flow is a basic conditions for any system to work normally. According to those stated above, the work flow of power adaptation is designed as following:

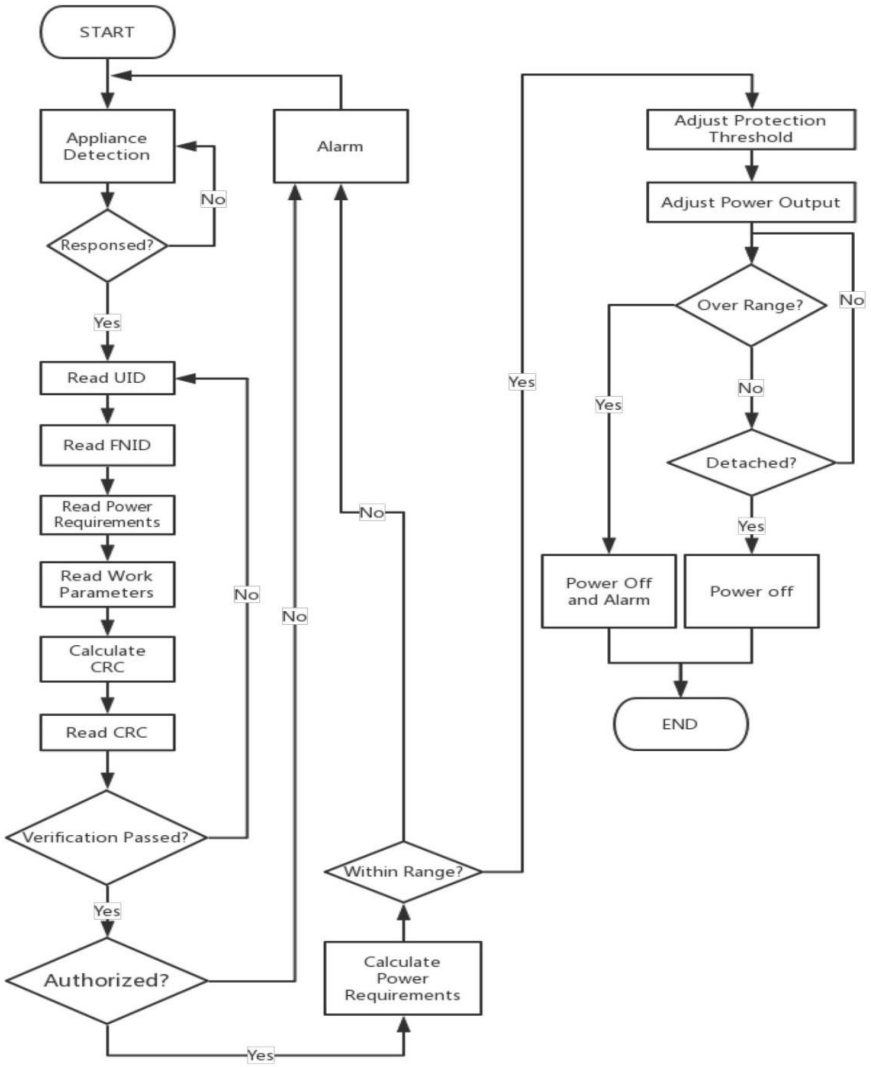


Image33 UPP Working Flow Graph

As shown in image33, actual working flow of power adaptation is divided by 6 main steps as flowing:

① Detection on Insertion of Appliances

Power supply device running UPP makes instructions to detect connection of appliances ceaselessly, and if an UPP appliance connect with the power supply device at this time, detecting instruction gets response and the power supply ends will start next operation.

② Authentication of Appliances

Power supply ends read UID of appliance in their tags and examine the authority of the UID through the list of authorized appliances. If the appliance has the permissions of using electricity, it will conduct next operation, otherwise handle as abnormal connection.

③ Read and Procession of Appliances Information

Power supply ends read information in tags of appliances and know their power requirements (about voltage, current and power consumption etc.) and safety protection parameters and take these data compared with those within the ranges both of power supply and safety protection, if the parameters were in the adaptable range, they conclude agreement and begin delivering power, otherwise, will handle as abnormal requirements.

④ Supply Power on Requirements

On basis of power requirements, power supply device will automatically adjust and start its internal adapting unit to deliver required power to meet appliance's requirements. The appliance will thus get electricity and start to work.

⑤ Protection Based on Actual Parameters

On basis of the safety protection parameters and capacity itself, power supply device will automatically set parameters of internal inspection and protection units (might be hardware or software), and perform safety protection on both power supply and use parts comprehensively.

It will conduct protection operation (switch off electric connection) and conduct handling of abnormal circumstances while detects danger or potential danger.

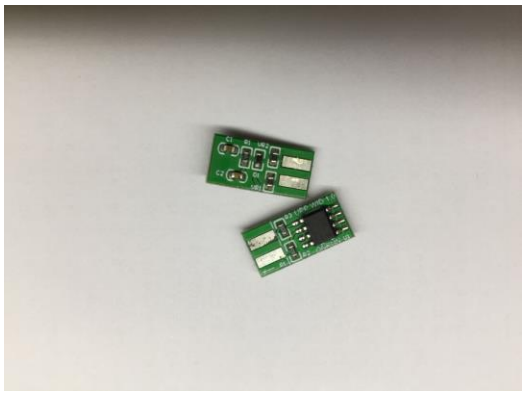
⑥ Switch off and Reset

In the course of delivering power, power supply device will ceaselessly make detecting instructions, if at this time appliance disconnect with power supply device (pull out or drop off), detecting instruction will not be responded. Power supply device will then find the removal of electrical appliance and switch off the power automatically. The power supply device will be back to original state while it is disconnected with appliances.

Performance Evaluations and Tests of UPP Prototypes

I. Physical Pictures of UPP DEMO Prototypes

According to the schemes and protocols of UPP stated above, here offers a DEMO of power adapter operating UPP and conducted tests on its performance effect.



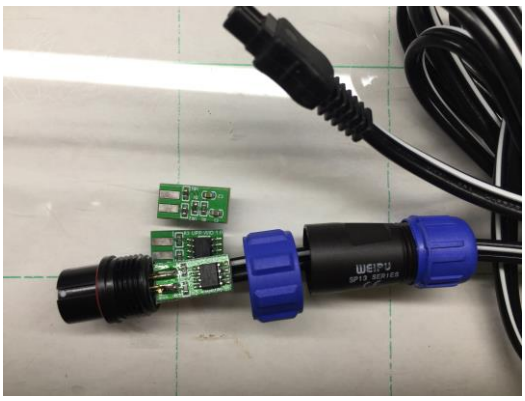


Image34-35 WID Tags Installed in DC Plugs

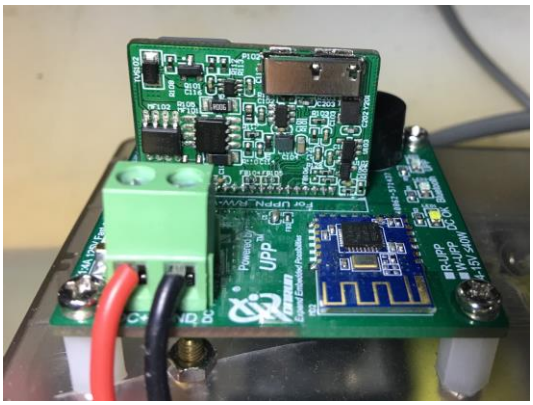
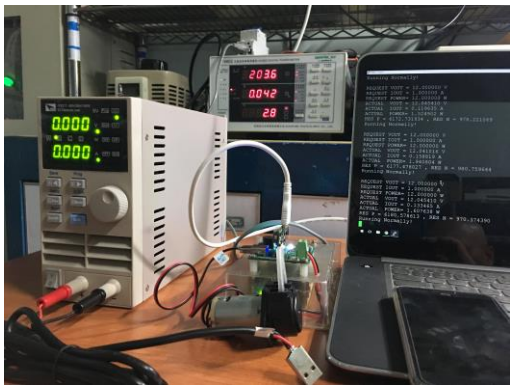


Image36-37 Prototype of UPP Low Voltage DC Power Adapter

II. Test Report of UPP Power Adaptation

UPP Prototypes Performance Test Report

Image38 Sample Picture



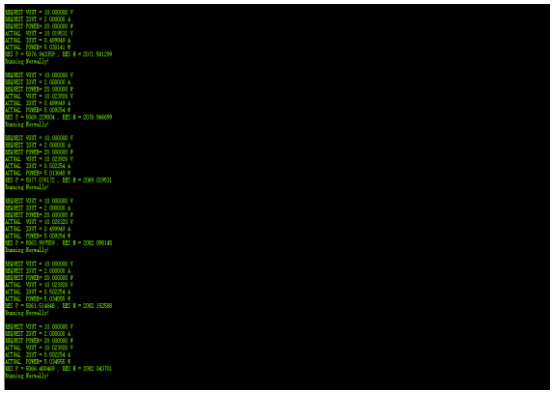


Image39-40 Test Procedure Photo

(i)Regulation Information

Tester	Li Chentian
Date	09-10-2017
Test Environment	26.0℃, 80.00% R.H. ,Indoors

(ii) Sample Information:

Sample Model	EVB_UPPN_R/W-V1.0
Power Input	16VDC 3A max.

Adaptation Range	5~15VDC,4A/45VA max
UID	U756A123BD
UPP Protocol Category	WID-UPP,DC-CAT Ⅰ(5~15V),45W
Monitoring Parameters	DC Voltage, DC Current, DC Power, DC Energy
Communication I/O	Bluetooth BLE4.0, USB, USART
UPP Channels	1

(iii) Instrument and Equipment Information

No.	Category	Model	Manufacturer ID	Accuracy
1	Bench Multimeter	Agilent 34401A	MY47049352	±0.01%
2	Regulated DC Power Supply	GWINSTEK PS80-13.5	EL191865	±0.2%
3	Waveform Generator	Agilent 33522A	MY47243352	±0.01%
4	Digital Oscilloscope	Agilent MSO-X 3024A	MY52441781	±0.1%
5	V/I Generator	Victor VC04	999299859	±0.1%
6	Computer Workstation	DELL PowerEdge R730	DWPTS72	Digital
7	Insulation resistance meter	UNI-T UT512	3100166260	±5.0%
8	Electronic Load	ITECH IT8211	600109010717510036	±0.2%
9	Sound level meter	TES TES-52A	130909787	±0.2%

(iv) Functional Test Items(U756A123BD)：

No.	Name	Test Procedure and Requirements	Conclusion
1	WID Tag Accessing Correctness Test	Plug and unplug WID Tag for 10 times, compare the data displayed in console terminal and the data in the tag.	10 Correct Trials, Passed
2	WID Tag Access Response Time Test	Plug and unplug WID Tag for 10 times，CalculatedΔt=T2–T1 must less than 0.2s.	About 0.05s,Passed
3	WID Tag Data Verification Test	Plug in 10 WID Tag with 1⁄48 random error data, All Tags must be rejected.	All rejected, Passed
4	OCP Test	Plug in electrical load of 150% REQUEST IOUT, the power should be	Latency Error ±3%, Passed

		switch off within ±5% of preset OCP latency.	
5	OLP Test	Plug in electrical load of 150% REQUEST POUT, the power should be switch off within ±5% of preset OLP latency.	Latency Error ±3%, Passed
6	Reverse Current Protection Test	Input 0.01A of reverse current with a 22.5V constant current source , the current should be disconnected within ±5% of preset latency.	Latency Error ±3%, Passed
7	Short Circuit Protection Test	Short the power output of the sample with a ≤10mΩ conductive object at MAX_VOUT and MAX_IOUT conditions, the current should be disconnected within 10ms .	Latency about 4.55ms, Passed
8	Overvoltage Condition Test	Apply 150% of rated input voltage on the sample and repeat test item 1~7.	Passed
9	Overvoltage Damage Test	Apply 1000% of rated input voltage on the sample, the fuse should break the circuit with no smoke, fire and explosion.	Passed

(v) Parametric Test Results (U756A123BD)：

No.	Item	Ideal Value	Actual Value	Unit	Tolerance	Conclusion
1	Minimum Adaptation Volt.	4.5	4	V	≤-5%	Passed
2	Maximum Adaptation Volt.	15	15.5	V	≥5%	Passed
3	Continuous Power（T_{rise}≤40℃）	45	48	W	≥5%	Passed
4	Insulation Resistance	≥100	211	MΩ	+∞	Passed
5	Output Voltage Error(24hr)	0%FS	0.4%FS	-	±1%	Passed
6	Voltage Measuring Error	0%FS	0.12%FS	-	±1%	Passed
7	Current Measuring Error	0%FS	0.11%FS	-	±1%	Passed
8	Power Measuring Error	0%FS	0.12%FS	-	±1%	Passed
9	OCP Latency	100	103	ms	±5%	Passed
10	OLP Latency	100	98	ms	±5%	Passed
11	RCP Latency	10.0	9.9	ms	±5%	Passed

12	Output Overshoot	0%	5.4%	-	≤10%	Passed
13	Output Ripple (@4A 10.0V)	50	35.4	mV p-p	≤100	Passed
14	Alarm Sound Level	85	88.5	dB	≥80	Passed
15	Power Efficiency (@4A 10.0V)	90%	94%	-	≥85	Passed
16	Load Switch Leakage(@24V)	100	45.5	μA	≤100	Passed
17	WID Excitation Voltage	3.3	3.29	V	±5%	Passed
18	WID Excitation Current	10	18.5	mA	≥10	Passed
19	WID Baud Rate	100	100.1	kbps	±1%	Passed

(vi) Test Outcome: Pass

Tester: Chentian Li

Date and Time: On 10 Sept. 2017

III. Test Conclusion

UPP device developed on basis of this protocol achieved following aims:

First, it could operate UPP correctly and fast, read power parameters of appliance stored within WID chip and conduct verification assuring data correctness on basis of design requirements. It proved the destination of reading parameters had been carried out completely.

Second, it can deliver power with correct voltage and other electric parameters according to requests by appliances and/or those set by users, in addition to keep relative electric parameters stable within designed time. It means the destination of automatically adapting power

to meet different requirements has been achieved completely.

Third, it can accurately set safety protection parameters on basis of parameters both of appliances and/or set by users. It will thus make sure the safety specifications of both power supply and appliances to done, in addition to conduct right handlings while abnormality and danger happen in course of power adaptation. It means the aim to perform protection on basis of actual parameters has been carried out well.

In summary, UPP device developed here meets all parameters designed and all engineering goals proved to have been achieved completely.

Creativity, Scientific, Practicability and Scientific Meanings

I. Creativity

Universal Power-adapting Protocol (UPP) is a set of entirely new power adaptation standards developed with advanced electronic technology and based on issues found in present power adaptation. The power adaptation devices based on such standards boast of following noted creativities in contrast with existing power adapters:

（i） **Create the Protocol-based Idea for Power Adaptation.** The model changes present way of connection between power supply and

appliances with electric contact only to the one with both electric and digital contact at the same time. It thus alters the way and nature of connection between power supply and appliances in power adaptation completely nowadays.

Just as stated above, all relations between power supply and appliances of power adaptation devices prior to this project are no more than a simple electric connection in which electric contact between power supply and appliances is the only condition necessary to start delivering power. There the power supply end doesn't know power requirements by the electrical appliance and the electrical appliance doesn't know whether the power supply end can supply electricity meeting its requirements or not. Such a way of "contact and power" will inevitably bring about much issues.

But in the relationship of power adaptation here, prior to power delivery, power supply and appliances must conduct "Communications" and conclude an "Agreement" on "Communications". Prior to setup of relationship for power adaptation, electrical appliance stored such information as its power parameters and ID in information tags of the electrical appliance. While plugs is connected with the power supply end electrically, the power supply end read relative information and compare the power requirements to the ones of itself. The power supply only delivers power to the appliances which were within its range and work

normally and thus no power will be delivered to external debris and/or over range appliances.

（ii）Create a Model of Power Adaptation of Delivering Power on Requirements

A noted feature of this project is that the electricity delivered by power supply end is based on the requirements by electrical appliance. Therefore, the electricity delivery is able to meet the requirements of all kinds of appliances within its adaptation range. This creativity design avoids the drawbacks (convenience issues, environmental damages etc.) of present power adaptation.

As stated above, it is known that the project suggested for power adaption of high voltage AC appliances two technological schemes, i.e. “Magnetic Relay Scheme” and “MOSFET Scheme” which could ensure power delivery on requirements, while suggested for low voltage DC appliance a scheme “Digital Switch Adjustable DC Power”. These schemes stated above provided the hard ware condition for conducting power adaption on basis of requirements. For the more, it can also be seen in the parts of “Topological Graph of Power Supply and Use Protocol” and “Design on Data Content and Format of Power Supply and Use Protocol” that this project did not only create a hardware condition but also a software one for conducting delivering and using electricity on basis of requirements. All above can be seen in the “Working Flow Graph

of Power Adaption”.

（iii）Create a model of “Protection Based on Actual Parameters” for Power Adaptation.

According to those stated above, at present, protections for power adaptation are basically the one featuring “Preset, and Unchangeable” in which protections always work inefficiently. The safety protections pay little attention to actual parameters of appliances and they might cause lots of potential safety risks.

But as stated above, in the relationship of power adaptation set up here, power supply devices can know parameters of electrical appliances completely and automatically set inside parameters of detecting and protection units on basis of both parameters of safety protection demanded by electrical appliances and tolerance of themselves. In the course of delivering power, it can offer a desirable safety protection attention to both power supply and appliances. While danger or potential danger is detected, protections would start instantly to prevent dangerous situations from taking place.

The safety protections of “Protection Based on Actual Parameters” make safety protection of power adaptation based on complete acquirement of parameters of power supply and appliances and pay attention to safety requirements of power supply and appliances equally. It thus eliminate variant potential risks resulted from mismatched

parameters, and thus make much safer performance of power adaptation.

（iv）Create a model of "Delivering and Using Power on Authentication" from which might keep power thief and accidental electric shock away.

As stated above, present model of power adaptation is the one in which power delivering will begin as soon as when there is a conductor contact. This model does not only offer a possibility for thieves to steal electricity, but also plant a seed of accidental electric shock.

Attention to issues of present power adaptation, this technological project put forward the model of adaptation on authentication in which power supply end reads the UID of electrical appliance in the information tag of appliance and checks the authority of power delivery. The power supply end will not deliver any electricity unless it knows that the electrical appliance has a corresponding permission.

The model of power adaptation which based on authentication replace present "Contact and Power" model of power adaptation in which power delivery begins only depends on contact of conductors. This new model will not only make it great difficult for theft to steal electricity, but also prevent almost all short circuits and electric shocks resulted from "Invading" of water drops, conductive debris and so on.

（v）Create a Mode of Power Adaptation Featuring "One to More"

As stated above, all present models of power adaption are the one of “One-to-One”. Such models did bring not only great inconvenience to people, but also great pressure to environmental protection.

A remarkable feature of power adaption relationship set up on UPP is creating one relationship of “One-to-Many” in which one power supply end can adapt power for countless appliances within its range theoretically. An adapter will thus have a longer life (no longer discarded with appliances) and serve much more appliances. This will therefore solve such issues as inconvenient to journeys, source waste and environmental pollution.

II. Scientific

Scientific of this project includes the following:

（i）The Project Stems From Reality

This project originated from study on existing issues and their causes, therefore, it has a solid practical base.

（ii）This Project Based on Existing Technology

From those stated above, the whole technological scheme is based on existing technology. Each technological point related to this project has been selected based on comparison and contrast among all possible schemes, and therefore each technological point selected finally was scientific completely.

（iii）Application Stems from Simulations and Experiments

In the course of design and development of this project, almost each work unit had two steps, the first is computer simulation and the second is experimental test. Therefore, all working units of this project had been based on practicality. Practice is the only test of truth, therefore all working units here had been proved objectively.

In summary, this project is highly scientific.

III. Practicality

As stated about creativity of this project hereinabove, it is clearly illustrated that this project solved issues which have existed but couldn't overcome for a long time completely. This project can therefore apply to all existing power adapting devices used in industry, agriculture, and households and boast of a great applying spectacle.

IV. Scientific Significances

1. It is first time to put forward protocol-based idea to solve issues in power adaptation and get success. Here, power parameters, variety, performances and other parameters of different appliances are descripted with a ubiquitous standard. It thus achieve the aim to provide suitable power and safety protection for various appliances along with their requirements through one power adapter. Such an idea can also be used to solve issues of parameter adapting of electric signals (included but not limited power and sensors' signals). For example, with protocol-based specifications on signals, ranges, calibration information

and the like, only a piece of tag is needed to fix in the connectors of sensors and related parameters of sensors can then input automatically while sensors are connected. It will thus simplify installation and use greatly and with a field bridge model, one DAQ device can be competent to any sensor within range. Furthermore, with large capacity of and fast speed of access information tags, especially WID tags, it can conduct such performance as multiple point calibrate information storage which almost can’t be performed through traditional input methods. This will provide possibility to specify those sensors remarkably featuring nonlinear through linear way. Many sensitive components which are unable to be used as sensors because of their high nonlinearity will be able to use as sensors. This will significantly broaden objective range possible to be sensed by us.

2. The power adaptation devices designed here makes power adaptation devices digitalize and create a digital link between power supply and appliances which provides a physical base for conducting various transmission of information between power adaptation devices and appliances. For example, replacing passive WID with intelligent information tags consisting of low power microcontrollers and upgrading UPP a little, instructions from internet by users or automatic control systems could then be sent to those intelligent tags through information channels and represented as level changes of GPIOs and/or parametric

adjustments of electric equipment. The information from appliances can also be uploaded through the same channel to the Internet furtherly. Contrast with general remote control and examination which must be fixed complete devices with performance of communication, explanation, control, input and output (for example, to make an air-conditioner with performance of remote control and parameter feedback, there must be network module, embedded computer module, input and output module and so on), UPP devices do not only decrease the complexity and cost, but also share such resources as data link, intelligent control and the like together. This will effectively reduce idle and waste of resources after the appliances were deprecated.

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Chentian Li's Resume

Chentian Li, 17 years old, student of grade 11 of No. 1 High School of Zhuhai City of Guangdong Province. Like Tesla for his imagination without any limitation and actualization. Classmates said he is the one coming from E planet, and media called him as " Teen-age Edison". Like to ask questions and had asked "Why" more than one hundred thousand prior to 3 years old. Enjoy "time-travel" among "Schools" of electronic information, chemical-biology and engineering design.

1. Successive twice elected by Chinese Science and Technology Association in 2016 and 2017 as a member of Chinese Delegation to join Intel International Science and Engineering Fair (ISEF) and wined honor prize in 2016 and the forth place of prize in 2017.

2. Applied for the first potent of invention "Intelligent Management System of Outdoor Manhole Cover and Risk Alarming Against Thief and Loss in Dec. 2010 while still in grade 5 which was approved in Dec.2012 (Invention Potent Number: ZL. 201010594660.9）. Up to now, there are 6 invention patents in publication which range from electronic information, machine engineering to sensing collection and the like.

3. In August 2017, won the first place of prize in the 32nd CASTIC; in Dec. 2016, won 1st place of prize in 16th Awarding Program For Future Scientists; in August 2015, won the 1st place of prize in 30th CASTIC; in August 2016, won "China Youth Science and Technology Innovation

Award; in August 2016, 2012 won respectively the 2nd place of prize in 31st and 28th CASTIC; and in 2017, 2016, 2015, 2013, 2012, 2011 won the 1st place of prize in Guangdong Adolescent Science & Technology Innovation Contest; further Chentian Li was also the Trainee of 2015 Ying Cai Ji Hua.

4. In 2013, Chentian Li created “Center Studio” at home, up to now, the studio has boasted of following equipment: a Workstation of Dell R730, an Agilent OSC of MSO-X-3024A, an Agilent Function Generator of 33522, an Agilent Multimeter of 33522A, a GWINSTEK LCR-821, a GWINSTEK Frequency Meter of Gsp9330, a set of GLPK PCB Plate Machine, and a GWINSTEK Power Supply, a Kikusui Power Supply and an electric load, a power parameters detector and so on. These instruments and devices might be used to conduct almost all works related to design, emulation, manufacture and test.

5. Wenyuan Junior Middle School from which Chentian Li graduated has “ Li Chentian Studio” which won the 2nd place of prize in Scientific & Technological Activities Achievements Exchange & Exhibition Fair of National Scientific Qualities of 2015 Guangdong Province.

6. There are about 40 members in “Li Chen Tian Maker Activities Workshop” created by Chentian Li in No. 1 High School. This workshop is armed with varieties of advanced electronic, chemical instruments and units. The innovative teams of this workshop guided by Chentian Li are

very active and excellent, up to now, have wined 3 the 1st place of prizes of CASTIC, 4 the 1st place of prizes, 4 the 2nd place of prizes, and more than ten the 3rd place of prizes in Guangdong Adolescent Scientific & Technological Innovative Contest.

South TV Station, CNS(China News Services), Zhuhai TV Station, New Express, Wenhui Bao of HK, Yangcheng Evening News, Nanfang Daily, Southern Metrololis Daily, Xinmin Evening Daily, Zhuhai Daily, Zhujiang Daily and some other media have all reported many news about Chentian Li.