

## Power Consumption Information Acquisition Terminal Based on Beidou Research and Application of Remote Communication Unit

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### **Abstract**

*With the successful networking and all-round application of the National Beidou Satellite Communication System, an automatic meter-reading system based on Beidou satellite communication technology is proposed, as well as the establishment of system software and hardware platform. In order to realize the application of Beidou communication system in power centralized reading system, The urgent task is to solve the function realization of the remote communication unit of the acquisition terminal, including hardware structure design, communication protocol conversion and communication transmission, and conforming to the existing communication protocols and standards. The difficulty of this subject lies in adding Beidou communication module into the solidified structure of the existing communication unit, to achieve the synchronous transmission of the collected data and Beidou position information. Through processing in accordance with the protocol, the electric energy data of the collected terminal and Beidou information can be uploaded to the main station of the system, and the real-time safe and reliable requirements can be met.*

**Keywords:** *Remote communication unit, Beidou communication module, Protocol conversion*

### **I . Introduction**

Beidou satellite navigation system is a global satellite navigation system independently developed and operated by China. With the continuous advancement of smart grid construction, The requirements for the reliability and quality of power grid operation are getting higher and higher. The construction of smart grid will become the infrastructure to drive China's economic development in the next 30 years. During the 13th Five-Year Plan period, the State Grid will start with the goals of power grid structure, construction quality, power grid safety and innovative development, building a safer, more efficient and stronger power grid. Beidou system has the unique advantage of no need of building a private network base station or laying a special optical cable, as well as its unparalleled information security, combining Beidou satellite communication system with smart grid automatic operation organically, and meeting the standard requirements from the aspects of hardware system, software scheme, environmental safety, etc., finally a Beidou power metering remote concentrated meter-reading system suitable for the whole power system has been designed and implemented. The geographic information of electrical equipment applied to power terminal equipment is the key information for big data analysis of electrical equipment to improve power efficiency. Therefore, the design of a remote communication unit of electrical information acquisition terminal based on Beidou came into being

LTE series communication unit of power consumption information acquisition terminal based on Beidou can realize data transmission and interaction of power consumption information acquisition terminal through remote communication mode (4G), meanwhile, the location and time information of the power metering terminal can be collected, which can provide important technical support for the calculation of local time service rate for metering power asset management, thus realizing the landing of ubiquitous Internet of Things in the field of power metering.

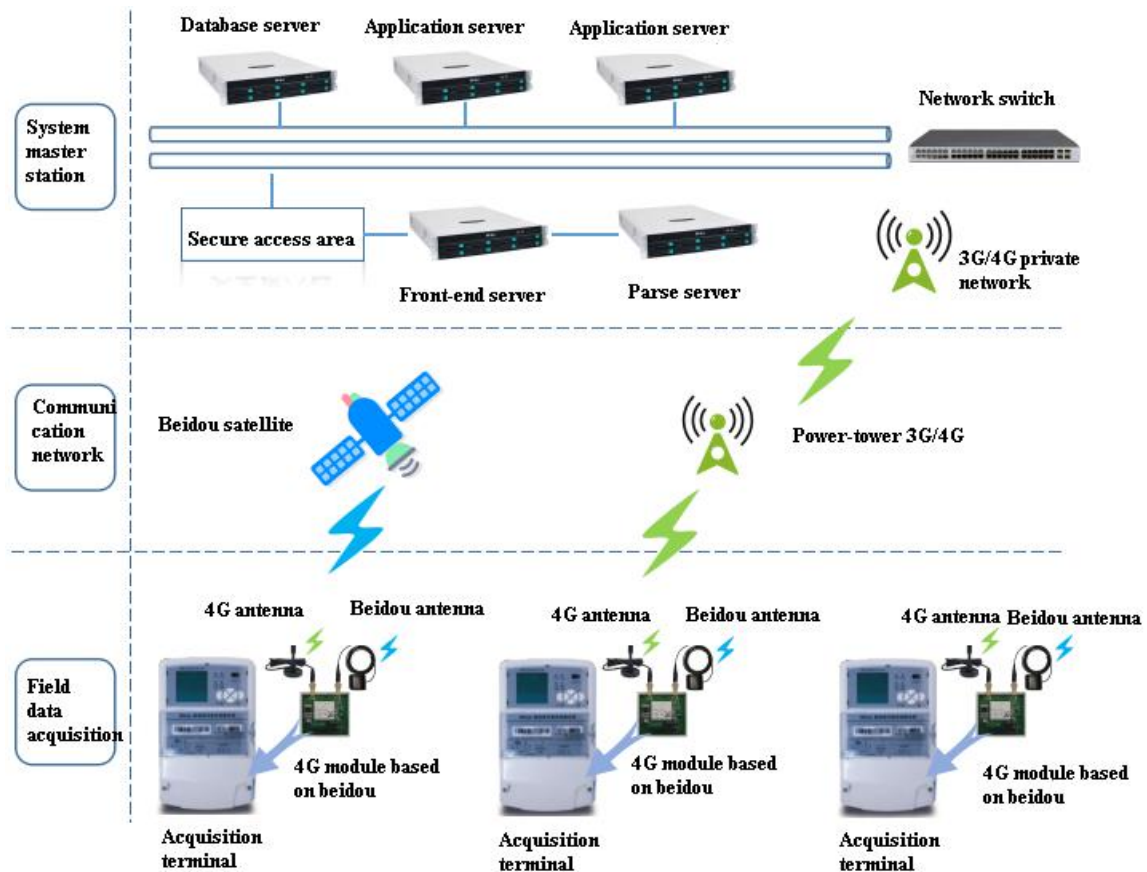
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The communication module built in the communication unit of LTE series acquisition terminal based on Beidou is an industrial-grade high-performance module of China Netcom, With the high integration and low power consumption, it supports the 2G/3G/4G network system of the three major operators of China---Mobile, Unicom, and Telecom, and it can also fully meet the needs of data collection and command issuance in the power industry and provide an excellent communication solution for smart grid or other public utilities

## II. Ideal Power Metering System (as is Shown Below)



*Fig.1 Ideal Power Metering System*

The workflow is as follows:

- The Beidou communication module obtains the position information of the acquisition terminal through the Beidou antenna
- The acquisition terminal is responsible for collecting the electric energy data of the remote field acquisition terminal
- The position information and electric energy data of Beidou are transmitted to communication management machines (analysis server and front server) through communication layer (4G network)
- The communication management machine accesses the main station of the system through the safe access area, and stores the electric energy data to the large-capacity database

- The display interface is constructed at Beidou master station layer to monitor and manage the position information, and upload the electric energy data to the metering automation master station system through the mobile communication module.

### **III. Hardware Structure Design of Electric Energy Acquisition Terminal Based on Beidou**

Project constraints (bottlenecks encountered at present). After years of investment, the State Grid has purchased and deployed a large number of metering equipment, having established a perfect and reliable power metering system., but most of the equipment does not have Beidou communication function, thus, it is impossible to report the location information of equipment quickly and accurately. The State Grid expects to carry out the transformation with least cost and most convenience on the basis of existing equipment, to provide Beidou positioning information for all metering equipment. Through repeated analysis and demonstration, a 4G+Beidou two-in-one communication module solution is proposed to provide Beidou positioning information by replacing the communication module without changing the hardware and software of metering equipment

The research and development of Beidou power metering remote centralized reading system involves the study of many key technologies from scheme design to implementation test. With such perfect hardware scheme design, the requirements of reliable communication protocol conversion, low power consumption, simple structure and low cost can be met at the same time.

#### ***A. Positioning Standard Module***

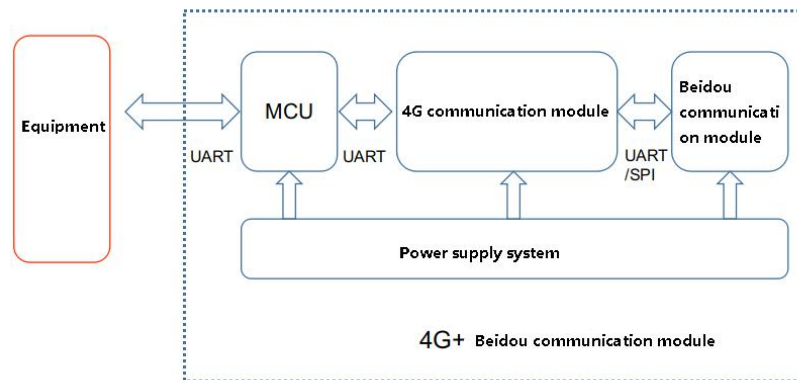
Develop a wireless communication module that can directly replace the existing wireless communication module on typical metering automation terminals such as low-voltage concentrator and negative control terminals, with integrated with 4G uplink technology and Beidou RNSS positioning technology 4G micro-power embedded positioning standard module. Beidou positioning module automatically searches for stars and provides position information conforming to NEMA-183 mark through serial port. The equipment address is the unique identification information of the equipment, which is needed by the communication module to bind with Beidou positioning information and report to the platform system in a unified way

#### ***B. Beidou Rdss Communication Module***

The application realization in terminal equipment is limited by the size structure and power supply requirements of the original GPRS module, On the basis of meeting the original functions, Beidou RDSS communication module needs to integrate microprocessor, Beidou RDSS RF transceiver chip baseband circuit and power amplifier chip, Beidou RNSS positioning chip with timing function chip added separately. The selection of all devices is considered from the perspectives of size, power supply and performance

#### ***C. Structure and Information Optimization***

According to market and technical requirements, and the demand analysis on products, the processing speed requirements and interface requirements of MCU are determined, such as the number of SPI interface or Uart interfaces, On that basis of the existing terminal uplink module size structure, its structure has been optimized, by adding Beidou RDSS positioning chip, and Beidou communication antenna on the basis of the original 4G communication, obtaining Beidou positioning information, and transmitting electric energy data and Beidou information to the system master station through the original 4G network. The preliminary hardware design of this product is shown in Fig. 2



*Fig.2 The Principle Block Diagram of Communication Module Based on Beidou*

The workflow is as follows:

- The MCU monitors and forwards data between the device and the 4G communication module
- The MCU obtains the device address information from the data message of the device
- MCU obtains position information from Beidou module
- The MCU packages the equipment address and Beidou location information and sends them to the platform
- The MCU monitors the application of position inquiry and sends heartbeat message regularly

#### **D. Hardware Circuit Module**

Main control unit: The MGU with ARM7 core which is selected, has the highest working frequency of 55MHz and the working temperature of-40(85 °C), with rich peripheral interfaces and easy to expand.

Beidou communication module: Its functions include positioning, time service, position report, etc.. Positioning allows to share position information of data acquisition terminals, and time service can provide high-precision time information and realize network time synchronization

Power supply part: Support AC and DC wide voltage input, that is, 220(1 ± 20%) V or 110(1 ± 20%) V AC (frequency 47(63Hz) 220(1 ± 20%) V or 110(1 ± 20%) V DC, and output 24V DC voltage to supply power to the control unit and Beidou communication module.

Other peripheral circuits: Realize the communication between the terminal and the meter, as well as the date display of the meter. Upgrade the prompt of debugging and alarming, etc.

## **IV. External Structure and Communication Interface**

### **A. Schematic Diagram of External Structure and Dimensions**

#### **1 ) Schematic Diagram of External Structure and Size of Type Iii Remote Communication Unit of Special Transformer Acquisition Terminal**

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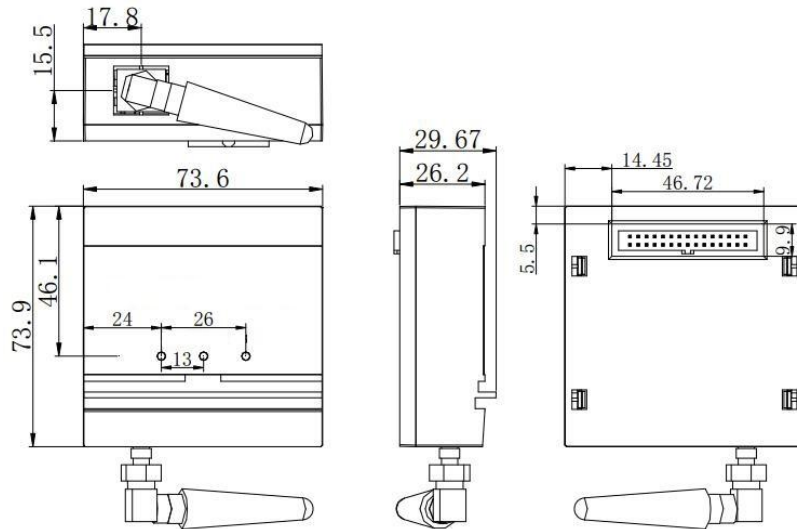


Fig.3 Schematic Diagram of Shape Structure and Size of Type Iii Remote Communication Unit of Special Transformer Acquisition Terminal (Refer to Real Object)

**2 ) Concentrator Type I Telecommunication Unit Shape Structure and Dimension Schematic Diagram**

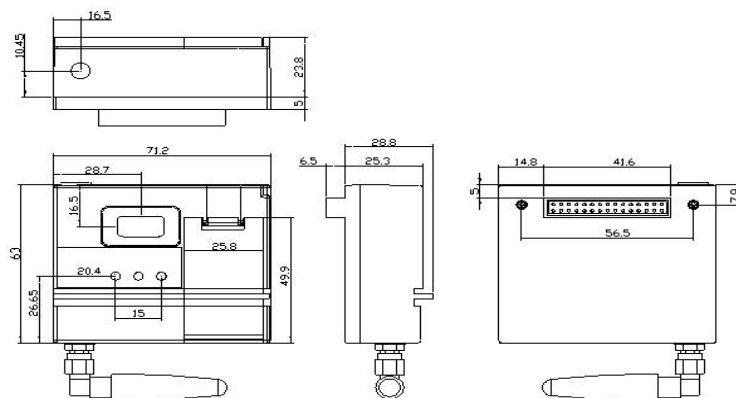
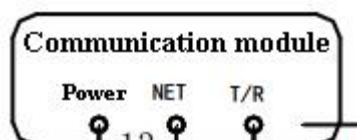


Fig.4 Indicator Lamp of Type Iii Remote Communication Unit of Special Transformer Acquisition Terminal (Refer to Real Object)

**B. Telecommunication Unit Status Indication**

**1 ) Status Indication of Type Iii Remote Communication Unit of Special Transformer Acquisition Terminal**

The indicator lights of three remote communication units are omitted from the Type III flip nameplate of the special transformer acquisition terminal, as shown in Fig. 5



*Fig.5 Telecommunication Unit Indicator Light*

Power lamp-module power-on indicator lamp, red light turning on indicates module power-on, red light turning off indicates module power-off;

NET lamp-communication Module and Wireless Network Link Status Indicator Light, with color Green;

T/R lamp-module data communication indicator, with lights red and green, red light flashing indicates that the module receives data, and green light flashing indicates that the module sends data

**2 ) Concentrator Type I Telecommunication Unit Status Indication**

The indicator lights of three remote communication units are missing from the nameplate of concentrator type I flip cover, as is shown in Fig. 6



*Fig.6 Concentrator Type I Telecommunication Unit Indicator (Refer to Real Object)*

Power lamp-module power-on indicator lamp, red light turning on indicates module power-on, red light turning off indicates module power-off;

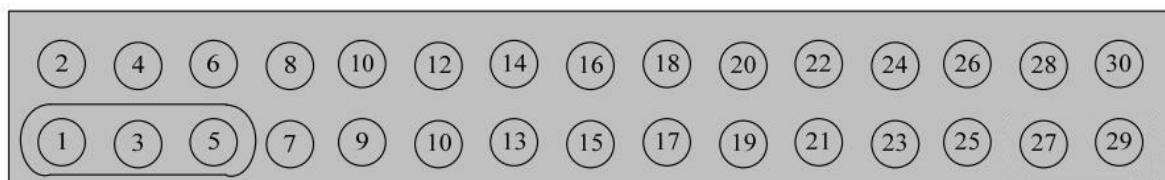
NET lamp-Module and Wireless Network Link Status Indicator Light, with color Green;

T/R lamp-module data communication indicator, with lights red and green, red light flashing indicates that the module receives data, and green light flashing indicates that the module sends data

**C. Telecommunication Unit Interface**

**1 ) Definition of Type Iii Remote Communication Unit Interface of Special Transformer Acquisition Terminal**

The weak current interface of Type III remote communication unit of special transformer acquisition terminal adopts 2×15 double-row pins as connectors. The interface definition is shown in Fig. 7, and the interface pin definition of remote communication unit is shown in Table 1.



*Fig.7 Definition of Interface of Type Iii Remote Communication Unit of Special Transformer Collector Terminal*

*Table 1 Definition Description Of Interface Pin of Type Iii Remote Communication Unit of Special Transformer Acquisition Terminal*

Module corresponding to pin number	Signal sort	Signal name	Signal direction  (Modules aimed at)	Instructions
1,3,5	Power Supply	VDD5v	Power input	Power input of communication module, $5V \pm 0.25 V$ , with its instantaneous maximum current 1.5 A
2	Power Ground	GND	Power input	Ground input of communication module power input
4	USB	USB-HP	USB differential signal	USB HOST +
6	USB	USB-HN	USB differential signal	USB HOST -
7	Power Ground	GND	Power input	Ground input of communication module power input
8	Serial signal	RXD	Output	Module serial output signal (3.3 V/TTL)
9	Serial signal	TXD	Input	Module serial input signal (3.3 V/TTL)
10	Output signal 1		Output	Module serial output signal (3.3 V/TTL)
11	Output signal 2		Output	Module serial output signal (3.3 V/TTL)
12	Output signal 3		Output	Module serial output signal (3.3 V/TTL)
13	Input Signal 1		Input	Module serial input signal (3.3 V/TTL)
14	Input Signal 2		Input	Module serial input signal (3.3 V/TTL)
15	Modular control	RST	Input	The communication module reset control signal, when "0" is displayed, the communication module is in reset state (3.3 V/TTL)
16	Input Signal	ON/OFF	Input	Module on/off signal input

17	Power Ground	GND	Power input	Ground input of communication module power input
18	State recognition	STATE0	Output	Module type recognition
19	State recognition	STATE1	Output	Module type recognition
20	State recognition	STATE2	Output	Module type recognition
21	State recognition	STATE3	Output	Module type recognition
22	State recognition	STATE4	Output	Module type recognition

23	Power Supply	VCC3v3	Power input	Logic circuit operating power supply, with voltage of 3.3 V $\pm$ 0.3 V, and maximum current 50mA
24	Power Supply	GND	Power input	Ground input of communication module power input
25	Network signal	TD+	Network differential signal	Ethernet transmission
26	Network signal	TD-	Network differential signal	Ethernet transmission
27	Network signal	RD+	Network differential signal	Ethernet reception
28	Network signal	RD-	Network differential signal	Ethernet reception
29	Network signal	/LED_ACT	Input	Input signal of network indicator light, active low level, indicates that data is being transmitted on the network
30	Network signal	/LED_LINK	Input	Network indicator light input signal, active low level, indicates that the network physical connection has been established

**2 ) Concentrator Type I Telecommunication Unit Interface Definition**

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The weak current interface of concentrator I remote communication unit adopts 2×15 double-row pins as connectors. The interface definition is shown in Fig. 8, and the interface pin definition of remote communication unit is shown in Table 2

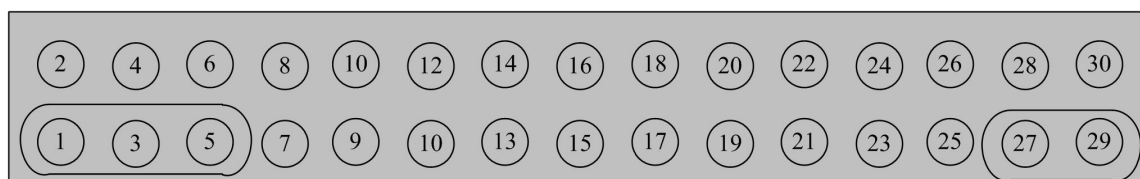


Fig.8 Concentrator Type I Telecommunication Unit Interface Definition

Table 2 Concentrator Type I Telecommunication Unit Interface Pin Definition Description

Module corresponding to pin number	Signal sort	Signal name	Signal direction  (Modules aimed at)	Instructions
1,3,5	Power Supply	VDD 5V	Power input	Power input of communication module, $5V \pm 0.25 V$ , with its instantaneous maximum current 1.5 A
2	Power Ground	GND	Power input	Ground input of communication module power input
4	USB	USB-HP	USB differential signal	USB HOST +
6	USB	USB-HN	USB differential signal	USB HOST -
7	Power Ground	GND	Power input	Ground input of communication module power input
8	Power Supply	VDDUSB	Power input	USB interface dedicated power input, with its voltage of $5V \pm 0.1 V$ , and maximum current 500mA
9	Serial signal	RXD	Output	Module serial output signal (3.3 V/TTL)
10	Serial signal	RTS	Input	Module serial input signal (3.3 V/TTL)
11	Power Ground	GND	Power input	Ground input of communication module power input

12	Serial signal	CTS	Output	Module serial output signal (3.3 V/TTL)
13	Serial signal	TXD	Input	Module serial input signal (3.3 V/TTL)
14	Serial signal	DTR	Input	Module serial input signal (3.3 V/TTL)
15	Serial signal	DCD	Output	Module serial output signal (3.3 V/TTL)
16	Power Ground	GND	Power input	Ground input of communication module power input
17	Power Ground	RI	Output	Module serial output signal (3.3 V/TTL)
18	State recognition	STATE3	Output	Module type recognition
19	State recognition	STATE4	Output	Module type recognition
20	Modular control	IGT	Input	Communication module control signal,"1", indicates that the communication module is in working mode (3.3 V/TTL)
21	Power supply control	PCTRL	Input	Module power control signal, turn off module power when it shows "0"(3.3 V/TTL)
22	Modular control	RST	Input	The communication module reset control signal, when "0" is displayed, the communication module is in reset state (3.3 V/TTL)
23	Reservation	NC	Reservation	Reserved signal, with no definition yet
24	State recognition	STATE0	Output	Module type recognition
25	Power Supply	GND	Power input	Ground input of communication module power input
26	State recognition	STATE1	Output	Module type recognition
27	Power Supply	VCC3v3	Power input	Logic circuit power supply, with its voltage of 3.3 V ± 0.3 V, and maximum current 50mA
28	State recognition	STATE2	Output	Module type recognition

29	Power Supply	VCC3v3	Power input	Logic circuit operating power supply, with voltage of 3.3 V $\pm$ 0.3 V, and maximum current 50mA
30	Power Supply	GND	Power input	Ground input of communication module power input

## V. Basic Parameters

Electromagnetic compatibility	It has good electromagnetic compatibility and meets the test requirements of relevant national standards		
Operating temperature	The temperature ranges -40 °C ~ +70 °C, and the relative humidity is $\leq$ 100%		
Atmospheric pressure	63.0 kPa ~ 108.0 kPa (altitude 4000m and below)		
Overall dimension:	Remote Communication Unit (Special Transformer Acquisition Terminal Type III/4G)	Telecommunications Unit (Concentrator Type I/4G)	
	FK3-LTE	JZQ-LTE	
	73.9 mm (length)*73.6 mm (width)*26.2 mm (thickness)	63 mm (length)*71.2 mm (width)*25.3 mm (thickness)	

## VI. Practical Application of Remote Communication Unit of Power Consumption Information Acquisition Terminal Based on Beidou

The remote communication unit of electric energy acquisition terminal based on Beidou was actually tested and operated in Qingshan District, Baotou City, Inner Mongolia this time, collecting information such as electric energy and Beidou position from 100 metering points. In the test system of metering marketing, the monitoring screen with switching function realizes the collection and monitoring of electric energy data through client software. It is reliably transmitted to the metering master station through the data transmission device DTU. After a period of stable operation, the system data acquisition stays complete and reliable with its online rate of the metering centralized reading terminal based on Beidou over 99%, and the online data integrity rate 100%, the automatic reading model 100%, and the data transmission latency is very low

## VII. Conclusion

Construction and application of automatic meter reading system based on Beidou satellite communication technology, It not only effectively collects various electric quantity data of remote terminals, At the same time, the Beidou position information of the terminal can be obtained, which is also beneficial for Inner Mongolia Power Grid to realize the monitoring and control of the electric energy collection terminal more comprehensively, It provides effective real-time electric quantity data for power grid system analysis and prediction, and also provides more comprehensive and reliable basic data for power grid economic and security analysis, which has strong

practical significance and popularization value.

### VIII. Acknowledgment

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