Installation Instructions

APN-MOD Series of AutoPhase[tm] Digital Power Transducers

Models with MODBUS Output

APN-MOD Series AutoPhase* Digital Power Transducers measure the power demand (kW) and energy consumption (kWH) of any single phase or three phase, 50 or 60 Hz electrical system. The transducers sit directly on a Modbus network and provides 24 data points. The units also show kW and kWH on the LCD display.

APN-MOD-PC-MX-LM

Software Version 1.00.00

If the Transducer you are installing is not listed here, call NK Technologies at 1-800-959-4014 for the correct Instruction Sheet.

Models covered by these instructions

Example: APN-MOD-PC-MX-LM
Network power transducer with Modbus output, module level, LCD on module.

APN – [ ][ ][ ] – [ ][ ] – [ ][ ] – [ ][ ]

Series	Output	CT Input	Case Style	Display
Network Power Transducer	MOD Modbus RTU	5A 5 Amp CTs (Ratio:5) PC ProteCT Low voltage output CTs	MX Module (Aluminum) MN Module in NEMA 1 encl. M4 Module in NEMA 4 encl. BX Board Level	LM LCD on Module LC LCD on enclosure (MN case only) LR LCD shipped loose, remote mount by others

Installation Overview

NK Technologies's APN Series Power Transducers are easy to install, wire and program. NK Technologies' exclusive AutoPhase[tm] Technology automatically does the hard work for you. That's the AutoPhase Advantage.

You need to perform the following functions:

1. Mount the APN transducer.
2. Install the Current Transformers (CTs) and wire them into the APN.
3. Connect the voltage inputs.
4. Program the CT amp rating, kWH pulse rate , alarm setpoints, AutoPhase, and node address.
5. Connect the Modbus Network.

Now the AutoPhase Advantage takes over and performs the following steps automatically:

A. Identifies all CT inputs by phase.
B. Corrects any polarity reversals (wiring errors) in the CT inputs.
C. Identifies all voltage inputs by phase.
D. Matches current and voltage inputs by phase.
E. Senses, selects and programs the correct input voltage level (120, 208, 480 or 600 VAC) and number of phases (1 or 3 phase).
F. Calculates the Maximum kW from the voltage level and CT amp rating.
G. Begins communication on the Modbus network bus and displays the instantaneous kW and total kWH.

The AutoPhase Advantage eliminates the tedious and sometimes dangerous task of rewiring or reconnecting mis-wired CTs and voltage inputs.

NK Technologies, 1400 Dell Ave., Suite A., Campbell, CA 95008,
Phone 800-959-4014 or 408-871-7510, FAX 408-871-7515, sales@nktechnologies.com

APN-MOD Rev1.1, 5/00 P/N 79-020-1101

APN-MOD TRANSDUCERS SHOULD BE INSTALLED BY QUALIFIED ELECTRICIANS IN COMPLIANCE WITH ALL LOCAL CODES AND STANDARDS. MAKE SURE POWER IS OFF BEFORE MAKING CONNECTIONS. EXERCISE EXTREME CAUTION WHEN EVER WORKING ON OR NEAR ENERGIZED CIRCUITS.

HAZARDOUS VOLTAGES EXIST INSIDE THE UNIT. THERE ARE NO USER SERVICEABLE PARTS INSIDE THE UNIT. FOR SERVICE AND REPAIR CONTACT THE NK TECHNOLOGIES FACTORY.

Step 1: Mount the Transducer

Module Level products (APN-MOD-xxx-**MX**) are designed to be mounted in a code approved enclosure furnished by others. Models APN-MOD-xxx-**MN** and -**M4** are already mounted in a NEMA-1 or NEMA-4 enclosure, respectively.

Mount the enclosure in a clean, dry location with suitable clearance for wiring and operation of the keypad and display. Units may be mounted in any orientation that is convenient and are not sensitive to magnetic fields. Be sure the temperature and humidity is within specifications. *P. 6*

Step 2: Install and Wire the Current Transformers

Verify which transducer model that you have before proceeding. Models with suffix "-PC" are designed for use with ProteCT Current Transformers with 0-0.333V output. Models with suffix "-5A" are designed for use with traditional 5A CT's.

APN - MOD-□□ - xx-xx
CT Input: 5A 5 Amp CTs (Ratio:5)
PC ProteCT

MODELS WITH "-PC" CT Input ProteCT Current Transformers Only

NEVER CONNECT AN APN-MOD TRANSDUCER DESIGNED FOR ProteCTs TO CURRENT OUTPUT CTs (100:5, 200:5, etc.) DOING SO WILL DAMAGE THE TRANSDUCER AND VOID WARRANTY.

ProteCT™ Current Transformers can be installed on a live conductor if absolutely necessary. We highly recommend that you turn off power before installing the ProteCT to reduce the chance of accidental shock.

Verify that the ProteCT amp rating is equal to or slightly greater than the maximum amperage the conductor will carry. Proper ProteCT selection is important for instrument accuracy. Contact NK Technologies if you have any questions.

The ProteCT split core design makes installation easy. The side opposite the wire leads is marked with the amperage rating and is removable. Pull off this side, place the sensor over the conductor and snap the sensor back together. Do not force since the connection is keyed. Keep the mating surfaces clean as dirt or grit can affect accuracy.

ProteCT current transformers have low voltage outputs (0 - 0.333V) that reduces the likelihood of electric shocks. Unlike traditional Current Output CTs (100:5, 200:5, etc.) ProteCTs do not produce dangerous voltages when their leads are opened.

Use shielded, twisted wire, 16-22 AWG. Wire lengths up to 500 feet will not affect accuracy. Using unshielded wire may cause accuracy problems.

Three Phase Loads

Connect each ProteCT's pair of wires to a pair of terminals labeled "C.T.1, C.T.2, and C.T.3 as listed below and shown on Figure 1, Page 6.

Default Phase Relationships

Phase	Voltage Input Wire	CT Input Terminals*
L1	BROWN	CT1
L2	ORANGE	CT2
L3	YELLOW	CT3
Neutral**	WHITE	N/A

* Install ProteCT with LABEL to LINE (Source) and WHITE wire on TOP Terminal

** If Present. For 3 wire systems, safe off white wire.

Single Phase Loads

Connect one ProteCT's leads to the pair of terminals labeled "C.T. 1"as listed below and shown on Figure 2, Page 6.

Default Phase Relationships

Phase	Voltage Input Wire	CT Input Terminals*
HOT	BROWN	CT1
Neutral	ORANGE & WHITE	N/A

* Install ProteCT with LABEL to LINE (Source) and WHITE wire on TOP Terminal

MODELS WITH "-5A" CT Input 5 Amp Output CTs Only

DANGER ! ! RISK OF PERSONAL INJURY !

1. **Do not turn on the monitored power (CT Primary) until the CT output (CT Secondary) has been wired and connected to the APN-MOD.**
2. **Do not connect the CT Secondary to the APN-MOD while the Primary is under load.**
3. **Never open the secondary of any Current Output type CT while the primary is under load.**

FAILURE TO OBSERVE THESE WARNINGS CAN CAUSE PERSONAL INJURY, INSTRUMENT DAMAGE AND VOID WARRANTY.

Current Output CTs (also called Ratio:5) should not be installed on a live conductor. Turn off power before installing the CT to reduce the chance of accidental shock. Verify that the CT amp rating (first number in the ratio) is equal to or slightly greater than the maximum amperage the conductor will carry. Proper CT selection is important for instrument accuracy. Contact NK Technologies if you have any questions.

To install a CT, turn off and lock out power to all phases. For solid core CTs, thread the power wires through the center aperture. For split core CTs, take apart the removable leg of the CT, place the sensor over the conductor and gently snap the sensor back together. Be careful to keep the mating surfaces clean. Dirt or grit on the mating surfaces can affect accuracy.

Three Phase Loads

Connect CT output to a pair of terminals labeled "C.T.1, C.T.2, and C.T.3 as listed below and shown on Figure 1, Page 6.

Default Phase Relationship

Phase	Voltage Input Wire	CT Input Terminals*
L1	BROWN	CT1
L2	ORANGE	CT2
L3	YELLOW	CT3
Neutral**	WHITE	N/A

* Install CT with LABEL or H1 side to LINE (Source) and WHITE wire (X1) on TOP Terminal.

** If Present. For 3 wire systems, safe off white wire.

Single Phase Loads

Connect one CT's leads to the pair of terminals labeled "C.T. 1"as listed below and shown on Figure 2, Page 6.

Default Phase Relationship

Phase	Voltage Input Wire	CT Input Terminals*
HOT	BROWN	CT1
Neutral	ORANGE & WHITE	N/A

* Install CT with LABEL to LINE (Source) and WHITE wire (X1) on TOP Terminal.

Wire Size, Type & Lead Length

Use stranded wire rated for the expected voltages. Size wire based on local code, CT's allowable burden or lead length, which ever gives the largest wire size. Burden is the total opposition to flow of current on a transformer secondary. It is generally expressed as VA on CT data sheets. Use the table below to determine minimum wire sizes for 5A output CT. Lead length is the *total* wire run (out and back), Always use copper conductors.

Maximum Lead Length in Feet

CT Burden		Wire Size, Copper AWG			
VA	Ohms[1]	16	14	12	10
1	0.04	8	12	20	31
2	0.08	15	25	39	62
3	0.12	23	37	59	93
4	0.16	30	49	78	124
5	0.20	38	61	98	155
7.5	0.3	57	92	146	233
10	0.40	76	123	195	310
15	0.60	113	184	293	465
20	0.80	151	245	390	620
30	1.2	227	368	585	930
40	1.6	302	491	780	1,240
50	2.0	378	613	976	1,550

[1] VA expressed as Ohms with 5 amp current flow

Step 3: Connect the Voltage Inputs

Connect the APN-MOD Transducer to the same power source that the CTs are sensing. Please note that the APN-MOD is powered from the power it is monitoring.

Follow all local codes for high voltage connections. The APN-MOD has internal fuses so external fusing may not be required. Check with local code authorities to be sure. We recommend providing some means of disconnecting power to allow for future service. This can be a circuit breaker or disconnect switch. Make all connections with code approved connectors or on a terminal strip rated for the appropriate voltage.

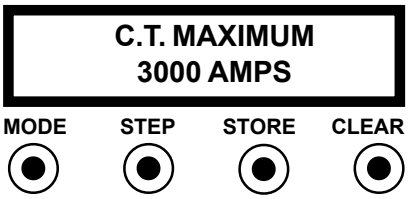
For Connection details, see Step 2 above and Figures 1 and 2 on Page 5.

All your wiring should be installed and tested. Check that all connections are tight and that all local codes have been followed.

Using The Programing Buttons
Press one button at a time. Hold the button down until the LCD display changes. This may take up to one second.

Apply power to the APN-MOD.
Once power is applied, the LCD will display the instantaneous kW and the accumulated kWH. The numbers you see may be different than in this illustration but the LCD format will be the same.

Program the CT Amp Rating
Press the **MODE** button until the LCD displays "C.T. MAXIMUM" like this:



Now press and hold the STEP button until the LCD displays the amp rating of the CTs you are using. Release the button. Check that the correct amp rating is being displayed. Press the STORE button until the screen looks like this:

The CT Amp rating is now stored in nonvolatile memory.

Check the Maximum Watts
Press the MODE button until "MAXIMUM WATTS" is displayed. The APN-MOD calculates MAXIMUM WATTS from the CT amperage and the nominal applied voltage. The MAXIMUM WATTS value is not affected by fluctuating input voltage. The MAXIMUM WATTS value determines the span of the kW outputs. Use this value to calibrate your analog input.

If You Want To Clear The kWH Total
Press the MODE button until the LCD displays kW and kWH. Press the CLEAR button until the kWH value becomes 000000.00. You have reset the kWH to zero. The APN-MOD now begins a new accumulation of kWH.

AutoPhase Programming

In the event of incorrect wiring -- CT polarity reversal and/or phase mismatch -- the patented AutoPhase feature will sort the voltage and current signals internally, so no rewiring is necessary.

IMPORTANT: In order for the Autophase feature to work properly, the internal microprocessor will require adequate signal amplitude to sort the signals. A minimum of 7% of the full scale CT value is needed. For example, if 100A CT's are used, a load of at least 7A on each phase is needed to perform the AutoPhase function.

Press the **MODE** button until "AUTOPHASE NOW" is displayed.

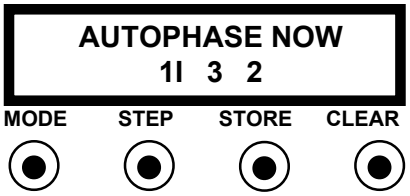
To perform the AutoPhase function, simply press the **STEP** button. The display will briefly show "WORKING..." while the signals are being sorted.

When the microprocessor has completed the sorting, the information is stored in nonvolatile memory. The display will then show how the unit was actually wired. Because the information is stored in nonvolatile memory, the APN will retain this information even on loss of power to the transducer.

AutoPhase Programming cont.

How to Determine Phase Arrangements:

The numbers displayed provide information on how the



APN was actually wired.

The position indicates the voltage phase:

Left - Corresponds to the BROWN lead
Middle - Corresponds to the ORANGE lead
Right - Corresponds to the YELLOW lead

The number itself represents the actual CT number. If an "I" appears next to a number, the APN has determined that a polarity reversal exists on that particular CT.

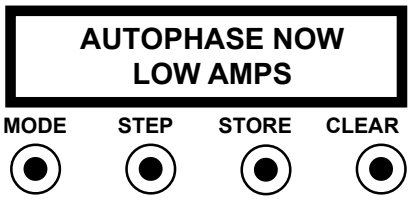
The display example above shows "1I 3 2." This indicates that the BROWN lead is matched with CT1 with CT1 reversed; the ORANGE lead is matched with CT3; the YELLOW lead is matched with CT2.

When the APN is shipped from the factory, the default phase relationship is set to "1 2 3." This means that BROWN, ORANGE, AND YELLOW are matched with CTs 1, 2, and 3, respectively. **PRESSING THE CLEAR BUTTON WILL CHANGE THE SETTING BACK TO THE DEFAULT PHASE RELATIONSHIP. ANY PREVIOUS PHASE MATCH-UPS WILL BE LOST.**

Low Amps Error Message:

If the load is such that the current is below the 7% threshold, the unit will display "LOW AMPS" when attempting to acitvate the AutoPhase function. The unit will revert back to the previous phase relationship last stored in memory.

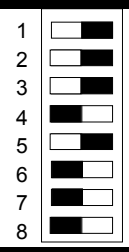
Wait until there is sufficient load before attempting to activate the AutoPhase function again.



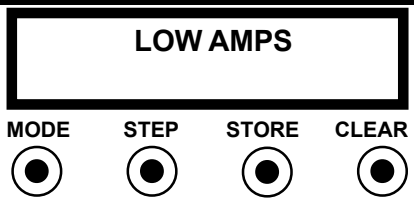
Setting Node Address

The node address is set through series of eight dip-switches allowing a possible address range of 1-247. After converting your decimal address to binary either by hand or with a calculator you can set the dip-switches by flicking them to “ON” for a binary 1 or “OFF” for a binary 0. As an example, the illustration on the right shows the address set at the decimal value of 23 or the binary value 00010111.

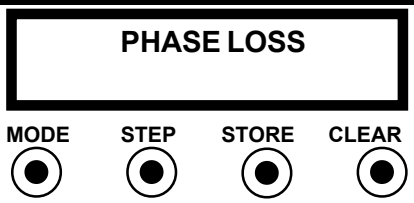
Note that the switch reads from top to bottom.



Error Messages



The amperage input is too low for AutoPhase to determine the correct phase relationships. AutoPhase needs at least 5% of the CT amp rating.



In three phase configuration, one voltage phase has been lost.

Status LEDs

Status LEDs
The APN-MOD has three status LEDs that let you know how the unit is working.

Network Activity
This LED flashes during normal communication sessions with the APN-MOD

On Line
This LED is on when the APN-MOD is on line.

Wattmeter Access
This indicates normal internal communication by blinking every 5 seconds.

Figure 1: Three Phase Wiring

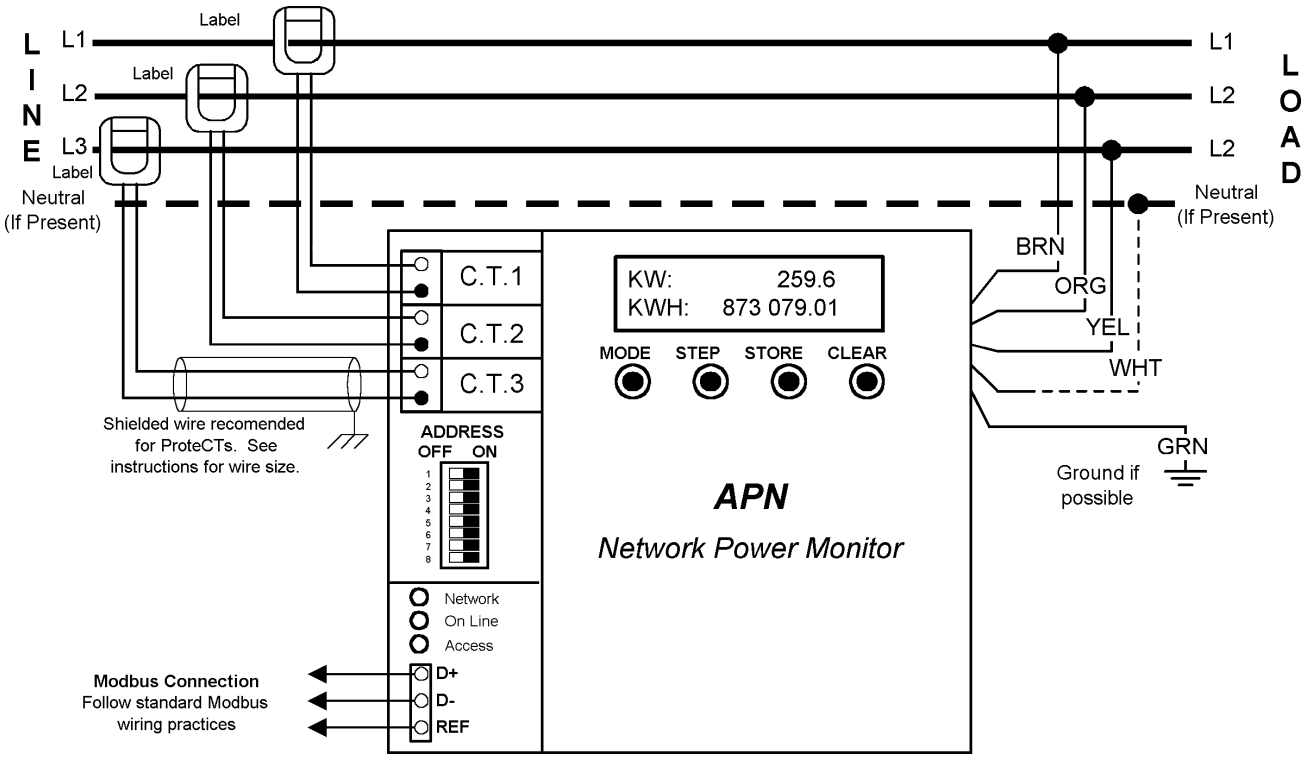
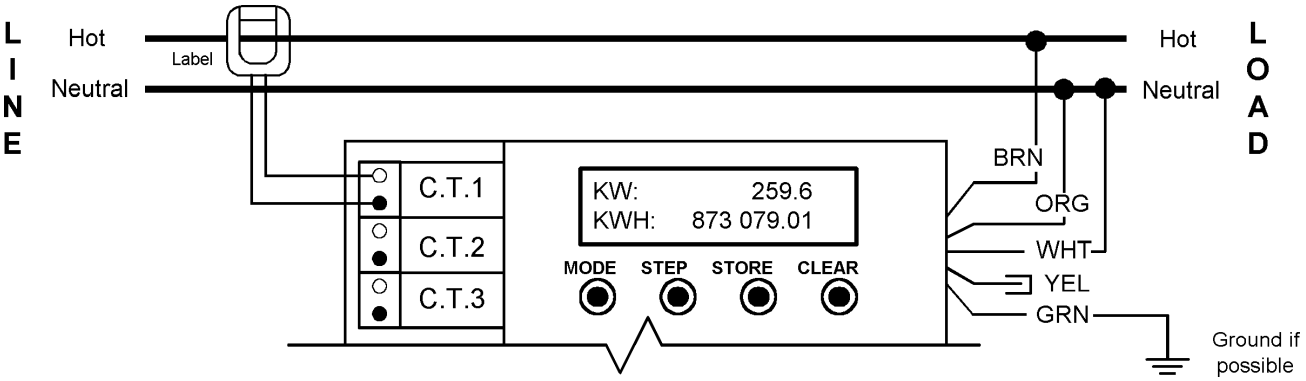


Figure 1: Single Phase Wiring



*See **Figure 2 "Three Phase Wiring"** for Network Connection*

Useful Formulas

A. To find AMPS if KW or KVA are known:

1ϕ: $I = \frac{kW \times 1000}{E \times pf}$ 3ϕ: $I = \frac{kW \times 1000}{E \times pf \times 1.73}$

B. To find KW if AMPERAGE is known:

1ϕ: $kW = \frac{E \times I \times pf}{1000}$ 3ϕ: $kW = \frac{E \times I \times 1.73 \times pf}{1000}$

Where:
E= Volts,
I = Amperes,
kW = Kilo Watts
pf = Power Factor (use 1.0 for sizing purposes)
kVA = kW x pf

* APN, AutoPhase and ProteCT are Trade Marks of NK Technologies, Inc.

Voltage Inputs	208, 480 & 600 VAC, 50 or 60 HZ, Automatic selection Consult Factory for 240 VAC/ 1 phase
Connection	Five # 18 AWG leads, pre-stripped and tinned, 12 " long
Isolation Voltage	3,750 VAC
Current Inputs	"-PC" Option: 0-0.333 VAC (ProteCT Only) "-5A" Option: 0-5 ACA (Standard 5A output CTs)
Connections	Captive screw terminal blocks, accept # 16-22 AWG wire (Current inputs and network connection)

Dimensions	
Module	9.0"H x 6.5"W x 2.3" D (22.9 x 16.5 x 5.3 CM)
NEMA1 Enclosure	10"H x 10.0"W x 4" D (26 x 26 x 10 CM)
Environmental Conditions	
Temperature	-18 to 50 C, 0 to 122 F
Humidity	0-95% RH, Non condensing
Altitude	0-2000 Meters, 0-6,500 feet
Installation	Overvoltage Category II
Pollution	Pollution Degree 2

MODBUS Communication

COMMUNICATIONS The APN-MOD communicates in RTU mode. Communications are set for 9600 baud, 8 data bits, 1 stop bit and no parity.

ADDRESS SELECTION The APN-MOD uses an eight position dip switch to assign a network address. Note that slave addresses are valid from 1 to 247. If the address is not within this range, the unit will turn itself off-line and will not respond to network activity.

MODBUS Function Codes, slave commands and support indication. If a non-supported command is sent to the APN-MOD, the APN responds with an exception.

Code	Name	Supported
01	Read Coil Status	N
02	Read Input Status	N
03	Read Holding Registers	Y
04	Read Input Registers	N
05	Force Single Coil	N
06	Preset Single Register	N
07	Read Exception Status	N
08	Diagnostics	Y
09	Program 484	N
10	Poll 484	N
11	Fetch Comm Event Counter	Y
12	Fetch Comm Event Log	N
13	Program Controller	N
14	Poll Controller	N
15	Force Multiple Coils	N
16	Preset Multiple Coils	N
17	Report Slave ID	Y
18	Program 884/M84	N
19	Reset Comm Link	N
20	Read General Reference	N
21	Write General Reference	N
22	Mask Write 4x Register	N
23	Read/Write 4x Registers	N
24	Read FIFO Queue	N

Diagnostic Codes (Function Code 08) Diagnostic sub-function codes supported in the APN.

Sub-Code	Name	Supported
00 00	Return Query Data	Y
00 01	Restart Communications	Y
00 02	Return Diagnostic Register	N
00 03	Change ASCII Input Delimiter	N
00 04	Force Listen Mode	Y
00 05	Reserved	N
00 06	Reserved	N
00 07	Reserved	N
00 08	Reserved	N
00 09	Reserved	N
00 10	Clear Ctrs and Diagnostic Register	Y
00 11	Return Bus Message Count	Y
00 12	Return Bus Comm. Error Count	Y
00 13	Return Bus Exception Error Count	Y
00 14	Return Slave Message Count	Y
00 15	Return Slave No Response Count	N
00 16	Return Slave NAK Count	N
00 17	Return Slave Busy Count	N
00 18	Return Bus Character Overrun Count	N
00 19	Return Overrun Error Count	N
00 20	Clear Overrun Counter and Flag	N
00 21	Get/Clear Modbus Plus Statistics	N
00 22+	Reserved	N

Report Slave ID (Function Code 17) showing the responses for the report slave ID command.

Field Name	Name
Slave Address	Echo slave address
Function	11h
Byte Count	1Dh
Slave ID	FFh
Run Indicator	FFh
Model Number	10 bytes
Wattmeter Code Version	8 bytes
Wattmeter PCB Revision	4 bytes
Wattmeter Serial Number	5 bytes
Error Check	CRC

APN-MOD Holding Register Locations. All data is stored in locations set up as numeric quantities and are also mirrored in additional locations as packed BCD (see table below).

Holding Register (4x)	Value	Units	Range	Numeric Type	# Bytes
0000	Phase 1 Volts	True RMS Volts	0 to 700V	Floating Point	4
0002	Phase 2 Volts	True RMS Volts	0 to 700V	Floating Point	4
0004	Phase 3 Volts	True RMS Volts	0 to 700V	Floating Point	4
0006	Phase 1 Current	True RMS Amps	000.00 to 9999.9	Floating Point	4
0008	Phase 2 Current	True RMS Amps	000.00 to 9999.9	Floating Point	4
0010	Phase 3 Current	True RMS Amps	000.00 to 9999.9	Floating Point	4
0012	Kilowatts Phase 1	kW	000.00 to 9999.9	Floating Point	4
0014	Kilowatts Phase 2	kW	000.00 to 9999.9	Floating Point	4
0016	Kilowatts Phase 3	kW	000.00 to 9999.9	Floating Point	4
0018	Kilowatts Total	kW	000.00 to 9999.9	Floating Point	4
0020	Kilowatt-Hours	kWh	000000.00 to 999999.99	Floating Point	4
0022	Volt-Amps Phase 1	kVA	000.00 to 9999.9	Floating Point	4
0024	Volt-Amps Phase 2	kVA	000.00 to 9999.9	Floating Point	4
0026	Volt-Amps Phase 3	kVA	000.00 to 9999.9	Floating Point	4
0028	Volt-Amps Total	kVA	000.00 to 9999.9	Floating Point	4
0030	Volt-Amp Hours	kVAh	000000.00 to 999999.99	Floating Point	4
0032	Power Factor Phase 1	None	0.5000 to 1.0000	Floating Point	4
0034	Power Factor Phase 2	None	0.5000 to 1.0000	Floating Point	4
0036	Power Factor Phase 3	None	0.5000 to 1.0000	Floating Point	4
0038	Total Power Factor	None	0.5000 to 1.0000	Floating Point	4
0040	Frequency Phase 1	Hz	45.00 to 80.00	Floating Point	4
0042	Frequency Phase 2	Hz	45.00 to 80.00	Floating Point	4
0044	Frequency Phase 3	Hz	45.00 to 80.00	Floating Point	4
0046	CT Ratio	Amps : 5	5 to 30000	Integer	2
0047	Under Volt Alarm Set'g		Bit Definitions	Integer	2
0048	KWH per pulse Setting		Bit Definitions	Integer	2

Holding Register - Packed BCD Values for systems that do not support floating point math. Each "packed BCD" register is held in two consecutive holding registers for a total length of 4 bytes. For those values that contain a decimal point, a "D" is inserted into the "packed BCD" string to indicate the location of the decimal point. Example:, Phase 1 Current = 63.25 Amps, the byte string returned would be (reg 55)00 06 (reg 56)3D 25.

Holding Register (4x)	Value	Units	Range	Numeric Type	# Bytes
0049	Phase 1 Volts	True RMS Volts	0 to 700V	"Packed BCD"	4
0051	Phase 2 Volts	True RMS Volts	0 to 700V	"Packed BCD"	4
0053	Phase 3 Volts	True RMS Volts	0 to 700V	"Packed BCD"	4
0055	Phase 1 Current	True RMS Amps	000.00 to 9999.9	"Packed BCD"	4
0057	Phase 2 Current	True RMS Amps	000.00 to 9999.9	"Packed BCD"	4
0059	Phase 3 Current	True RMS Amps	000.00 to 9999.9	"Packed BCD"	4
0061	Kilowatts Phase 1	kW	000.00 to 9999.9	"Packed BCD"	4
0063	Kilowatts Phase 2	kW	000.00 to 9999.9	"Packed BCD"	4
0065	Kilowatts Phase 3	kW	000.00 to 9999.9	"Packed BCD"	4
0067	Kilowatts Total	kW	000.00 to 9999.9	"Packed BCD"	4
0069	Kilowatt-Hours	kWh	000000.00 to 999999.99	"Packed BCD"	4
0071	Volt-Amps Phase 1	kVA	000.00 to 9999.9	"Packed BCD"	4
0073	Volt-Amps Phase 2	kVA	000.00 to 9999.9	"Packed BCD"	4
0075	Volt-Amps Phase 3	kVA	000.00 to 9999.9	"Packed BCD"	4
0077	Volt-Amps Total	kVA	000.00 to 9999.9	"Packed BCD"	4
0079	Volt-Amp Hours	kVAh	000000.00 to 999999.99	"Packed BCD"	4
0081	Power Factor Phase 1	None	0.5000 to 1.0000	"Packed BCD"	4
0083	Power Factor Phase 2	None	0.5000 to 1.0000	"Packed BCD"	4
0085	Power Factor Phase 3	None	0.5000 to 1.0000	"Packed BCD"	4
0087	Total Power Factor	None	0.5000 to 1.0000	"Packed BCD"	4
0089	Frequency Phase 1	Hz	45.00 to 80.00	"Packed BCD"	4
0091	Frequency Phase 2	Hz	45.00 to 80.00	"Packed BCD"	4
0093	Frequency Phase 3	Hz	45.00 to 80.00	"Packed BCD"	4
0095	CT Ratio	Amps : 5	5 to 30000	"Packed BCD"	4
0097	Under Volt Alarm Set'g		Bit Definitions	Byte	4
0099	KWH per pulse Setting		Bit Definitions	Byte	4