ENERNET
Corporation

Model K20
Power Measurement Recorder System

PRODUCT DESCRIPTION
and Specifications

TECHNICAL OPERATORS MANUAL
Connection Diagrams

November 1996

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Revised 11/96

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MODEL K20 POWER MEASUREMENT SYSTEM

TECHNICAL MANUAL

1.0 PRODUCT DESCRIPTION

The model K20 family of meter/recorders consists of integrated power measurement and data recording instruments. Used extensively by electric utilities to accurately and comprehensively measure and record AC electrical energy, the K20 is ideal for residential, commercial and industrial electric power metering applications, as well as measuring parameters such as temperature, flow and status.

The model K20-4 provides 16 channels of true RMS power measurement: Volts, Amps, Watts, kVA, kWh, kVAh and waveforms. In addition, the K20-4 provides 15 analog and 16 digital or pulse input channels, such as contact closures, electric utility pulse initiating meters, gas utility meters, and flowmeters, plus 8 digital output control channels. The smaller K20-3 recorder, provides 8 power, 8 analog, 8 digital input and 4 digital output channels. Data is stored in nonvolatile memory and can be accessed locally, or via modem. Memory is expandable from 128K to 1M bytes. Multiple K20 recorders can be networked together to share a single modem. Each data channel can be viewed in real-time either locally or via modem.

SOFTWARE: PC/AT control and data management application support software is available for the K20 data logger family. In addition, K20 recorders are MV-90® and Synernet™ compatible.

2.0 K20 MOUNTING & POWERING

As a general rule, we recommended the K20 not be mounted in an area which receives prolonged exposure to sunlight or other heat sources. The standard enclosure is rated for outdoor applications, however, proper weathertight connectors must be used to maintain the enclosures NEMA 4 rating.

2.1 Mounting the K20 Recorder

Select a surface constructed of wood, wall board, concrete or block wall to mount the K20. The area should have sufficient space to accommodate opening the door of the enclosure and associated conduit needed to supply power and signal wiring to and from the recorder.

When mounting the recorder to a concrete or block wall, as well as other surfaces, it is often advisable to mount a back-board of plywood. The back-board can be mounted with four (4) anchors, minimizing the disruption to the wall and making it far easier to mount the recorder enclosure(s), wiring trough, conduit and other instruments. Locate and drill four holes of proper diameter to accommodate the selected fastening device.

Locate and mark the positions where enclosure penetrations are needed to attach conduit or other wiring connectors or grommets. Drill or punch the required holes and install the required fittings. Follow all local and national electrical codes that apply to your installation. Please note that we recommend you bring all wiring in through the bottom of the enclosure. Also, the polycarbonant material of the enclosure may under certain conditions crack when punched. We therefore recommend drilling. A sharp unibit works very well.

2.2 Powering the K20 Recorder

Attach all conduit or wiring accessories and pull wires up into K20 enclosure. Refer to the wiring configuration section drawings for proper termination diagrams.

NOTE:
All K20 terminals are designed for low-voltage only. All high-voltage terminations must be made inside of approved electrical junction enclosures. Only qualified personnel, knowledgeable and familiar with residential/commercial/industrial electrical wiring and associated local and national electrical code should make high-voltage terminations.

YOU SHOULD CAREFULLY VERIFY AC VOLTAGE, CURRENT AND RECORDER SIGNAL WIRING BEFORE APPLYING POWER TO THE K20.

2.3 Connecting Power to the K20

The K20 is powered by a UL listed 24Vac 20VA energy limited power transformer. Using its 1/2" NPT nipple, It can be mounted on a standard junction box (J-box) with all high-voltage wiring done inside the J-box or through the side of a panel. Power transformers can be ordered to accommodate different primary voltages from 120 to 277Vac. It will be stamped or otherwise marked as to the proper primary voltage. This transformer must be powered through some from of switched over current protection such as a fused disconnect or circuit breaker. The 24Vac secondary wires of the transformer are connected to the 24 volt input terminals on the K20 termination board which is mounted on the right-hand side of it's enclosure. The connection is not polarity sensitive.

2.4 Potential Transducer Wiring

A special potential transducer (PT) packaged in a standard 4"X4" J-box is used to bring each electrical phase of an electric service into the K20. This is not done to power the recorder in any way, that is entirely done by the transformer discussed above. The PT is used to form resistive isolation between the main electrical service phases and the K20 and to reduce the high-voltage of the electrical service to low-voltage while preserving phase relationship. Refer to the wiring configuration section drawings for a termination diagram.

You will see that the PT has four (4) termination points labeled A, B, C and N, for high-voltage ac connection and five colored wires leaving from a low-voltage terminal strip. The wires from the PT are color coded to match the industry standard electrical color code as follows:

Black — Phase A
Red — Phase B
Blue — Phase C
White — Neutral
Green — Ground

These wires are connected to the K20 termination board typically in the PT1 location. (See wiring configuration diagrams.) High-voltage wiring is connected to the A, B, C and N terminals typically using the color code stated above. The green wire is bonded to the J-box itself. The PT supplied with the K20 can connect directly to any 120/208/240/277Vac service. A second PT, wired to the PT2 input allows one K20 to make measurements on two separate services. This is an important and unique feature. It is useful for example in commercial buildings where lighting and HVAC is powered from the 277/480 building distribution while receptacle loads are powered from individual step down transformers. PT1 can sample the potential of the 277/480 services and PT2 can be wired to each phase of the 120/208 step down transformer. Any CT or combination of can be related to any phase of either PT1 or PT2 inputs.

2.5 Phase Relationship

The measurement of true power in ac circuits requires the measurement instrument to make successive instantaneous readings of voltage and current on each phase used by a load. Current is measured through the use of Current Transformers which are placed on wires feeding electrical loads of interest (Current Transformers (CT) are discussed in detail in section 4). Many commercial building loads are three phase. To correctly meter, it is necessary to know exactly which phase a CT is on to ensure it is measured relative to that phase in the K20 recorder. In most cases, phases are color coded as above throughout a building. Even so, care must be taken to see that each CT is on a conductor that is traceable to the same phase at the K20 recorder.

3.0 ELECTRIC METERING — THEORY OF OPERATION

(Paste in something that John already has from other writings or other products. Don't get this too technical. This is a users manual not a text book so we only need enough here to help the user understand how to make measurements CTs.)

4.0 CURRENT TRANSFORMERS

The current transformer or transducer (CT) used by the K20 are shunted with built-in resistors. Unlike current output CTs which generate a current, these produce a voltage proportional to the current flowing in the wire the CT is placed around. At full scale current, a K20 CT will produce a 333mV signal. As a result of the built-in shunt, there are a number of advantages which are important to end-use metering. First, they are safe to handle even when the circuit they measure is active. Second, there is no practical limit to the length of signal connection wire used and the wire can be of small gauge. Third, with a fixed and very small burden (built-in shunt), the CT can be made relatively small, allowing their use inside of cramped panels and switch gear.

CTs are available in several styles, Solid core, Split core, and Bus bar split core. Solid core CTs are the least expensive but require the user to disconnect the wire of the circuit to be measured and pass it through the CT. This is often not possible or not advisable for reasons of loads that can not be turned off or wire too large and difficult to work with to consider disconnection. Split core CTs make it very easy to capture loads because the CT actually splits apart so that it can go around a wire or wires and in some fashion snap back together. Split core CTs are by far the most used style of CT in end-use metering work. Bus bar CTs are specially built to go around a bus bar. They are generally rectangular in shape. Although less often used, the bus bar style CT is sometimes the only option.

ENERNET Corporation can supply any style CT and can also provide virtually any custom size both physically and electrically.

4.1 CT Aggregation Techniques

In order to conserve channel capacity, CTs can be wisely used in ways that automatically aggregate like end-use loads. CTs and like end-use circuits can be grouped through three techniques discussed in this section. Each technique is illustrated in the wiring configuration section of this document. The *like phase / like size* rule applies when applying aggregation techniques. This means you must take care to see that each circuit you wish to combine with another is on the same electrical phase and that all CTs you desire to combine are the same ampacity; e.g., you can not connect a 50A CT and a 100A CT together. Diagrams section 8.0 will make these concepts abundantly clear.

4.1.1 Multiple Conductors

Multiple conductors (on the same phase) can be passed through a single CT. The current flowing through each wire combines in the CT with the CT output reflecting the sum. It is often practical to do this within an electrical panel. In the typical panel of a commercial building, circuits are fed out of the top of the panel. Wiring, from the bottom most circuit to the top, follow up the sides of the panel and out the top. In a panel with mixed end-uses, the like phase wires feeding the circuits of interest can be gathered towards the top and passed through individual CTs. A common application example is picking up several lighting circuits in a panel with other non-lighting loads. Figure *x.x* in the wiring configuration section illustrates how to group all of the 'A' phase, 'B' phase and 'C' phase circuits near the top of the panel.

4.1.2 CT's in Series

Sometimes the like end-use loads of interest are not all located in the same panel. When this is the case, CTs can be put in series with the output from one CT connected to be additive with that of another. In the same way as you would do with two or more batteries, connecting the positive terminal of one battery to the negative of the next and so on, you connect the black lead of CT1 to the white lead of CT2 and so on (See figure x.x). Once again, the like phase / like size rule applies. As long as each CT is measuring loads on the same phase, this technique will work. When using this technique, you must keep in mind that the maximum input signal of the K20 recorder is 333mV. Therefore, the sum of all CT's with their respective loads at full scale must added to ≤333mV. For example, if you have four (4) 50A maximum loads you wish to meter, you will need to install 200A CTs on each load to ensure that when they are put in series, the resulting signal, if they are all on at full load, will not exceed 333mV. Obviously, you are giving up some resolution here by using a 200 amp CT to measure a load that can not exceed 50 amps. Good judgment must be used. If your maximum 50 amp load can also go down below 20 amps, you will run the risk of going below the linear range of the CT.

4.1.3 CT's in Parallel

Putting CTs in parallel is another method of load aggregation. This method is used in a similar fashion as the series CT technique above. It is in many ways a cleaner technique from a wiring standpoint and does not require attention to the potential of over ranging the input of the recorder. Paralleling CTs does require attention to certain other detail.

To simply connect the wires from multiple CTs in parallel, the like phase / like size rule applies along with one other rule, *like impedance*. This means simply that you should not have one CT presenting a significantly larger or smaller resistance than any other CT. What does this mean from a practical standpoint? Don't have CT1 with 10 feet of wire connected to CT2 with 100 feet of wire. If you think of each CT as a resistor, your goal is to have each resistor exactly the same. To do this, you should keep all CT wiring the same length and type of wire and you should not mix CT brands. (Manufacturer 'A' will not necessarily use the same size shunt resistor as manufacturer 'B'.) In actual practice, most of the time it is very easy and natural to do this. A typical example of using this method is in inside of a large distribution panel from which several like end-use loads using large gauge cable are fed. The CTs used will likely be in close proximity to each other, very often, the standard eight feet lead length on new CTs will be enough to connect all leads. A single signal cable, probably with three (3) pairs of wires to accommodate three phases, is pulled to the area and all CT leads by phase are connected, white to white leads and black to black. The single cable is then pulled back to the K20 and terminated.

In some cases, though less often, CT signal wires are coming from different locations in a building and therefore are of different length and perhaps are made by different manufactures. In this case, the paralleling technique can still be used with the addition of series resistors in the leads of each CT. Referring to figure x.x in section 8.0, note that we have placed in series with each CT a 10K ohm 1/4 watt 5% resistor. 10K ohms is significantly more resistance than that introduced by the signal wire or the relatively small value built-in resistors used to shunt the CTs. Use this configuration anytime lead lengths are different or it is necessary to mix CT brands.

When configuring the K20 power channels through Parset software supplied with your K20, you must specify the CT rating of each CT input. When paralleling CTs, the effective CT value becomes the sum of all CTs put in parallel. We call this a virtual CT. For example, if you were to put four (4) 50A CTs in parallel, you will have created a virtual CT rating of 200A and that is the value you must specify to the K20. If you had three (3) 50A CTs, the virtual CT value would be 150A and that is the rating you would specify to the K20.

4.2 CT Disaggregation Techniques

The same three techniques we use to aggregate loads through the use of CTs can also be used to disaggreate loads. A common example is when an entire panel is almost completely powering one end-use type with the exception of a few circuits of another end-use type. The methods described below provide a means of getting rid of the unwanted loads within the CT itself.

4.2.1 Multiple Conductors

As we have learned in 4.1.1 above, multiple conductors (on the same phase) can be passed through a single CT. The current flowing through each wire combines in the CT with the CT output reflecting the sum. If the direction of current flow in a wire is opposite that of another, the CT is in effect summing a positive and negative signal. In the case of a panel which is nearly all one end-use except for a few nuisance circuits which you do not want, the Multiple Conductor approach can often be used.

Referring to figure x.x, consider a panel as depicted in that drawing. CTs are snapped on at the mains feeding the panel. With circuits fed out of the top of the panel, the wires feeding the nuisance circuits can be looped around and fed back through the appropriately phased CT at the mains; e.g., 'A' phase nuisance circuit to 'A' phase mains CT etc. Current flowing through the mains is the sum of all the current being fed by all circuits in the panel including the nuisance circuits. By putting the nuisance circuit wires through our CTs in this way, current flowing in those circuits cancel their own contributing *emf* within the mains CT. The CTs on the mains then produce a signal proportional to the current flowing in all of the other circuits except the nuisance circuits.

It is sometimes necessary to extend a nuisance circuit wire so it can reach the CT and be looped. By national electrical code, an electric panel is not to be used as a junction box and therefore technically should have splices or wire-nuts in it. It is usually allowed for short term periods however of a year or even more with the understanding that it will be undone at the completion of a monitoring period. If it is to be permanent, a junction box may be needed on the side of a panel where the circuit wires can be routed and spliced.

4.2.2 CT's in Series

The same effect can be created using the series CT technique. As was previously explained in section 4.1.2, multiple CTs can be wired in series as one would batteries. To subtract the signal of a CT from one or more others, simply orient the CT around the conductor it is to measure in the opposite direction or reverse the leads in the series chain. This is done to solve the same type of situation as described in multiple conductors above. In many cases, wiring in commercial buildings is too large to allow manipulation. Instead, additional CTs allow us to accomplish the same end.

4.2.3 CT's in Parallel

Reversing the orientation of a CT on a conductor will also affect the desired signal subtraction when wiring CTs in parallel. If you would rather, you may reverse the leads to obtain the same result. All other rules and tips given in section 4.1.3 apply to this dissagregation technique.

4.3 Conductor Wrapping

A handy method of improving resolution is wrapping the wire of the circuit to be measured multiple times through the same CT. This technique in effect reduces the CT ratio and can be used to essentially tune the CT to the load or resize the CT if it is inappropriate for the load you wish to measure. For example, suppose you have a 100A CT on hand and the load you would like to meter is approximately 5 amps. Passing the conductor through the 100A CT four (4) times effectively creates a 25A CT. The signal out with 5 amps flowing in the circuit is exactly what it would be if one pass was made through an actual 25A CT.

5.0 ANALOG CHANNELS

Depending on the model being used, the K20 recorder can provide up to 15 single ended analog channels. These channels are very versatile, directly accepting 0 - 5vdc, 4 - 20mA, 1000Ω PRTD, and LM 34/35 IC temperature sensors.

5.1 Instrumentation Power

5.2 Input Channel Type

5.2.1 Standard ±5 Volt Input

5.2.2 LM 34 & 35 Temperature Sensor

5.2.3 1K Ohm PRTD

5.2.4 4-20mA Input

5.2.5 0 - 1.333K Ohm Resistance Input

6.0 PULSE CHANNELS

7.0 VERIFICATION TROUBLE SHOOTING

There is of course any number of reasons why you may have a problem getting your verification numbers to work out. Fortunately, the most common problems are easy to find and correct. The following list of things to check should help you find most of your problems.

1. Recorder is not powered. (Check ON/OFF switch and circuit breaker)
2. Recorder failure. (No Activity Lamp)
3. The load you are monitoring is not on. (Turn it on and attempt to cause it to run in a steady state manner.)
4. Voltage Potentials are not live. (Check circuit breaker or other source of these potentials.)
5. One or more CTs are improperly oriented. (Check that each CT is facing towards the Line. Reorient if incorrect. You can also switch the CT wires at the recorder if reorientation is inconvenient.)
6. One or more CTs are on the wrong phase. (Verify that each CT is properly phased. Proper phasing means that the ‘A’ Phase CT is around the wire that corresponds to the ‘A’ Phase voltage potential wire, ‘B’ Phase CT is around the ‘B’ Phase potential wire and so on — See connection diagrams that follow.)

8.0 CONFIGURATION DRAWINGS

(See attached connection diagrams.)

9.0 TECHNICAL SPECIFICATIONS

FOR MORE INFORMATION CONTACT

E N E R N E T
C o r p o r a t i o n

307 Dewittshire Road, Dewitt, New York 13214

Phone: (315) 449-0839
Fax: (315) 449-3056