PhaseID System

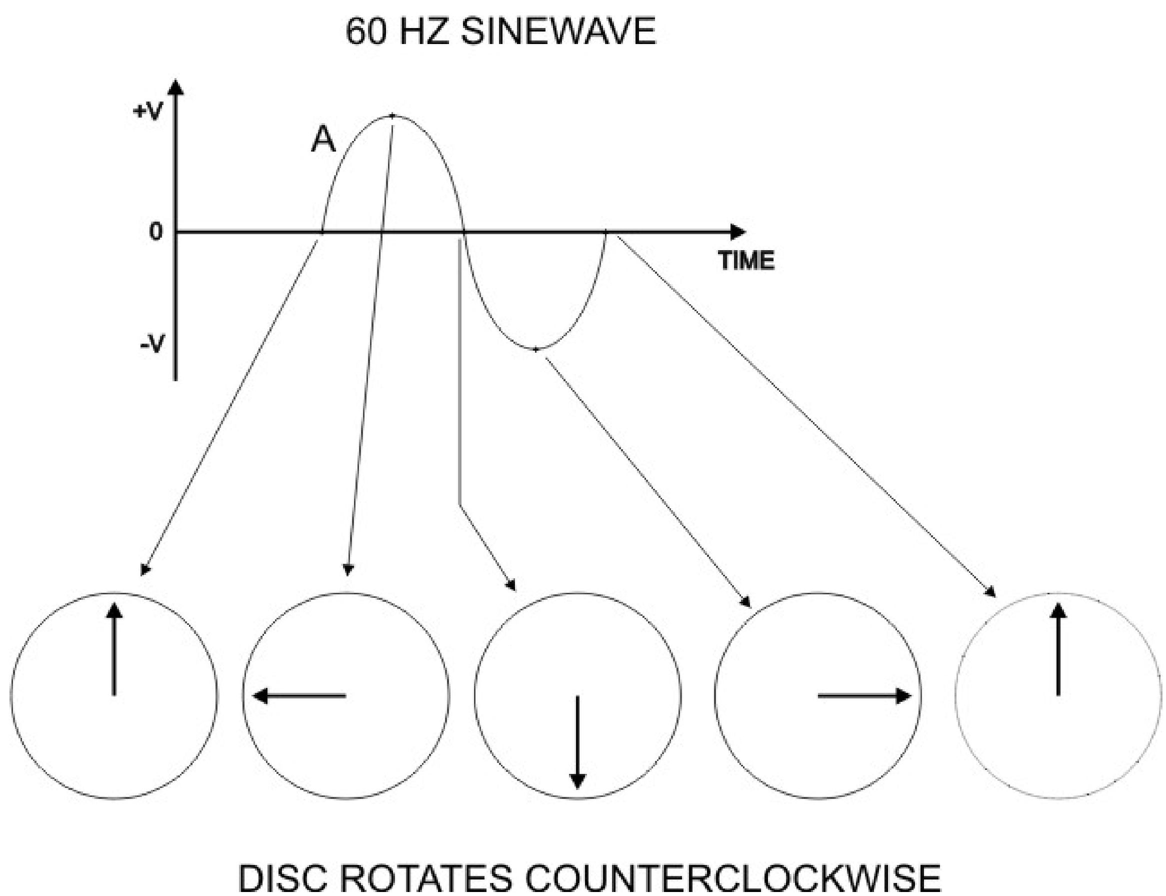
Principal of Operation

The concept behind the PhaseID System is very simple: A timing signal from the Global Positioning System (GPS) is used to simultaneously measure voltage phase at a reference location and at a field location in a 3-phase power system, and the readings are compared. Since the phase attribute at the reference location is known, the phase attribute at the field location can be determined. Here is how it works.

Assume you connect a synchronous motor to phase “A” of a 60 Hz power line. A synchronous motor is one that rotates at the power line frequency, in this case, at 60 revolutions per second or 3600 revolutions per minute (RPM).

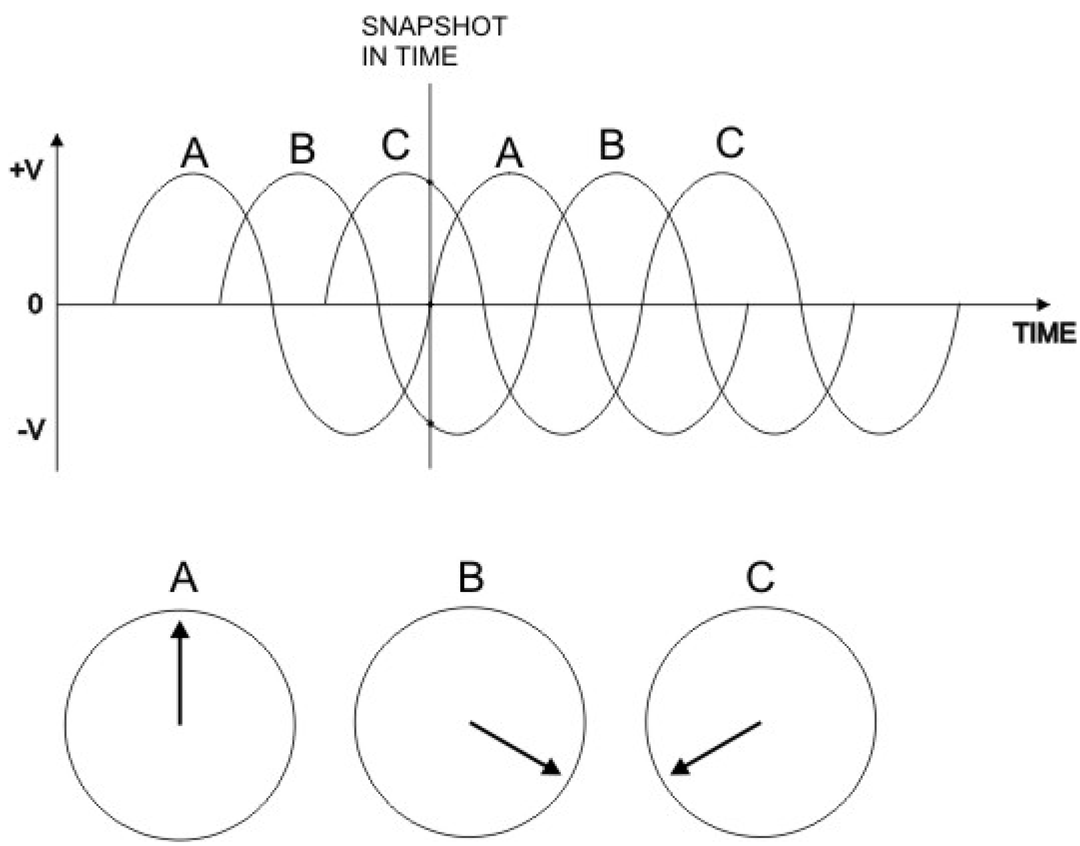
Connect a disc to the motor shaft and draw an arrow on the disc so that the arrow points up when the voltage changes from negative to positive. For each complete voltage cycle, the disc will rotate through 360 degrees as illustrated below.

Figure 1.1



Now take two other identical synchronous motors and connect them at the same location to phases "B" and "C". Use a strobe light or high speed camera to take a snapshot of the orientation of the 3 disc arrows simultaneously as illustrated below. Although the orientation of the phase "A" arrow is completely arbitrary, the orientation of the phase "B" arrow will always be 120 degrees behind the phase "A" arrow. Likewise, the phase "C" arrow will always be 120 degrees behind the phase "B" arrow and 240 degrees behind the phase "A" arrow.

Figure 2.1



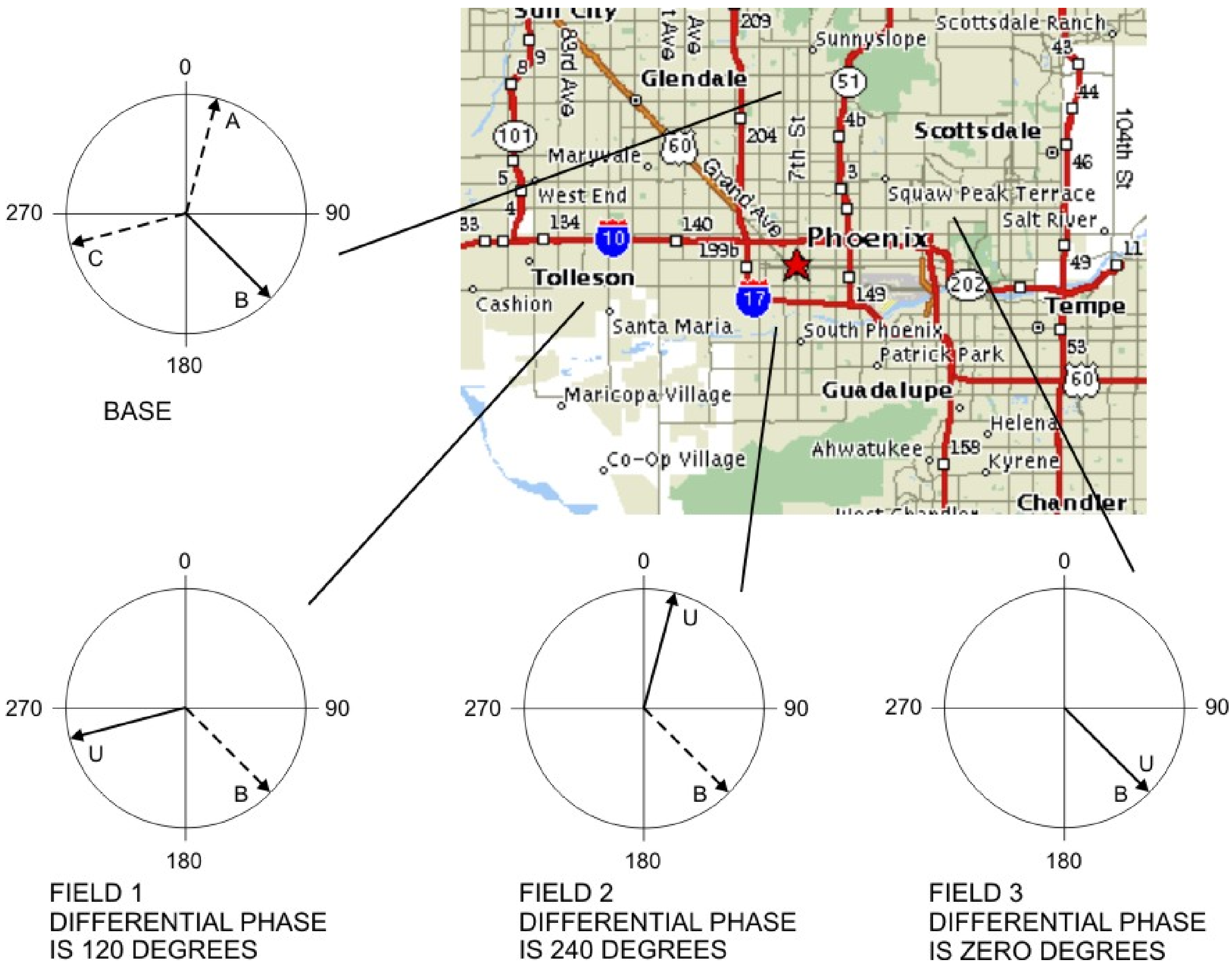
Therefore, if it was known that the reference motor was connected to phase "B", the phase to which a second similar motor was connected could be determined simply by noting the relative orientations of the second motor arrow with respect to the reference motor arrow.

When the two motors are at different locations, a means of obtaining a snapshot of both arrows at the same instant must be provided. In the PhaseID System, a GPS timing signal is used at both the reference and field locations to take the snapshots. Although GPS is usually used only to determine a user's location, once the user's location is known, the GPS can provide a very accurate synchronized timing signal to both users. After the two snapshots are taken at both locations, they only have to be exchanged to determine the unknown phase attribute at the field location.

In the illustration below, the base station (reference motor) is known to be connected to phase “B”. Field motors are connected to unknown phases at 3 different field locations. By taking a snapshot of all 4 disc arrows at the same instant and comparing the field arrow orientations with the base arrow orientation, it is obvious that field 1 is on phase “C”, field 2 is on phase “A”, and field 3 is on phase “B”.

In the PhaseID System, electronic phase measurements are taken instead of actual picture snapshots of arrows on synchronous motor discs. However, the principal of operation is exactly the same.

Figure 3.1



Phase Identification Products

There are currently 3 phase identification products on the market that all use GPS timing signals to simultaneously take phase measurement snapshots at a reference and field location. These 3 systems primarily differ in the manner in which they exchange the reference and field location phase measurement data.

The 2 competing systems use real time cell phone modems to send the reference location phase measurement to the field location where it is compared with the field location phase measurement and the unknown field phase attribute is determined. The PhaseID System takes an entirely different approach. To eliminate the cell phone requirement, the field phase measurement data is displayed to the user, who can then communicate it to the reference location in any convenient manner and time of their choosing. Here is how it works.

At the base station, the reference phase is measured once every GPS second and stored in a file on a computer along with the GPS time at which the phase was measured. The field probe takes a phase measurement at a GPS second as it contacts the line being identified. The phase measurement and GPS time are encoded into a 9-digit sequence and displayed by the probe. The user then communicates this sequence to the base station operator. When the sequence is typed into the computer, the unknown field phase attribute is identified which is then communicated back to the user.

PhaseID System Data Exchange

The PhaseID System unique method of phase data exchange between the base and field units was chosen because it provides the optimum usability of the system. The primary reasons for choosing this data exchange method are listed below.

The PhaseID System does not require a real time data link to operate. Anyone who uses cell phones knows the frustration of busy signals, dropped calls, poor reception, and no cell coverage when making normal phone calls. When a cell modem data link is added to the phone, these problems just get worse because data communications are much more unforgiving than voice communications. The PhaseID System does not require a cell phone or any other real time data link to operate so all these communication problems are eliminated by design.

When phase identifying an entire neighborhood or service section, there is no reason the field probe operator needs to know the phase attributes as they are being measured. With the PhaseID System, the 9-digit sequence can be simply recorded on a measurement form and entered into the base station computer after all measurements are completed. Therefore, no field time is wasted waiting for phase data communications between the reference and field.

When an immediate identification of phase attribute is required, the PhaseID System allows phase data to be communicated with the base in the most appropriate manner. Typically, this will be by radio or cell phone contact with dispatch. However, if the phase measurement is being taken in a deep valley or other location where radio or cell phone communications are not available, the user can simply drive to the top of the hill or move to a different location to call in the 9-digit sequence and receive the unknown phase attribute.

One of the PhaseID System's prime design requirements was to allow the system to be used by lower cost unskilled workers. Placing the phase attribute identification function at the base station allows a smaller, lower cost, and less complicated field probe to be used. Although linemen are required to make primary voltage phase measurements, anyone, including meter readers, can make secondary 120 volt outlet phase measurements. The field probe is operated by a single push button. At the base station, any data entry person can enter the 9-digit field probe sequence. All the phase identification skill resides in the computer software. The base station can service an unlimited number of low cost field probes so it is affordable to acquire as many probes as necessary to get the work done.

The PhaseID System base station can be place in dispatch locations and used by multiple individuals on multiple computers. It does not have to be placed in isolated substations nor is its use restricted to one user at a time. Reference phase data is archived indefinitely. Meter readers can collect phase data during their normal rounds and download it to the base station computer once a day, week, or month.

Phase Attributes Identified

The PhaseID System automatically indicates all 12 possible phase attributes. On primaries, phases A, B, and C are identified. On secondaries, phases are identified as A, -A, B, -B, C, -C, AB, -AB, BC, -BC, CA, or –CA. That is, both the in-phase and-out phase of normal 120 volt service is identified. The two primaries (AB, BC, or CA) feeding delta connected transformer secondaries are also identified.

Field Probe Reference Ground

Voltages are always measured between two points. For phase attribute identification, the voltage must be measured between the line under test and ground. In the PhaseID System, a coiled ground wire and clip is built into the field unit to ensure that phase measurements are always made with respect to ground. In contrast, systems that use a wireless probe must obtain a ground reference via capacitive coupling to earth ground. This is not a problem when measuring an isolated single phase primary because everything else in the measurement environment is ground.

However, what happens in a crowed 3-phase environment in which the probe tip is touching one phase and the probe case is near another phase? In this situation, the probe case will capacitive reference itself to the second phase (or a combination of the second and third phases plus ground) which will give erroneous phase measurements.

Use in Buildings

The PhaseID System uses an advanced GPS receiver that can maintain timing lock with a single GPS satellite in view. It also incorporates a highly stable internal oscillator that allows timing lock to be maintained for up to 5 or 10 minutes when no satellites are available. Therefore, once locked, the field unit will usually maintain lock indefinitely inside most buildings can be used inside totally shielded vaults or buildings for short periods to obtain phase attribute readings.

GPS and Cell Connect Time

The competing phase identification products both require the operator to achieve GPS and cell modem lock before the system can be used. GPS lock times have been reported to be as long as 15 minutes on one of the systems.

The GPS lock time on the PhaseID System field unit is on the order of 1 minute when first turned on for the day. It is on the order of 10 to 20 seconds if the unit had been turned off within the last 2 hours. Also the GPS receiver used is an advanced roving model that will automatically update its timing position, so no lock time is required if the field unit is left on. Its long battery life allows someone who uses the instrument constantly, like a meter reader, to leave the unit on during the entire work day. When left on, phase measurements can be taken immediately at each stop without waiting for GPS lock delays. Of course, no cell phone modem lock time delays are ever required with the PhaseID System.

Phase Identifying Large Areas

Although the PhaseID System will be used by linemen for troubleshooting and maintenance purposes, the real power of the PhaseID System lies in its ability to quickly phase identify an entire utility system. The soon to be introduced small lightweight data logging field probes can be easily carried by meter readers and plugged into any outside 120 volt receptacle, which are usually accessible on nearly every residential or commercial building. Since no GPS or cell lock time is required, obtaining a phase code adds no more than approximately 30 seconds per location to their workload. Once a day, week, or month, the collected data can be downloaded to a special base station computer program which will automatically calculate the phase attribute at every location. As a side benefit, the GPS coordinates of each location are also displayed.

Think about it. If a utility knew which phase (or pair of phases from a delta wired transformer) fed every building in their system, they could probably update their entire phase attribute data base without ever having to probe a HV primary. Thus, maps and data bases can be updated without requiring the skills or expense of linemen or utility engineers. The personnel labor cost savings of this alone will far exceed the price of the PhaseID System.

How to Use the Field Probe

The following is an overview of how to operate the field probe. See the instruction manual supplied with the unit for details.

The field probe is operated by a single push button switch. It has two modes, MEASUREMENT MODE and DISPLAY MODE. To turn on the instrument, press and hold the button for at least 2 seconds and then release it. The instrument will power up in MEASUREMENT MODE. Pressing and holding the push button for at least 2 seconds will turn the instrument off. Pressing, but not holding the push button, will select either HIGH voltage mode or LOW voltage mode.

After a phase measurement is acquired, the instrument will automatically enter DISPLAY MODE. Pressing and holding the push button for at least 2 seconds will return the instrument to MEASUREMENT MODE where either another phase measurement can be taken or the instrument can be turned off.

Pressing, but not holding the push button in DISPLAY MODE, sequences through the 9-digit sequence three digits at a time.

When the instrument is turned on, it starts to look for GPS satellites. As soon as 4 are found, the GPS determines its position and initiates a once a second timing signal. The progress of the satellite search is indicated on the display. When a measurement is ready to be taken, “HI” is indicated on the display. The probe is now set up to take primary voltage phase measurements. Pressing the push button toggles the instrument to display “LO” which indicates the probe is now set up to take secondary phase measurements. Pressing the push button again returns to “HI” mode.

Touching the probe to line voltage illuminates the yellow lamp. The green lamp will blink as phase measurements are taken. When it comes on steady, the phase measurements are completed and the instrument is now in display mode.

Pressing the push button extinguishes the green lamp and displays the first 3-digit sequence code. Pressing it again displays the second 3-digit sequence. The next press gives the third sequence and another press starts over with the first sequence. In this way, the operator can either call in or write down the phase sequence code in groups of 3 digits.

Three adapters are available with the field probe. The bushing pin is used for primary voltage phase measurements, the secondary adapter contains a standard 120 wall plug for secondary voltage phase measurements, and the dead front adapter for primary phase measurements on elbows.

Field Probe Use Above 20KV

Field probe extension resistors can be obtained for use of the field probe above 20KV. However, the field probe can be used successfully on 69KV primaries in some cases by not connecting the ground wire. To use, the ground wire must be securely wrapped around the probe and clipped to its support. Without a ground connection, care must be taken to only take phase measurements where the primaries are widely separated from each other. This usually occurs in substations where the primaries may be separated from each other by 6 to 10 feet or more. If the primaries are close to each other, phase errors will be obtained because the instrument will capacitive reference itself to other phases instead of ground as was explained earlier.

How to Set Up the Base Station

The base station consists of a rooftop antenna, a small coupler box, and the PC software. Standard LAN cable can be used to connect the antenna to the coupler. Origo can supply reasonable lengths of high quality LAN cable certified for outside or in-building use.

To setup the base station, first run LAN cable from an unobstructed rooftop location to your computer location. The antenna should be able to view as much of the sky as possible. If this is not possible, locations on the side of your building, or even next to a window, will work. Strip the ends of the LAN cable and crimp on the supplied spade terminals using pliers at the antenna end as directed in the instruction manual. Strip the LAN cable at the coupler end and insert the wires into the terminal block inside the coupler as directed.

Connect the coupler to the PC serial input using the supplied standard 9-pin D connector cable. Plug the coupler line cord into a 120V wall socket. Install the software onto the PC and the base station is ready to go. Refer to the installation manual for step-by-step details.

How to use the Base Station

Insert the CD into the PC and follow the on-screen instructions to install the base station software. When the program runs the first time, you can select the default setup choices or supply your own. The software asks you to name the directories where the phase data, configuration file, and report files will be stored if you don't accept the defaults.

Since you probably don't know the phase attribute of the wall socket the coupler is plugged into, the software initially assumes the reference is on phase "A". The next step is to go to a substation, or other location where phase attribute is deficiently known, and take a phase measurement with the field probe. Enter the 9-digit field sequence code into the program using the mouse and the phase attribute at the field location will be displayed. If the field location attribute is correct, the reference phase is on "A". If not, refer to the supplied chart to change the base station attribute to the one indicated. It will not have to be changed again unless the phase feeding the base station building wall socket changes. The base station can be on any of the 12 possible phase attributes so buildings served by delta transformers, as well as in-phase and out-phase wall sockets, can be used for reference phase.

The 9-digit field sequence codes are entered into the base station program simply by clicking on the on-screen keypad using the mouse. No typing is ever required to use the program after it has been setup. In addition to the 9-digit sequence, Livefront or Deadfront must be selected depending on whether the field probe obtained its reading touching bare conductors or through the deadfront adapter. Clicking on the Confirm Readback button displays the field probe phase attribute.

If a printed report is desired, the Print Report button can be clicked which will print a page listing the input sequence, the phase attribute, and all significant setup parameters. The report can also be automatically saved in a default file or in a named file of your choice.

If the field probe data was collected earlier, the date the data was collected can be entered using an on-screen calendar. For detailed instructions on how to use the all the features of the base station software, refer to its instruction manual.