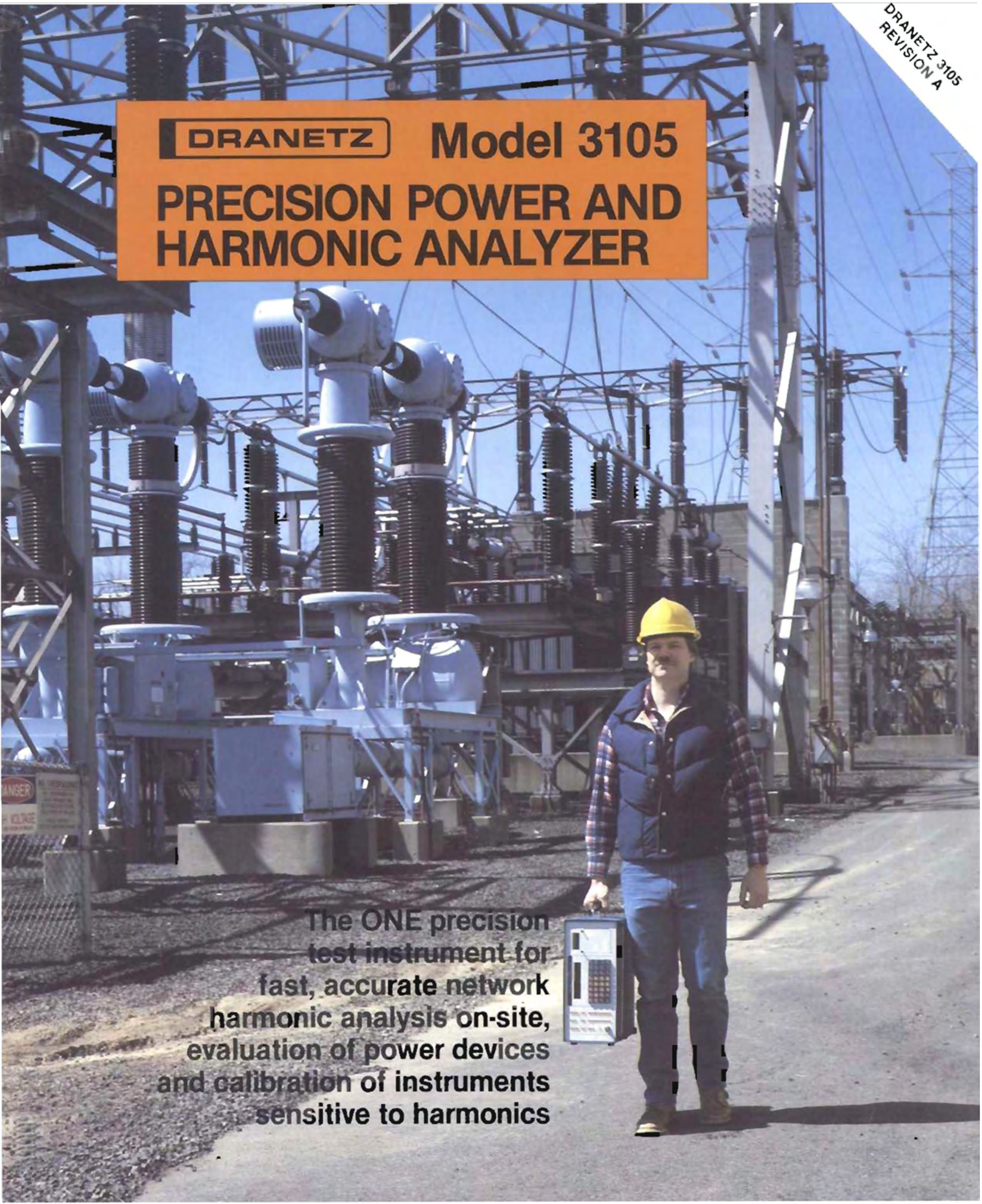
DRANETZ 3105
REVISION A

DRANETZ

# Model 3105

# PRECISION POWER AND HARMONIC ANALYZER



The ONE precision test instrument for fast, accurate network harmonic analysis on-site, evaluation of power devices and calibration of instruments sensitive to harmonics

# PROBLEM: Power System Failure Due To Harmonics

Although a small amount of harmonic distortion in plant and utility power systems has been tolerated for years, the increasing use of non-linear devices of many kinds, in addition to large static power converters, has aggravated the problem of harmonic pollution. In an increasing number of systems the problems can no longer be ignored. Particularly, the variety of waveform distorting SCR controllers in industry at a time when the cost of power is rising has made it more difficult to prevent loss of production, equipment damage and interference with communications systems due to excessive harmonics*.

*At present, there are no uniform U.S. specifications for the amount of harmonic current, voltage distortion or telephone interference allowed from harmonics. IEEE Guide 519(3) recommends a 1.5 – 8% limit depending on power and use. U.K. Recommendation G.5/3(20) limits voltage distortion to 1.5 – 5% for continuous use; for the EEC the limit is 2% or less.

**(see Harmonic Pollution References on rear cover)**

## Are my power or equipment problems caused by harmonics?

In order to determine if a serious harmonic pollution problem exists in a system a combination of a preliminary investigation and experimental or on-site harmonic measurements is needed to determine the answer. Key information relates to your plant equipment.

#1 **Are power system resonances (usually due to power factor correcting capacitors) near a harmonic?** When correcting the power factor of a typical industrial power system to .85 or .90, resonances can occur even up to frequencies as high as 2500 to 3000 Hz, which is in the range of the 50th harmonic of 50 Hz and 60 Hz respectively.

#2 **Is a static converter large with respect to the power system feeding it, i.e., is the system impedance relatively high?** If so, there may be enough power in the harmonics to excite the resonance in the system.

## Common Causes of Excessive Harmonics

Utility rates are structured to minimize power system investment and encourage high power factor loads. The user, therefore, must take responsibility for adding reactance (VARS), usually in the form of relatively economical large power capacitors. Capacitive VARS improve the power factor and thus the efficiency of power use. Capacitors, however, when in parallel with the inductances of motors, transformers, reactors, etc., create a resonance circuit at some frequency. If the resonance frequency is on or near a harmonic generated by a non-linear device such as a static converter, the harmonic current may excite the resonance circuit, which can result in greatly amplified harmonic current. The large current oscillations in turn produce voltages, all of which can cause costly damage, equipment malfunctions and interference.

### Harmonics may be caused by any non-linear load.

Static power converters generate harmonics. They are widely used to control the speed and torque of heavy machines such as:

| | |
|---|---|
| Pumps | Machine tools |
| Fans | Rolling mills |
| Hoists | Oil or gas drill rigs |

Other non-linear devices generating harmonics are:

| | |
|---|---|
| Welders | AC heating controls |
| Arc furnaces | AC and DC motor controllers |
| Fuel cells | Switching or phase-controlled power supplies |
| Discharge lighting | Transformers (near saturation) |
| Battery chargers | |

## Are You Likely To Suffer From Harmonic Problems?

The harmful distortion created by excessive harmonics on a power system is most likely to be found in plants and industries using heavy AC-DC static converters and non-linear motor controllers. These include (but are not limited to):

Electrochemical processors
Mining (mining machinery)
Pulp and paper mills
Printing (large presses)
Electric railroads
Ship propulsion (DC)
Oil and gas drilling
Steel and other rolling mills
Smelting (induction, arc furnaces)
Spinning and weaving

## Typical Warnings of Harmonic Pollution

**Power factor-correcting capacitors rupture,** or their fuses blow repeatedly due to harmonic overcurrent, which causes hot spots. (Constant overvoltage of even 5% can produce dielectric breakdown in a matter of days.)

**Transformers, generators and/or motors fail** due to overheating with high stator, rotor and/or core losses. (Eddy current losses increase as the square of the frequency.)

**Power is repeatedly interrupted** as overcurrents open circuit breakers.

**Drive motors are unstable** due to harmonic torque pulsations.

**Remote control and communication systems are disrupted.**

**Motor controllers, protective relays and computers fail;** thyristor triggering is unstable; Watthour meters, clocks and other electrical/electronic devices become unreliable.

**Power is lost due to heat loss in cables** from higher RMS current and skin effects. (Apparent resistance increases dramatically with frequency.)

**Fluorescent or mercury lighting overheats and fails** due to resonance within its magnetic ballast.

# The 3105 For On-Site Or Lab Harmonic Testing

The Dranetz Model 3105 Precision Power and Harmonic Analyzer is a highly portable instrument, specifically designed to simplify accurate power signal analysis in the laboratory or in the field. It performs 25 different measurements including the analysis of harmonic content up to the 50th harmonic. All measurements and calculations are available in less than one second so that decisions can be made and remedial actions evaluated on the spot.

The instrument is ideal for use virtually anywhere by qualified non-engineering-type personnel. Up to 8 different setups may be stored in memory for ready use. A built-in printer automatically records date and time of each measurement, which can be set to be taken unattended at 15 different times of day or at fixed time intervals, with results stored on an optional external cassette. The unit automatically restarts in its last setup after power interruption. Adjustments are minimal with automatic lock onto frequency and auto-ranging on input voltage. Either or both inputs can be isolated for safety and for elimination of ground loops and interaction with other devices.

The 3105 employs all-digital data processing and is compatible with computer- controlled automatic test systems. The optional IEEE-488 interface has a built-in interpreter mode. This allows the master computer to issue single mnemonic commands, which closely correlate with the the front panel commands, simplifying programming and debugging. Typical commands such as COMPLEX RATIO, POWER, THD and PHASE translate into CMRT, PWR, THD and PHSE. All front panel commands and settings can be remotely controlled via the IEEE-488 interface, giving the master computer complete control. Any one of eight complete sets of pre-programmed setups can be activated by a single computer command.

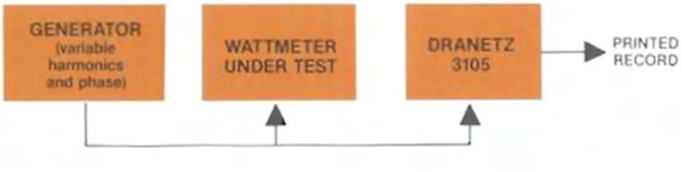
The 3105 calculates, displays and prints any or all of the following important quantities:

| | For each harmonic to 50th | For the fundamental | For the total signal |
|---|---|---|---|
| 1. Total harmonic distortion (THD) | | | • |
| 2. % of fundamental | • | | |
| 3. Phase difference from the fundamental-harmonic phase | • | | |
| 4. Magnitude ($V_{rms}$, $A_{rms}$) | • | • | • |
| 5. Real power (Watts) | • | • | • |
| 6. VA | • | • | |
| 7. VAR | • | • | |
| 8. Power factor (PF) | • | • | |
| 9. Ratio (impedance or admittance) | • | • | • |
| 10. Complex ratio (network impedance) | • | • | |
| 11. Frequency (to ± 0.01 Hz) | | • | |
| 12. Phase between 2 inputs (2 voltages, 2 currents or between V and A) | • | • | |

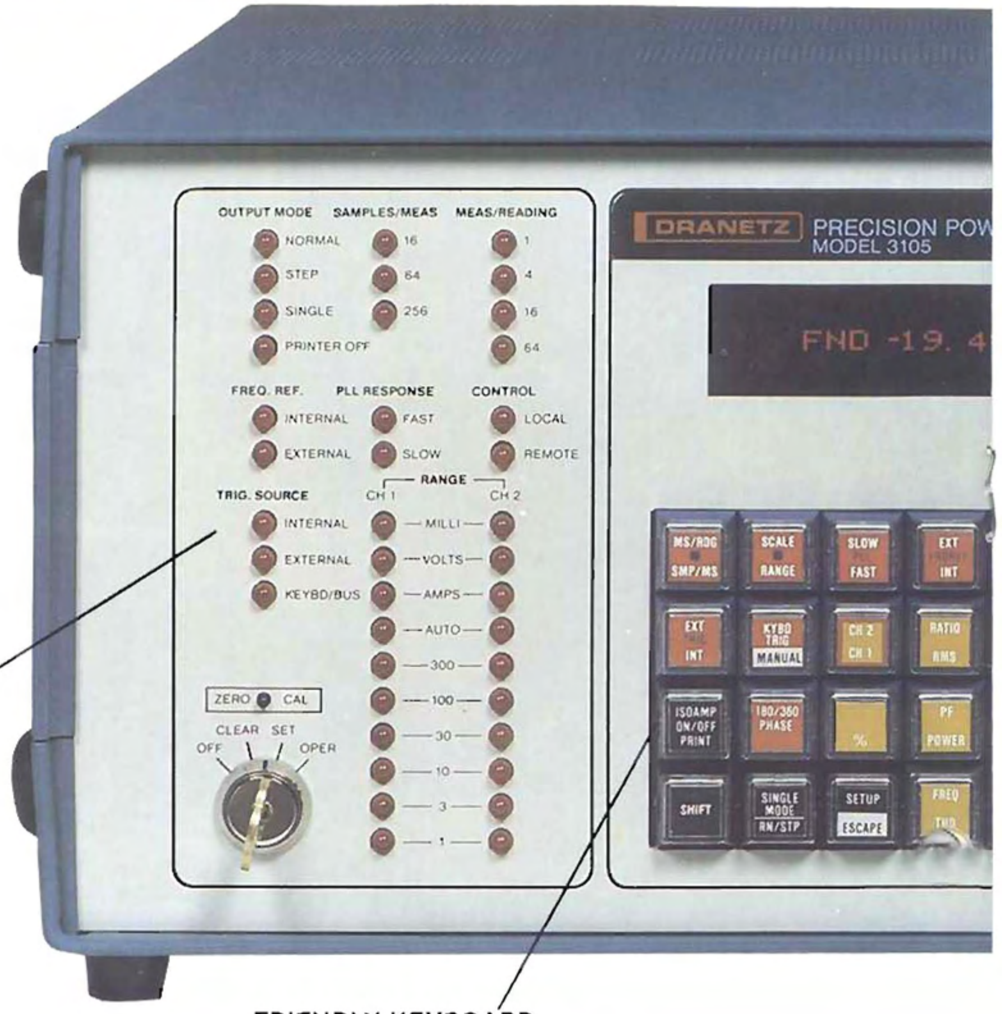
## Wattmeter Calibration

With the rapidly increasing cost of electric power, precision power measurements can mean substantial cost savings to electric utilities as well as to large power users. Watthour meters must, therefore, measure accurately over wide ranges of load and power factor, independent of waveform purity. Phase and harmonic distortion effects must be known to accurately calibrate power meters.

The Model 3105 is an unusual power measuring and calibration instrument, not only because of its precision but because it measures all important parameters simply and directly with the push of a button. Its true mathematical computations provide direct readings of voltage, current, power factor, phase, harmonic distortion and even the real and reactive components. For the first time in one simple, direct-reading unit, the 3105 makes possible the rapid measurement of the power, phase angle and real and imaginery components of each harmonic up to the 50th. Since every type of power measuring device has its own unique response to harmonics, the 3105 can pay for itself by accounting for unmetered power lost in harmonics. It can be used to calibrate power metering instruments directly in the field or used as a secondary standard in the calibration laboratory to insure the accuracy of "rotating" standards. A block diagram of typical meter calibration is shown below:



# The 3105...Fast, Accurate Harmonic and




**SIMPLE INDICATOR PANEL** shows status of the instrument setup at a glance; 8 setups can be stored and recalled by the operator.

**FRIENDLY KEYBOARD** allows single button selection of the measurement to be made and provides a means for numeric entry.

## Highlights of Built-in Flexibility

REPEATABILITY. . . Digital design insures the same accurate results every time. If the signal is particularly noisy, the average of many readings can be used to insure repeatability. Frequency instabilities (jitter) can be smoothed so that a reliable lock on the fundamental can be obtained for consistent measurements, whether using a separate external reference or locking onto the input signal itself.

FAST RESULTS . . . The time needed to collect data can be minimized by matching the sampling time to the number of harmonics of interest. The fewer the harmonics desired, the less time is required.

REMOTE COMMUNICATIONS . . . The 3105 can communicate directly or over a modem with an optional cassette recorder for unattended logging or with a digital computer, controller, TTY or digital printer via a built-in RS-232C interface. (An IEEE-488 interface is available as an option.)

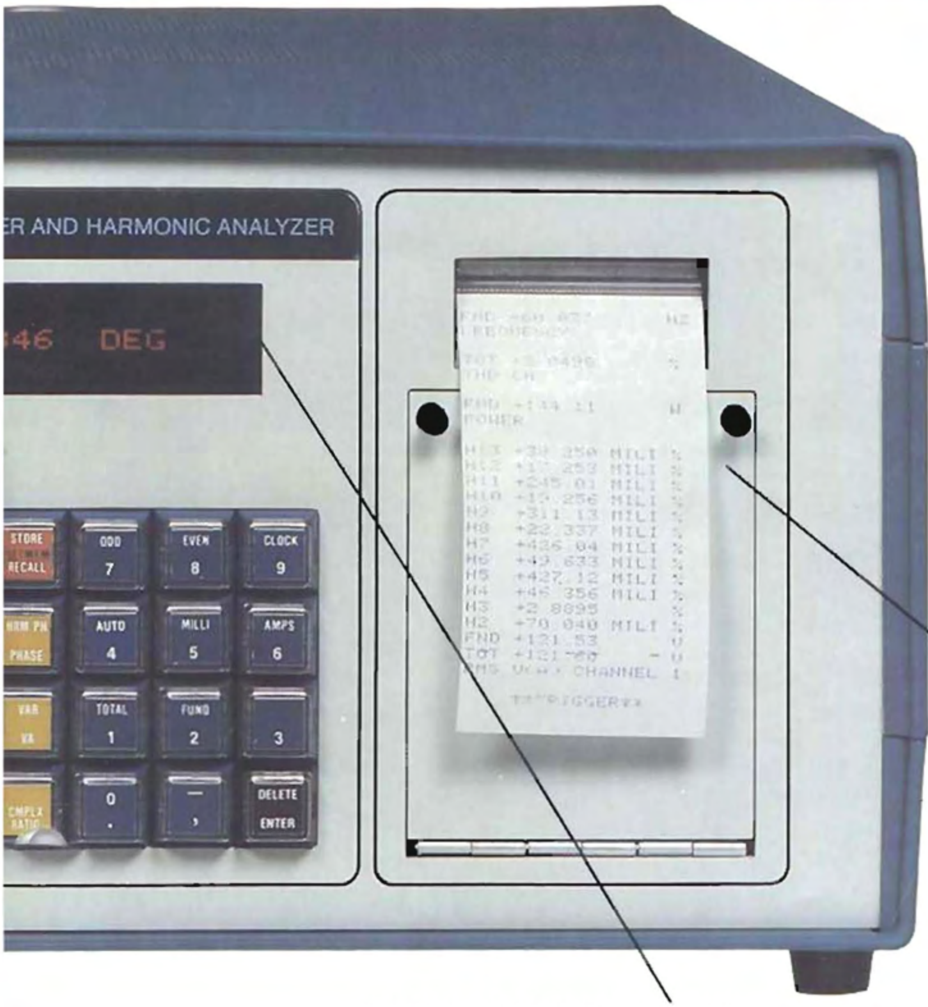
INPUT ADAPTABILITY. . . For on-site power system surveys an isolated input is provided. A non-isolated input is also provided for maximum precision in the laboratory.

## Important Uses

In addition to being ideal for power system harmonic analysis, the 3105 is also flexible enough for effective use in many other applications:

- Power network impedance calculations
- Evaluating harmonics generated by power equipment, power supplies and converters
- Detecting very low level harmonic disturbances that might affect com-

# Power Analysis On-Site or in the Laboratory




**BUILT-IN PRINTER** automatically records a complete set of readings with date and time; can log at 15 different times of the day or at time intervals.

**ILLUMINATED DATA DISPLAY** also provides confirmation during setup, warning messages and guidance during testing.

## For The 3105

munication systems, computers or other sensitive electronic equipment

- Magnetic materials testing
- Calibration and test of Wattmeters and other power instruments, which are affected by harmonics
- Rotating machine health diagnostics through the analysis of vibrational harmonics

## 6 Reasons Why The 3105 Is Best

Although there are other instruments that have been used in the past to perform a few of the simpler measurements or collect data for later computer analysis, the Model 3105 is the only instrument specifically designed for power and harmonic analysis. The 3105 is unique in its ability to perform **all** of the following in a single unit **on-site:**

- Instant calculation of harmonic distortion plus amplitude, percent and phase of each harmonic.
- Calculation of power in Watts, VA or VAR and power factor, as well as network impedance.
- Fast on-the-spot printed records with date and time recorded.
- Unattended logging of any or all parameters at up to 15 preset times or at preset intervals with results recorded on a tape cassette.
- Fast analysis up to the 50th harmonic of all parameters from one run of data.
- Digital precision for reliable, repeatable readings, even with ambient temperature variations.

# Solving problems...

# ...with the 3105

### WHY IS PHASE IMPORTANT IN HARMONIC ANALYSIS?

Phase is necessary to determine the degree of coincidence of the harmonics and the fundamental and thus the resulting total maximum magnitude. Phase is also needed to measure a system's harmonic impedance, i.e. its susceptability to harmonic pollution. In addition, harmonic phase can be used to determine the direction of harmonic current flow, and therefore if its source is within or outside the power user's plant.

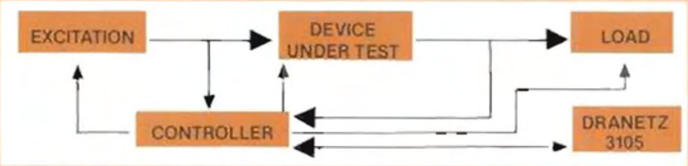
Also, phase difference between channels 1 and 2 for the fundamental and any harmonic is key to measuring power and dissipation, as well as knowing voltage and current without ambiguities.

The phase relation of each harmonic to the fundamental in the same channel as well as its amplitude and percent of the fundamental power is measured by the 3105.

## COMPUTER-CONTROLLED AUTOMATIC TESTING

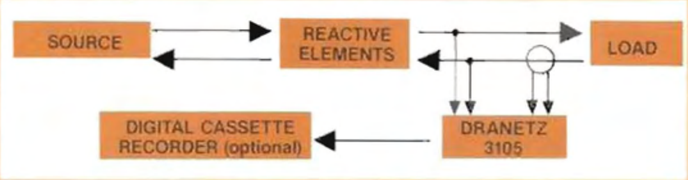
Fast, flexible computer-controlled digital measurement is needed in the automatic testing of power devices. The Model 3105 combines the measurement capabilities of several instruments . . . phase, power, frequency, voltage, current and harmonic distortion . . . in a single, unique, microprocessor-based precision unit with computer interface (RS-232C standard; IEEE-488 optional.)

Typically computer-controlled automatic systems are used in production testing of active or passive power devices, periodic monitoring of power systems or evaluating power generating units. A block diagram of a typical computer-controlled system is shown below:




## LOAD BALANCING

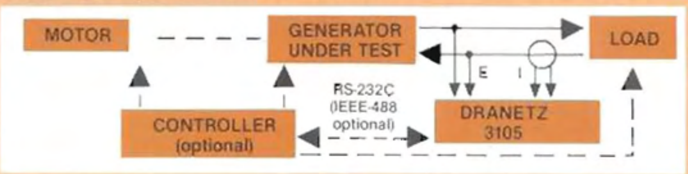
Excessive VARS or reactive power in a system can result in transmitting useless energy and therefore wasting power. Reactive power can be "tuned out" by adding reactive elements . . . capacitive or inductive loads. The 3105 is extremely useful in determining if reactive loads should be added and how large they should be, since it measures VARS directly. Because VARS can vary over time . . . hours, days, weeks . . . due to changing loads, the 3105 can serve as a VARS data logger, calculating and recording readings at as many as 15 different preset times of day or at preset intervals; the date and time of each reading is recorded as well. A typical monitoring system is shown below:




## GENERATOR EVALUATION

The evaluation of power generators prior to or during installation involves the measurement of performance under various conditions. (R&D and production evaluation require similar testing.) Typical tests include open-circuit voltage balance between phases with unbalanced load, open-circuit voltage saturation, efficiency and performance under various continuous and transient loads.

The 3105 is ideally suited for these types of tests. Fast, direct measurement and recording of RMS volts and current, Watts and VARS, phase angle and harmonic content can all be made with the one unit. Phase angle readings are accurate to 0.03°. If testing is under computer control the 3105 interfaces allow it to be used in a "hands off" mode. A typical generator test system is shown below.



# Specifications

## INPUTS:

Number of channels: two

**Isolated input mode:** 4, transformer-isolated, floating connectors for current or voltage; high and low inputs for each channel

**Non-isolated input mode:** 2 identical, arranged high and ground

**Frequency ranges:** isolated - 40 Hz - 3.2 KHz
non-isolated - 1 Hz - 500 KHz

**Amplitude ranges:** isolated - 50 - 500 V; 0.5 - 5A
non-isolated - 1, 3, 10, 30, 100, 300 V or mV

**Auto-range:** either or both input channels automatically select correct voltage range within 3 msec plus 2 × measurement time for each range changed

**Impedance:** isolated - 230 Kohms voltage; 0.02 ohms max. current
non-isolated - 1 megohm in parallel with 100 pf

**Correction factor:** programmable to automatically correct for loading effect of instrument and external potential and current transformers

**Crest factor:** 2.0 max. with full scale input

**Frequency reference:** automatic lock on input signal or ext. reference from 1 Hz to 500 KHz

## MEASUREMENTS:

**Number of harmonics:** up to 50th

**Maximum time per measurement (settable):**
16 samples (to 7th har.) - 1 cycle or 1.4 msec, whichever greater
64 samples (to 31st har.) - 1 cycle or 5.68 msec, whichever greater
256 samples (to 50th har.) - 1 cycle or 22.72 msec, whichever greater

**Analog settling time:** 20 $\mu$sec max. for pulsed sinewave to within rated accuracy (except when auto-ranging)

**Response time (for step change in frequency):**
fast (clean inputs) - 6 × measurement time or 4 msec, whichever greater
slow (noisy inputs) - 60 × measurement time or 40 msec, whichever greater

**Output reading repetition rate:** 4/sec display only; 2/sec for printer; 4/sec for remote output (RS232C or optional IEEE-488)

**Measurement trigger:** keyboard, int., ext. or via optional IEEE-488

## FUNCTIONS:

For each harmonic (ch 1 and/or ch 2):
- % of fundamental V and A
- phase difference from fundamental ($\theta_F - \theta_H$) — harmonic phase

For each harmonic and fundamental (ch 1 and/or ch 2):
- Volts (RMS), Amps (RMS)
- power, VA, VAR
- ratio, complex ratio
- power factor (PF)
- frequency (fundamental only)
- phase difference between ch 1 and ch 2 ($\theta_2 - \theta_1$)

For total signal (ch 1 and ch 2):
- total harmonic distortion (THD)
- power, ratio, Volts (RMS), Amps (RMS)

## KEY FEATURES:

**Real-time clock:** date and time displayed and printed; measurements can be preset for any of 15 times within 24 hours or at preset time interval. 1 hr battery backup to ride through power drop-outs

**Stored setups:** 8 different setups in non-volatile memory

**Auto restart:** unit automatically restarts in the default setup after temporary power loss; real-time clock is not interrupted

**Cassette recording:** automatic recording on cassette deck through standard RS-232C port (unattended operation)

## READOUT:

**Display:** 20 character alphanumeric LED

**Printer:** 20 column alphanumeric, thermal matrix-type strip; unless turned off, automatically reproduces all information on the display

**Interface:** standard RS-232C port (rear panel) for external cassette deck, TTY or digital printer, IEEE-488 optional

## ACCURACY OF MEASUREMENTS:

**FREQUENCY:** ± 0.02% (for fundamental)

**ISOLATED INPUT MAX. ERROR**

AMPLITUDE (V or A) — total, fundamental and harmonic

| (THD <25%) | 47Hz-450Hz | 450Hz-800Hz | 800Hz-2KHz | 2KHz-3KHz |
|---|---|---|---|---|
| ± % F.S. | 0.01 [F.S./input (in V or A)] | | | |
| plus | + | + | + | + |
| ± % reading in V | 0.04% | 0.15% | 0.5% | 1.0% |
| or | or | or | or | or |
| ± % reading in A | 0.05% | 0.15% | 0.5% | 1.0% |

PHASE (Θ) — voltage vs voltage or current vs current

| | | | | |
|---|---|---|---|---|
| ± deg | 0.05° | 0.05° | 0.15° | 0.25° |

VOLTAGE vs CURRENT

| | | | | |
|---|---|---|---|---|
| ± deg | 0.07° | 0.25° | 0.75° | 1.5° |

HARMONIC PHASE (θ)

| | | | | |
|---|---|---|---|---|
| ± deg | 0.15° | 0.5° | 1.0° | 2.0° |

(for harmonic number less than ½ number of samples/measurement)

**NON-ISOLATED INPUT MAX. ERROR:**

AMPLITUDE (V or A) — total, fundamental and harmonic (See Note 1.

| (THD <25%) | 1Hz-5Hz | 5Hz-40 Hz | 40Hz-25kHz | 25KHz-50khz | 50kHZ-100kHz | 100kHz-250kHz | 250kHz-500kHz |
|---|---|---|---|---|---|---|---|
| ±% F.S. | 0.15% | 0.10% | 0.05% | 0.1% | 0.1% | 0.25% | 0.5% |
| plus | + | + | + | + | + | + | + |
| % of reading | 0.10% | 0.05% | 0.05% | 0.4% | 0.4% | 1.0% | 3.0% |

PHASE (θ) — total and fundamental

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ± deg | 0.75° | 0.15° | 0.03° | 0.05° | 0.08° | 0.2° | 0.5° |

HARMONIC PHASE (θ) (See Note 7)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ± deg | 0.75° | 0.2° | 0.1° | 0.15° | 0.2° | 0.4° | 0.75° |

**VA OR AMPLITUDE RATIO MAX. ERROR (%):** $\Delta E$ = sum of % magnitude errors of CH 1 and CH 2

**REAL POWER MAX. ERROR (% VA):** $\Delta E(PF) + 1.75\Theta(1\text{-}PF^2)^{1/2}$; where $\Theta$ = phase error (V vs I) in degrees (above) and PF = power factor

**REACTIVE POWER MAX. ERROR (%VA):** $1.75\Theta(PF) + \Delta E(1\text{-}PF^2)^{1/2}$

## PHYSICAL:

**Size:** 17 in. (43.2 cm) wide × 15.5 in. (39.4 cm) deep × 7 in. (17.8 cm) high; with 3100-RB-2 Kit, height is 10.5 in. (26.67 cm).

**Weight:** approx. 45 lbs (20.5 Kgm)

**Temperature:** 0° to 45°C. operating; −40° to +55°C. storage

**Power:** 90 Watts, 95-130VAC or 190-250VAC (selectable); 47-63Hz

## OPTIONS:

101 — IEEE-488 Bus Interface

3100-RB-2 — RACK MT/COOLING KIT (consists of rack mount adapters, cooling fan assembly and 1.75 in. high blank panel)