
INSTRUCTION BOOK

**THRULINE[®] RF POWER METER MODEL 4421
AND
THRULINE[®] DIRECTIONAL RF POWER SENSORS
4020 SERIES, 4027A SERIES,
4027F SERIES, AND 4028 SERIES**

BIRD[®]

**Electronic Corporation
Cleveland (Solon) Ohio USA**

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Instruction Book Part Number 920-4421 Rev L

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Safety Precautions

The following are general safety precautions that are not necessarily related to any specific part or procedure and do not necessarily appear elsewhere in this publication. These precautions must be thoroughly understood and apply to all phases of operation and maintenance.

Keep Away From Live Circuits

Operating personnel must at all times observe normal safety regulations. Do not replace components or make adjustments inside the equipment with high voltage turned on. To avoid casualties, always remove power.

Shock Hazard

Do not attempt to remove the RF transmission line while RF power is present.

Do Not Service or Adjust Alone

Under no circumstances should any person reach into an enclosure for the purpose of service or adjustment of equipment except in the presence of someone who is capable of rendering aid.

Safety Earth Ground

An uninterruptible earth safety ground must be supplied from the main power source to test instruments. Grounding one conductor of a two conductor power cable is not sufficient protection. Serious injury or death can occur if this grounding is not properly supplied.

Chemical Hazard

Dry cleaning solvents for cleaning parts may be potentially dangerous. Avoid inhalation of fumes or prolonged contact with skin.

Resuscitation

Personnel working with or near high voltages should be familiar with modern methods of resuscitation.

Safety Symbols

WARNING


Warning notes call attention to a procedure which, if not correctly performed, could result in personal injury.

CAUTION

Caution notes call attention to a procedure which, if not correctly performed, could result in damage to the instrument.



The caution symbol appears on the equipment indicating there is important information in the instruction manual regarding that particular area. See pages 2, 6, 45, 47, and page 52 for specific cautions.

 **NOTE:** Calls attention to supplemental information.

Warning Statements

The following safety warnings appear in the text where there is danger to operating and maintenance personnel and are repeated here for emphasis.

WARNING

Never attempt to connect or disconnect RF equipment from the transmission line while RF power is being applied.
Leaking RF energy is a potential health hazard.

WARNING

The Bird 4421 contains no user-serviceable parts.
Do not remove its cover.

WARNING

To avoid personal injury, disconnect the power cord from the ac line before performing any maintenance, including fuse replacement or changing the line voltage setting.

Caution Statements

The following equipment cautions appear in the text whenever the equipment is in danger of damage and are repeated here for emphasis.

CAUTION

The interface module contains electrostatic discharge (ESD) sensitive components. Failure to observe ESD precautions can cause permanent damage.

CAUTION

Changing the sensor's connectors will invalidate calibration data, and may reduce the maximum power rating of the unit.

CAUTION

Be sure that the 115/230 voltage selector on the 4421's rear panel is set to the proper voltage before ac power is applied.

CAUTION

The Bird 4421 must be powered off when connecting or disconnecting the power sensor from the power meter.

CAUTION

Do not use the power sensor with a load VSWR greater than 2:1. Damage to the power meter, power sensor, or the RF power source could occur.

CAUTION

During remote operation, periodically monitor the bus service request line. Failure to detect a service request could result in equipment damage.

CAUTION

Due to the complexity of the Bird Power Sensor, field repairs beyond general maintenance should not be attempted. Removal or disturbance of the power sensor cover can result in cancellation of lifetime warranty.

CAUTION

Failure to install the properly rated fuse may result in equipment damage or nuisance failures.

Safety Statements



USAGE

ANY USE OF THIS INSTRUMENT IN A MANNER NOT SPECIFIED BY THE MANUFACTURER MAY IMPAIR THE INSTRUMENT'S SAFETY PROTECTION.

USO

EL USO DE ESTE INSTRUMENTO DE MANERA NO ESPECIFICADA POR EL FABRICANTE, PUEDE ANULAR LA PROTECCIÓN DE SEGURIDAD DEL INSTRUMENTO.

About This Manual

This manual covers the Bird 4421 RF Power Meter, Bird 4020 Series Power Sensors, Bird 4027A Series Precision Power Sensors, and Bird 4027F Series Precision Filtered Power Sensors. Specific models include:

Power Meter	4421			
4020 Series Sensors	4021	4022	4024	4025
4027A Series Sensors	4027A250K	4027A400K	4027A800K	4027A2M
	4027A4M	4027A10M	4027A12M	4027A25M
	4027A35M	4027A60M	4027A100M	4027A150M
4027F Series Sensors	4027F2M	4027F10M	4027F60M	
4028A Series Sensors	4028A250K	4028A400K	4028A2M	4028A3M
	4028A4M	4028A10M	4028A25M	
4028B Series Sensors	4028B10M			

This instruction book is arranged so that essential safety information appears in the front of the book. Reading the Safety Precautions before operating the equipment is strongly advised.

The remainder of this manual is divided into Chapters and Sections. At the start of each chapter, a general overview describes its contents.

Operation

First time users should read Chapter 1 – Introduction and Chapter 2 – Installation to get an overview of equipment capabilities and installation. Experienced operators can refer to Chapter 3 – Operating Instructions. All instructions necessary to manually operate the equipment appear in this chapter. If the power meter is equipped with a IEEE-488 GPIB Interface refer to Chapter 4 – IEEE-488 GPIB Interface. For the RS-232 Interface refer to Chapter 5 – RS-232 Interface.

Maintenance

All personnel should be familiar with preventative maintenance found in Chapter 6 – Maintenance. If a failure should occur, the troubleshooting section will aid in isolating and repairing the failure. A list of replacement parts with part numbers is also in this chapter.

Changes To This Manual

We have made every effort to ensure this manual is accurate. If you should discover any errors, or if you have suggestions for improving this manual, please send your comments to our factory. This manual may be periodically updated. When inquiring about updates to this manual refer to the part number and revision level on the title page.

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Power Meter

The Bird 4421 RF Power Meter is one component of a complete RF power measurement system. An RF power sensor such as a Bird 4021 is also required. The system can be controlled with the front panel buttons, or remotely with the optional interfaces.

Items Supplied

- Bird 4421 RF Power Meter
- AC Power Cord
- Sensor Cable
- Instruction Manual

Optional Accessories

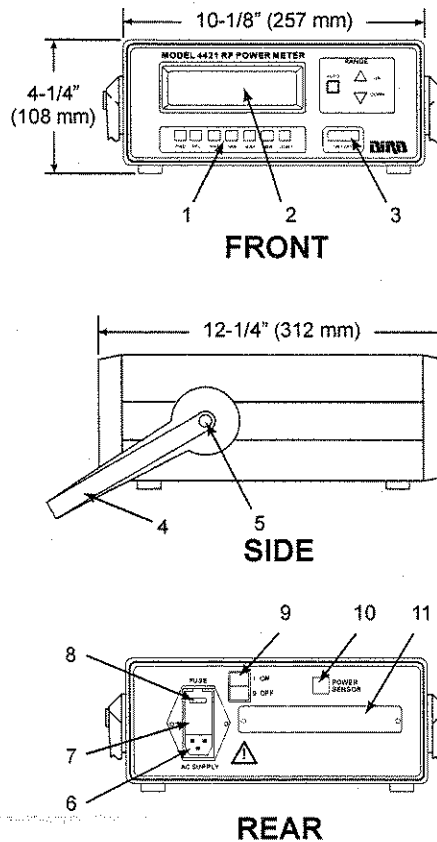
Panel Mount Kit (P/N 4421-250): Allows the Bird 4421 to be installed in a standard 19" panel for rack mount applications.

IEEE-488 GPIB Bus Interface Module (P/N 4421-488): Allows the 4421 to be remotely controlled over an IEEE-488 general purpose interface bus (GPIB). A GPIB controller, usually a computer, can then give commands and read data.

RS-232 Bus Interface Module (P/N 4421-232): Allows the 4421 to be remotely controlled over an RS-232 interface. A computer or terminal can then give commands and read data.

Null Modem Kit (P/N 4380-250): Contains the hardware necessary to allow the 4421 to be remotely controlled by controllers with different wiring arrangements. Requires an RS-232 interface module.

Figure 1
Bird 4421 Meter
Outline Drawing



1. Operating Push Buttons
2. LCD
3. ON/OFF Push Button
4. Handle
5. Central Button
6. AC Line Module
7. Access Door
8. Voltage Selector
9. Master ON/OFF Switch
10. Power Sensor Socket
11. Interface Module Access

Power Sensors

Power sensors are available with a variety of connectors; see "Available Connectors" on page 52 for a complete list. Since the accuracy is critically dependent on the connectors used at calibration, do not remove or change the connectors.



CAUTION

Changing the sensor's connectors will invalidate calibration data, and may reduce the maximum power rating of the unit.

4020 Series

Bird 4020 Series Power Sensors are designed for lab or field use and are accurate to within $\pm 3\%(1\sigma)$ of reading.

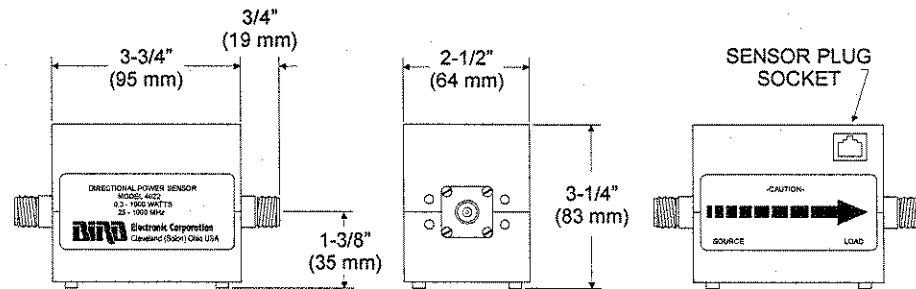
4027A Series

Bird 4027A Series Power Sensors are designed for use in semiconductor processing and calibration applications. Stringent calibration provides long-term unit-to-unit repeatability, allowing consistent amounts of RF energy to be applied to the etch process over many etch cycles. 4027A Sensors are accurate to $\pm 1\%(1\sigma)$ at specified calibration frequencies and power levels.

4027F Series

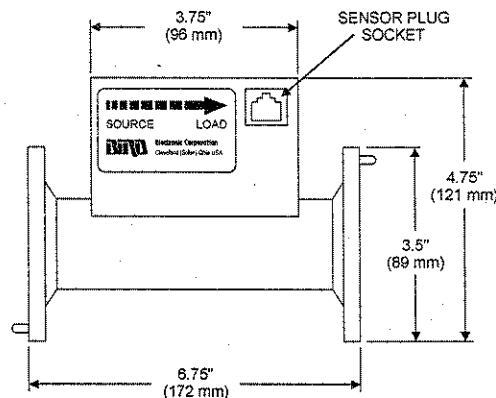
Bird 4027F Series Power Sensors are similar to the 4027A series. However, additional filtering allows the 4027F to ignore harmonics of the signal being measured. The 4027F is also less sensitive to AM components of the signal. 4027F Sensors are accurate to $\pm 1\%(2\sigma)$ at specified calibration frequencies and power levels.

Figure 2
Power Sensor
Outline Drawing,
4020, 4027A, 4027F,
and 4028A Series

**4028 Series**

Bird 4028 Series Power Sensors are high power sensors otherwise similar to the 4027A series. 4028A sensors are based on a 7/8" line, while 4028B sensors use a 1-5/8" line. 4028 Sensors are accurate to $\pm 2\%(2\sigma)$ at specified calibration frequencies and power levels.

Figure 3
Power Sensor
Outline Drawing
4028B Series only



Frequency and Power Ranges

4020 Series

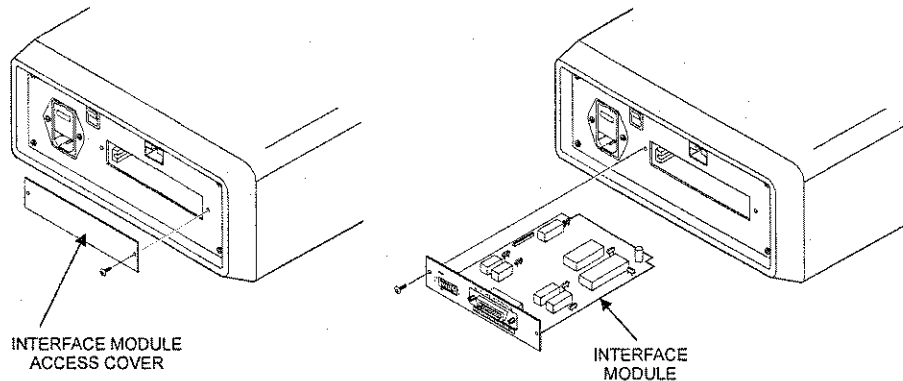
Model	Frequency Range	RF Power Range
4021	1.8 – 32 MHz	300 mW – 1 kW
4022	25 – 1000 MHz	300 mW – 1 kW
4024	1.5 – 32 MHz	3 W – 10 kW
4025	100 kHz – 2.5 MHz	3 W – 10 kW

4027A Series	4027A250K	250 – 400 kHz	3 W – 10 kW
	4027A400K	400 – 550 kHz	3 W – 10 kW
	4027A800K	800 – 950 kHz	3 W – 10 kW
	4027A2M	1.5 – 2.5 MHz	3 W – 10 kW
	4027A4M	3 – 5 MHz	3 W – 10 kW
	4027A10M	10 – 15 MHz	3 W – 10 kW
	4027A12M	10 – 15 MHz	300 mW – 1 kW
	4027A25M	25 – 30 MHz	3 W – 9 kW
	4027A35M	35 – 45 MHz	3 W – 7.5 kW
	4027A60M	45 – 65 MHz	3 W – 6 kW
	4027A100M	95 – 105 MHz	3 W – 5 kW
	4027A150M	150 – 170 MHz	3 W – 4 kW
	4027F Series	4027F2M	1.8 – 2.2 MHz
4027F10M		12 – 15 MHz	100 W – 10 kW
4027F60M		57 – 63 MHz	100 W – 3 kW
4028 Series	4028A250K	250 – 400 kHz	1 kW – 20 kW
	4028A400K	400 – 550 kHz	1 kW – 20 kW
	4028A2M	1.5 – 2.5 MHz	1 kW – 25 kW
	4028A3M	2.5 – 3.5 MHz	1 kW – 25 kW
	4028A4M	3.5 – 4.5 MHz	1 kW – 25 kW
	4028A10M	10 – 15 MHz	1 kW – 25 kW
	4028A25M	25 – 30 MHz	1 kW – 25 kW
	4028B10M	10 – 15 MHz	1 kW – 25 kW

This chapter provides information on preparing the Bird 4421 for use.

Interface Module

Figure 4
Interface Module
Installation



CAUTION

The interface module contains electrostatic discharge (ESD) sensitive components. Failure to observe ESD precautions can cause permanent damage.

To use the Bird 4421 remotely, the optional interface module must be installed (see Figure 4):

1. Unscrew and remove the interface access cover on the power meter's rear panel.
2. Remove the interface module from its conductive bag.
3. Align the module edges with the side guides in the meter and slide the interface module into the access slot.
4. Press on the front edge of the module until it seats fully.
5. Screw the module into place with the access cover screws.
6. Connect the power meter to a suitable controller using the cable supplied with the interface module.

Sensor Connection



CAUTION

Changing the sensor's connectors will invalidate calibration data, and may reduce the maximum power rating of the unit.

CAUTION

The Bird 4421 must be powered off when connecting or disconnecting the power sensor from the power meter.

1. Turn OFF the ON/OFF rocker switch on the meter's rear panel.
2. Align the latch on the cable with the notch of the "Power Sensor" socket on the power meter's rear panel.
3. Insert the cable until it clicks into place.
4. Connect the other end of the sensor cable to the sensor.

RF Line Connection

WARNING

Never attempt to connect or disconnect RF equipment from the transmission line while RF power is being applied. Leaking RF energy is a potential health hazard.

CAUTION

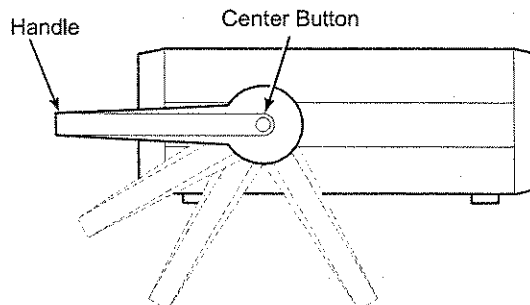
Do not use the power sensor with a load VSWR greater than 2:1. Damage to the power meter, power sensor, or the RF power source could occur.

Connect the end of the power sensor labeled "SOURCE" to the RF source. Connect the end labeled "LOAD" to the load or antenna. Reversing these connections will cause measurement errors.

Handle Operation

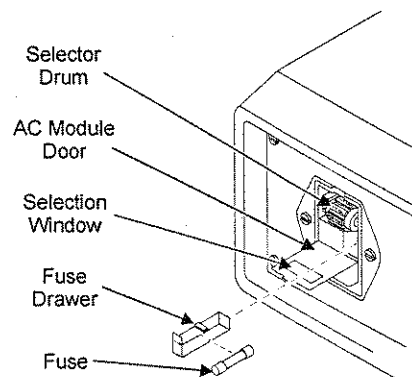
The handle on the Bird 4421 can be set to four different positions (see Figure 5). To adjust the handle, press the center buttons on both sides. Releasing the buttons will lock the handle into position.

Figure 5
Handle Positions



115/230V AC Power Selection

Figure 6
Voltage Selection



WARNING

To avoid personal injury, disconnect the power cord from the ac line before performing any maintenance, including fuse replacement or changing the line voltage setting.

CAUTION

Be sure that the 115/230 voltage selector on the 4421's rear panel is set to the proper voltage before ac power is applied.

CAUTION

Failure to install the properly rated fuse may result in equipment damage or nuisance failures.

Setting AC Voltage

The 4421 is factory set for 115 Vac input voltage. To change the voltage setting:

1. Open the ac module door and remove the fuse drawer and the voltage selector drum.
2. Install the new fuse and replace the fuse drawer.

AC Line Voltage	Fuse Rating
115 Vac	T250 mA, 5x20 mm Time Lag Fuse
230 Vac	T125 mA, 5x20 mm Time Lag Fuse

3. Rotate the voltage selector drum to the desired voltage:
 - For 115 Vac, position the drum so that the second line on the drum will be visible through the window.
 - For 230 Vac, position the drum so that the third line on the drum will be visible through the window.
4. Replace the voltage selector drum and close the ac module door.

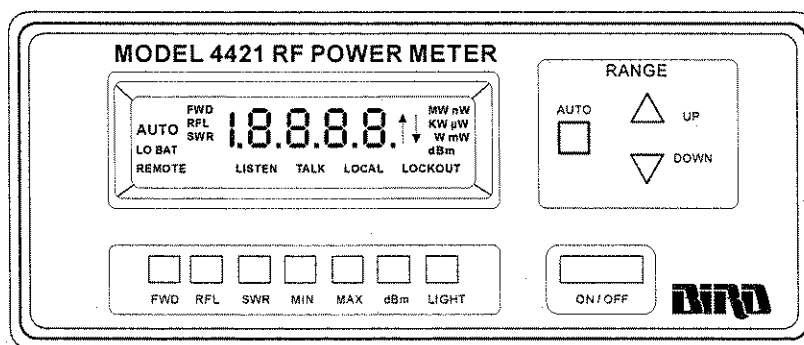
AC Line Connectors

To make the ac line cord compatible with European style sockets, users must install the appropriate connector on the power cord.

This chapter describes operator controls and indicators on the Bird 4421 RF Power Meter. If your power meter is equipped for remote operation using a GPIB or RS-232 controller, refer to the instructions in Chapter 4 or Chapter 5 respectively.

Push Button Functions

Figure 7
Push Buttons



Push Button	Description
FWD, RFL	Press to measure forward (reflected) RF power. FWD (RFL) indicator and current unit of measure turn on.
SWR	Press to measure standing wave ratio. SWR indicator turns on. Value displayed will be between 1.0 and 199.9
MIN, MAX	Used after pressing FWD, RFL, SWR, or dBm. Displays the minimum (maximum) measured value of the previous function as long as MIN (MAX) is held down.
dBm	Used after pressing FWD or RFL. dBm indicator turns on. Power is displayed in dBm units. Used after pressing SWR. Return loss is displayed.
LIGHT	Press to turn on or turn off the display's backlight. If left on, the light automatically shuts off after 30 minutes.
AUTO	Press to automatically set the scale. AUTO turns on.
UP, DOWN	Press to select the next higher (lower) scale. If the scale is too high for the power sensor, an error will be displayed. Used while AUTO indicator is on. Stops automatic scaling. AUTO indicator turns off.
ON/OFF	Press to turn the power meter on or off.

Error Codes

The Bird 4421 displays error codes when the RF power is either below the selected range (underrange) or above the selected range (overrange). Figure 8 displays the error codes and Figure 9 lists the function limits.

Figure 8
Error Codes

Symbol	Explanation
□□	Value greater than overrange limit of function
□□	Value less than underrange limit of function

Figure 9
Function Limits

Function	Limit	Error
FWD, RFL	Power > 199.9% of full scale or 120% of top range	Ovrange
FWD dBm, RFL dBm	Power > 120% of full scale Power < 3% of low range	Ovrange Underrange
SWR	FWD < 20% of low range FWD - RFL = 0	Underrange Ovrange
Return Loss	FWD < 20% of low range RFL < 20% of low range Return Loss > 40 dB	Underrange Underrange Underrange

Audible Warning

If the RF power level exceeds 120% of the power sensor's maximum power capability, the power meter will sound a warning buzzer.

This chapter discusses setup of the IEEE-488 interface module and describes the IEEE commands that apply to the Bird 4421. Operators should understand IEEE standard 488-1978 and have basic computer programming skills before attempting to write any programs.

CAUTION

During remote operation, periodically monitor the bus service request line. Failure to detect a service request could result in equipment damage.

Description

The Bird 4421 IEEE-488 interface module is a plug-in board that can be factory or field installed. An eight-position DIP switch is used to set operational conditions and interface addresses. The current bus status is displayed on the bottom line of the display.

Cable Connector

The interface module uses a standard IEEE-488 cable connector. Pin assignments are listed in Figure 10.

Figure 10
IEEE-488 Pin
Assignments

Pin	Designation	Type
1	D101	Data
2	D102	Data
3	D103	Data
4	D104	Data
5	EOI	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	D105	Data
14	D106	Data
15	D107	Data
16	D108	Data
17	REN	Management
18	GROUND	Ground
19	GROUND	Ground
20	GROUND	Ground
21	GROUND	Ground
22	GROUND	Ground
23	GROUND	Ground
24	GROUND, LOGIC	Ground

Interface Capabilities

The interface module's capability function codes are listed in Figure 11.

Figure 11
IEEE-488
Interface Module
Capabilities

Code	Name	Description
SH1	Source Handshake	Can handshake data or command bytes when the unit is acting as a source.
AH1	Acceptor	Can handshake the bus when it is acting as the acceptor of data or commands.
T5	Talker	Can send data over the bus to other devices. This capability exists only after the instrument has been addressed to talk, or after a reading in talk-only mode.
L4	Listener	Can receive device-dependent data over the bus. This capability exists only after the unit has been addressed to listen.
SR1	Service Request	Can request service from the controller.
RL1	Remote-Local	Can be placed in remote or local mode.
PP0	Parallel Poll	Does not have parallel polling capability.
DC1	Device Clear	Can be reset to factory settings.
DT1	Device Trigger	Can have its readings triggered.
C0	Controller	Does not have controller capability.
E1	Bus Driver Type	Has open-collector bus drivers.
TE0	Extended Talker	Does not have extended talker capability.
LE0	Extended Listener	Does not have extended listener capability.

Indicators

The bottom line of the power meter's display shows indicators describing the status of the Bird 4421 when used with the IEEE interface. These are:

REMOTE: When REMOTE is displayed, the power meter is being controlled through the interface. Measurements, units of measure, and certain other parameters may be changed from a remote location.

LISTEN: When LISTEN is displayed, the power meter is receiving data.

TALK: When TALK is displayed, the power meter is transmitting data. This is always shown when the unit is in "talker-only" mode.

LOCAL LOCKOUT: When LOCAL LOCKOUT is displayed, the push buttons are disabled and the power meter's functions are being remotely controlled.

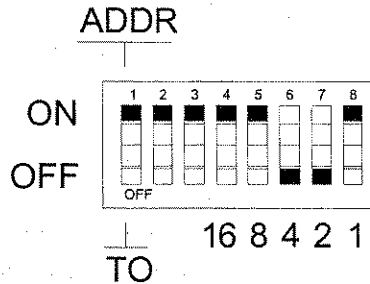
Setup

Dip Switch After installing the interface module, set the interface to ADDR (Addressable) by turning DIP switch 1 ON. This makes the 4421 respond to controller commands.

NOTE: A DIP switch is on when pressed in at the top, and off when pressed at the bottom.

Set the primary address using the DIP switches. The primary address is factory set to 6, but can be set to any value between 1 and 31 (0 is reserved for the controller) To set the primary address, turn OFF switches 4 – 8 so that the sum of the bits turned off equals the desired primary address. In Figure 12 below, the address is set to 6 (the off switches have values of 4 and 2).

Figure 12
IEEE Interface Default
DIP Switch Settings



NOTE: The primary address is used by the controller to refer to specific devices on the bus. When programming the controller, the address in the program must be the same as the address set on the interface module. Each device on the bus must have a different primary address.

Talker-Only Mode The Bird 4421 can be set up for manual operation while automatically sending data to an output device (Talker-Only Mode). To do so, turn DIP switch 1 OFF and cycle the power. TALK will be displayed.

In Talker-Only mode, pressing a button on the meter triggers a measurement. When the measurement is complete, the information is sent to the bus and LISTEN turns on momentarily. A listen-only device on the bus, such as a printer, can read the value. The power meter is then ready to accept another button press.

Command Syntax

The Bird 4421 accepts two types of commands. General bus commands are commands, such as Device Clear (DCL), that apply to any IEEE interfaced device. Device-dependent commands are specific to the 4421.

If an invalid command is sent to the unit, an error condition is placed in the serial poll byte and the offending command is not executed.

A group of device-dependent commands can be sent as a single string as long as like command categories are not repeated, for example: "PNFCFDT3TRG". This string sets up the 4421 to send no prefixes, read forward dBm, make one reading on "TRG", and triggers a measurement.

☞ NOTE: Commands can be entered in either upper or lower case.

☞ NOTE: Only the last command entered of each category will be executed. As a command string is processed by the 4421, each category of command is stored in a separate location. Two commands of the same category will be stored in the same location, so that the second will overwrite and erase the first one.

General Bus Commands

The general bus commands supported by the IEEE-488 interface module are listed in Figure 13. The syntax for executing general commands varies among controllers; check the documentation supplied with your controller for the proper command structure.

Figure 13
IEEE-488
General Bus
Commands

Command	Effect on Bird 4421
REN	Goes into remote mode when next addressed
GTL	Cancels remote mode, restores local operation
LLO	Locks out local operation
IFC	Goes into talker and listener-idle status
DCL	Returns to default conditions
SDC	Returns to default conditions
GET	Triggers reading in T2 and T3 modes
SPE, SPD	Puts the status byte on the bus

Remote ENable (REN)

- Function** Enables remote operation.
- Remarks** The unit must be addressed to listen after setting REN true.
The REMOTE indicator turns on when this command is received.

Go To Local (GTL)

- Function** Returns device to local operation.
- Remarks** Issuing a GTL command while the device is in Local Lockout mode does not clear the lockout condition.
The REMOTE indicator turns off.
The LISTEN indicator remains on.

Local LOfkout (LLO)

- Function** Disables local operation of all devices on the bus.
- Remarks** REN must be true to use LLO.
LLO is cleared by setting REN false.

InterFace Clear (IFC)

- Function** Terminates all bus activity and passes control to the system controller.
- Remarks** All devices are set to talker and listener idle states.
REN is set to false.
REMOTE, TALK, LISTEN, and LOCAL LOCKOUT modes are cancelled, and their indicators are turned off.

Device CLear (DCL)

- Function** Resets the status of all devices to an initialized state.
- Remarks** Does not change the current interface mode.
The 4421 returns to the factory default condition listed in Figure 14.

*Figure 14
IEEE-488 Default
Conditions*

Default Condition	Related Command
Forward Carrier Wave	FC
Auto Range ON	RYY
Two Terminators (CR LF)	YT
Prefixes YES	PY
Trigger One Shot on Talk Address	T1
All SRQ's OFF	M00
Send EOI with last byte of message	KY

Selective Device Clear (SDC)

- Function** Resets the status of a selected device to an initialized state.
- Remarks** Only the device addressed will be cleared.
The 4421 returns to the factory default condition.

Group Execute Trigger (GET)

- Function** Initiates a measurement for all devices set to trigger on GET.
- Remarks** The 4421 must be already set to trigger on GET.
Used to synchronize measurements of multiple instruments.

Serial Polling Enable/Disable (SPE/SPD)

Function Enables or disables the serial polling sequence.

CAUTION

During remote operation, periodically monitor the bus service request line. Failure to detect a service request could result in equipment damage.

Remarks The SPE command puts all devices in serial poll mode waiting to be addressed. The SPD command clears the SRQ bit (bit 6) and ends the polling sequence.

When addressed a device sends its status byte to the controller. A value of 1 for a bit means that the device condition that bit refers to is true. A value of 0 means that the condition is false.

The 4421 does not use all bits of the status byte. Figure 15 lists the bits used, along with a description and how to reset them.

Figure 15
IEEE Status
Byte Description

Bit	Name	Condition
6	SRQ	Set if a service request is generated by the 4421. If an SRQ has been received by the controller and this bit is cleared, other instruments on the bus should be checked to determine where the SRQ occurred. Cleared by a serial poll of the 4421.
3	Measurement Complete	Set when the power meter has completed a reading. Cleared by requesting a reading over the bus.
2	Reading Underflow	Set when the RF power is underrange and a reading has been completed. Cleared by requesting a reading over the bus.
1	Reading Overflow	Set when the RF power is overrange and a reading has been completed. Cleared by requesting a reading over the bus.
0	Error	Set if an illegal device-dependent command (IDDC) or illegal device-dependent command option (IDDCO) was received, or if the power meter fails the self test. Cleared by reading the U1 status word. The U1 word contains details on the error, see "Status" on page 24.

Device Dependent Commands

The device-dependent commands used by the 4421 Power Meter are listed in Figure 16, organized by category.


 NOTE: The programming card also has a complete command list.

Figure 16
IEEE-488
Device Dependent
Command
Summary

Category	Command	Description
Measurement	FC	Forward carrier wave
	FD	Forward dBm
	RC	Reflected carrier wave
	RD	Reflected dBm
	SW	Standing wave ratio
	RL	Return loss
	MN	Minimum value
	MX	Maximum value
Range	RYY	Auto range on
	R00 to R17	Manual ranges
	RNN	Auto range off, stay at present range
Terminators	YT	Two terminators: CR, LF
	YO	One terminator: CR
	YN	No terminator
Prefixes	PY	Prefix YES
	PN	Prefix NO
Triggers	T0	Continuous on TALK
	T1	One shot on TALK
	T2	Continuous on GET
	T3	One shot on GET
	T4	Continuous on measurement command
	T5	One shot on measurement command
Serial Polling	M00	Do not generate SRQ
	M01	Generate SRQ on error
	M02	Generate SRQ on measurement overrange
	M04	Generate SRQ on measurement underrange
	M08	Generate SRQ on operation complete
Status	U0	Send back current machine state
	U1	Send back error conditions
	U2	Send back revision levels
Self-Test	J0	Run self-test
EOI Response	KY	Send EOI on last byte
	KN	Do not send EOI on last byte
Writable Store	WXXXXXX	Place XXXXXX in RAM

Forward Carrier Wave (FC)
Forward dBm (FD)
Reflected Carrier Wave (RC)
Reflected dBm (RD)

Function Selects forward or reflected RF power measurement mode.
Remarks Measurement results are returned in Watts or dBm.

Standing Wave Ratio (SW)
Return Loss (RL)

Function Selects SWR or return loss match measurement mode.
Remarks Measurement results are returned in VSWR or dB.

Minimum Value (MN)
Maximum Value (MX)

Function Selects minimum or maximum measurement mode.
Remarks Another measurement must be selected before selecting min or max.
Returns the minimum (or maximum) value of the previous measurement type.

Range (Rxx)

Function Selects a measurement range listed in Figure 17.

Remarks If the selected range is outside the range of the connected power sensor, the command is ignored.

*Figure 17
Measurement
Ranges*

Command	Power Range
RYY	Turn auto range on
RNN	Turn auto range off. Keep present range
R17	18.0 – 199.9 MW
R16	1.80 – 19.99 MW
R15	0.180 – 1.999 MW
R14	18.0 – 199.9 kW
R13	1.80 – 19.99 kW
R12	0.180 – 1.999 kW
R11	18.0 – 199.9 W
R10	1.80 – 19.99 W
R09	0.180 – 1.999 W
R08	18.0 – 199.9 mW
R07	1.80 – 19.99 mW
R06	0.180 – 1.999 mW
R05	18.0 – 199.9 μ W
R04	1.80 – 19.99 μ W
R03	0.180 – 1.999 μ W
R02	18.0 – 199.9 nW
R01	1.80 – 19.99 nW
R00	0.180 – 1.999 nW

Terminators (Yx)

Function Selects the characters that follow the end of a data string. Set x to:

- “T” for two terminators; a carriage return(CR) and a line feed(LF).
- “O” for one terminator; a carriage return(CR).
- “N” for no terminator; message can be terminated by EOI.

Remarks Many controllers use the terminator sequence to recognize the end of an input string. Using incorrect terminators can lock the bus.

Prefixes (Px)

Function Turns the prefix mode on or off. Set x to:

- “Y” to enable prefixes.
- “N” to disable prefixes.

Remarks Prefixes are sent over the bus with the measurement, and indicate the status of the current measurement (see Figure 18 for examples):

- “FC,” “FD,” “RC,” “RD,” “SW,” “RL,” “MN,” “MX” indicates the measurement type.
- “U” indicates underflow; the value sent is “.000”.
- “O” indicates overflow; the value sent is “199.9”.
- “N” indicates normal; the value sent is a normal on-scale reading.
- “4421” indicates the Bird model number.

Figure 18
Prefix Examples

Data String	Description
NFC .0 .123W (CR) (LF)	Normal (N) forward carrier wave (FC), prefixes on
OFC 199.9W (CR) (LF)	Overflowed (O) forward carrier wave (FC), prefixes on
199.9W (CR) (LF)	Overflowed forward carrier wave, prefixes off
URD .000W (CR) (LF)	Underflowed (U) reflected dBm (RD), prefixes on

Triggers (Tx)

- Function** Selects the condition which will trigger a reading (see Figure 19).
- Remarks** Failure to trigger device before requesting a reading will lock the bus. T1 halts the bus until a reading is available. T0 and T1 do not set the measurement complete SRQ. T2, T3, T4, and T5 set a SRQ when the measurement is complete. Fastest reading rate is 2.4 readings/second; slowest is 1 reading/sec.

Figure 19
Trigger Conditions

Command	Trigger Condition
T0	Continuous on talk
T1	One shot on talk
T2	Continuous on GET
T3	One shot on GET
T4	Continuous on measurement command (FC,FD, RC, RD, SW, RL, MN, MX)
T5	One shot on measurement command (FC, FD, RC, RD, SW, RL, MN, MX)

SRQ Mask (Mxx)

- Function** Selectively masks status bits to prevent unwanted service requests. Set xx to the sum of the binary values of the desired SRQ trigger bits. For example, M12 would set the SRQ for both operation complete and underrange (values 8 and 4). Set xx to "00" to never generate an SRQ.
- Remarks** If a status bit is masked (bit set to 0), SRQs won't be generated for that condition.

Figure 20
SRQ Mask Bits

Binary Value	Bit Number	Message
1	0 (LSB)	Error (IDDC, IDDCO, self-test fail)
2	1	Measurement overrange
4	2	Measurement underrange
8	3	Operation complete
	4	Not Used
	5	Not Used
	6	Can't mask
	7 (MSB)	Not Used

Status (Ux)

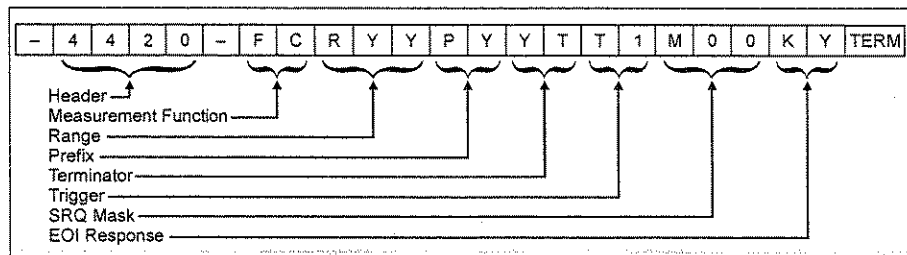
Function Reads a status word and returns the information as a string. Set x to:

- “0” for machine status.
- “1” for error status.
- “2” for revision history.

Remarks After sending the status command, a status word is sent the next time the unit is addressed to talk. To ensure the correct status is transmitted, the status word should be requested as soon as possible after the command is sent.

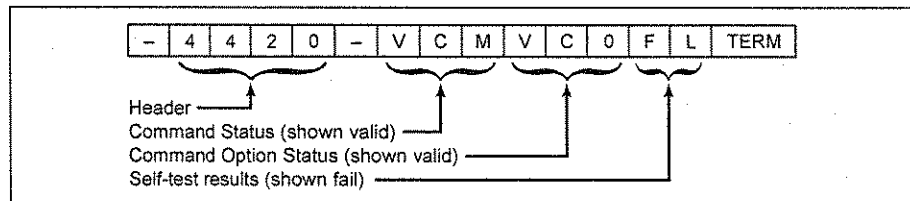
Machine Status Word (U0): The format of the machine status word is shown in Figure 21. The default values are also shown.

Figure 21
Machine Status
Word Format



Error Status Word (U1): The format of the error status word and the possible error messages are shown in Figure 22. When an error occurs, an error is also flagged in the status (serial poll) byte, and a SRQ may be generated (See “SRQ Mask” on page 23). All flags will revert to their non-error states after the U1 command is sent.

Figure 22
Error Status
Word Format

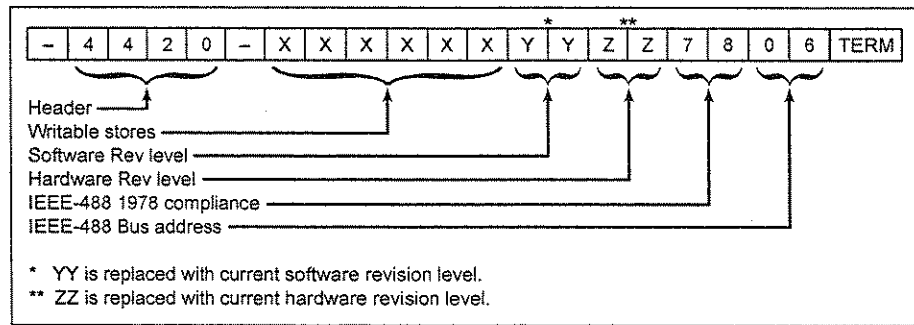


Status	Meaning	Description
ICM	Invalid Command	Set when an illegal device-dependent command (IDDC) such as V2 is received. (V is illegal)
VCM	Valid Command	Set when no IDDC is received.
ICO	Invalid Command Option	Set when an illegal device-dependent command option (IDDCO) such as T6 is received. (6 is illegal)

VCO	Valid Command Option	Set when no IDDCO is received.
PS	Self-Test Pass	Set when a self-test has been initiated by the J0 command and the test result is acceptable.
FL	Self-Test Fail	Set when the self-test has failed. (This is the default condition.)

Revision History Word (U2): The format of the revision history word is shown in Figure 23.

Figure 23
Revision History
Word Format



Self Test (J0)

Function Initiates a hardware and software test.

Remarks Results are stored in the U1 status word (see "Status" on page 24). "J0" must be sent each time before reading the result.

End Or Identify (Kx)

Function Enables or disables the End or Identify (EOI) signal. Set x to:

- "Y" to enable.
- "N" to disable.

Remarks Disabling EOI can cause some controllers to lock unless another terminator is used.

When enabled, EOI is only asserted at the end of a multiple byte string.

Writable Store (Wxxxxxx)

- Function** Storage for six bytes of ASCII data.
- Remarks** Data stored is lost when the 4421 is turned off.
Data is sent back as part of the U2 status word.

This chapter discusses setup of the RS-232 interface module and describes the RS-232 commands that apply to the Bird 4421. Operators should understand EIA Standard RS-232-C and have basic computer programming skills before writing any programs.

Description

The Bird 4421 RS-232 interface module is a plug-in board that can be factory or field installed. An eight-position DIP switch is used to set operational conditions such as baud rate, parity, and stop bits. The current bus status is displayed on the bottom line of the display.

Cable Connector

The interface module uses a standard 25-pin RS-232 connector. Pin assignments are listed in Figure 24. If the controller uses a different wiring arrangement, do not attempt to rewire the interface module's connector. A null modem kit should be used for rewiring instead.

Figure 24
RS-232 Pin
Assignments

Pin	Designation	Notes
1	Protection Ground	Chassis Ground
2	Transmit Data	
3	Receive Data	
4	Request to Send	(Output) Set true after module power up
5	Clear to Send	(Input) Set by input device. When true, it enables the module to transmit. When false, it disables transmission.
6	Data Set Ready	(Input) Set internally true by module
7	Signal Ground	Return path for data and control signals
8	Receive Signal DET	(Input) Set true by module
20	Data Terminal Ready	(Output) Set true after module power up

Indicators

The bottom line of the power meter's display shows indicators describing the status of the Bird 4421 when used with the RS-232 interface. These are:

TALK: When TALK is displayed, the power meter is transmitting data. This is always shown when the unit is in "talker-only" mode.

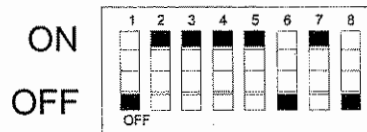
LISTEN: When LISTEN is displayed, the power meter is receiving data.

Setup

DIP Switch After installing the interface module, set the DIP switches according to application needs and the requirements of the controller. Available settings and factory defaults are listed in Figure 25.

NOTE: A DIP switch is on when pressed in at the top, and off when pressed at the bottom.

Figure 25
RS-232 Interface
Default DIP Switch
Settings



Switch	Function	Description			
1	Stop Bit	ON	1 Stop Bit		
		OFF	2 Stop Bits*		
2	Command Mode	ON	ENT command needed before sending reading to controller*		
		OFF	Trigger automatically sends reading Reading also sent when front panel push button pressed		
3	Word Length	ON	8 Data Bits*		
		OFF	7 Data Bits		
4,5	Parity	(4) ON	(5) ON	No Parity*	
		ON	OFF	Odd Parity	
		OFF	ON	Even Parity	
		OFF	OFF	Mark Parity	
6,7,8	Baud Rate	(6) ON	(7) ON	(8) ON	Auto Baud†
		ON	ON	OFF	110
		ON	OFF	ON	300
		ON	OFF	OFF	600
		OFF	ON	ON	1200
		OFF	ON	OFF	2400*
		OFF	OFF	ON	4800
		OFF	OFF	OFF	9600

* Factory setting

† For more information see "Auto Baud"

Auto Baud Auto Baud is used to automatically determine the correct transmission rate. After setting DIP switches 1 through 5, follow the steps below to use auto baud:

1. Set DIP switches 6, 7, and 8 to ON.
2. Connect a controller to the power meter.
3. Turn the power meter on.

4. Send the character U (hexadecimal 55) from the controller to the power meter.
5. Wait 1 second.
6. If the power meter's front panel displays LISTEN, the baud rate has been determined. If not, repeat steps 4 and 5.

If, after 30 seconds, the module cannot absolutely determine a baud rate, it will choose a rate based on data acquired during the test.

☞ NOTE: Auto Baud is the only automatically chosen setting. Other items such as parity and stop bits must be manually selected.

Talker-Only Mode The Bird 4421 can be set up for manual operation while automatically sending data to an output device (Talker-Only Mode). To do so, turn DIP switch 2 OFF and cycle the power. TALK will be displayed.

In Talker-Only mode, pressing a button on the meter triggers a measurement. When the measurement is complete, the information is sent to the bus.

Command Syntax

The Bird 4421 accepts two types of commands. General bus commands are commands, such as Initialize (INT), that apply to any RS-232 interfaced device. Device-dependent commands are specific to the 4421.

If an invalid command is sent to the unit, an error condition is placed in the serial poll byte and the offending command is not executed.

A group of device-dependent commands can be sent as a single string as long as like command categories are not repeated. For example: "PNFCFDT3TRG". This string sets up the 4421 to send no prefixes, read forward dBm, make one reading on "TRG", and triggers a measurement.

☞ NOTE: Commands can be entered in either upper or lower case.

☞ NOTE: Only the last command entered of each category will be executed. As a command string is processed by the 4421, each category of command is stored in a separate location. Two commands of the same category will be stored in the same location, so that the second will overwrite and erase the first one.

General Bus Commands

The general bus commands supported by the RS-232 interface module are listed in Figure 26.

Figure 26
RS-232
General Bus
Commands

Command	Effect on Bird 4421
INT	Returns to default conditions
ENT	Sends a reading to the controller
TRG	Triggers reading in T3 mode
B1 to B7	Selects a baud rate
XO/XF	Enables/disables software handshake

INiTialize (INT)

Function Resets the Bird 4421 and returns it to the factory defaults.

Remarks If INT is linked with any other command within a string, it must be separated from that command by a space.

ENTer (ENT)

Function Makes the power meter transmit a reading to the controller.

Remarks A measurement must have already been triggered, placing a reading in the output buffer.

To send a reading whenever a measurement is triggered, set DIP switch 2 to OFF. The ENT command will not need to be sent.

TRiGger (TRG)

Function Initiates a measurement if the power meter is in trigger mode (T3).

Baud Select (Bx)

Function Selects a baud rate listed in Figure 27.

Remarks When the meter recognizes a valid Bx command, its baud rate is immediately changed. (The controller is assumed to be transmitting at the new rate; otherwise sending commands would not be possible.)

This command overrides the DIP switch setting.

Figure 27
Baud Rates

Command	Baud Rate
B1	110
B2	300
B3	600
B4	1200
B5	2400
B6	4800
B7	9600

Xmission Flow Control (XO/XF)

Function Enables or disables the XON/XOFF flow control.

- XO enables flow control.
- XF disables flow control.

Remarks When data is being sent from the power meter to the computer and flow control is enabled, data transmission will be suspended when the XOFF character (hexadecimal 13) is sent by the computer. Transmission will resume when XON (hex 11) is sent by the computer. When data is being sent from the computer to the power meter, XOFF will be sent to the computer when the input buffer fills up. XON will be sent to the computer when the buffer has emptied.

Device Dependent Commands

The device-dependent commands used by the 4421 Power Meter are listed in Figure 28, organized by category.


 NOTE: The programming card also has a complete command list.

Figure 28
RS-232 Device
Dependent
Command
Summary

Category	Command	Description
Measurement	FC	Forward carrier wave
	FD	Forward dBm
	RC	Reflected carrier wave
	RD	Reflected dBm
	SW	Standing wave ratio
	RL	Return loss
	MN	Minimum value
	MX	Maximum value
Range	RYY	Auto range on
	R00 to R17	Manual ranges
	RNN	Auto range off, stay at present range
Terminators	YT	Two terminators: CR, LF
	YO	One terminator: CR
	YN	No terminator
Prefixes	PY	Prefix YES
	PN	Prefix NO
Triggers	T0	Continuous on ENT
	T1	One shot on ENT
	T3	One shot on TRG
	T5	One shot on measurement command
Status	U0	Send back current machine state
	U1	Send back error conditions
	U2	Send back revision levels
Self-Test	J0	Run self-test
Writable Store	WXXXXXX	Place XXXXXX in RAM

Forward Carrier Wave (FC)
Forward dBm (FD)
Reflected Carrier Wave (RC)
Reflected dBm (RD)

Function Selects forward or reflected RF power measurement mode.

Remarks Measurement results are returned in Watts or dBm.

Standing Wave Ratio (SW)
Return Loss (RL)

Function Selects SWR or return loss match measurement mode.

Remarks Measurement results are returned in VSWR or dB.

MINimum Value (MN)
MaXimum Value (MX)

Function Selects minimum or maximum measurement mode.

Remarks Another measurement must be selected before selecting min or max.
Returns the minimum (or maximum) value of the previous measurement type.

Range (Rxx)

Function Selects a measurement range listed in Figure 29.

Remarks If the selected range is outside the range of the connected power sensor, the command is ignored.

Figure 29
Measurement
Ranges

Command	Power Range
RYY	Turn auto range on
RNN	Turn auto range off. Keep present range
R17	18.0 – 199.9 MW
R16	1.80 – 19.99 MW
R15	0.180 – 1.999 MW
R14	18.0 – 199.9 kW
R13	1.80 – 19.99 kW
R12	0.180 – 1.999 kW
R11	18.0 – 199.9 W
R10	1.80 – 19.99 W
R09	0.180 – 1.999 W
R08	18.0 – 199.9 mW
R07	1.80 – 19.99 mW
R06	0.180 – 1.999 mW
R05	18.0 – 199.9 μ W
R04	1.80 – 19.99 μ W
R03	0.180 – 1.999 μ W
R02	18.0 – 199.9 nW
R01	1.80 – 19.99 nW
R00	0.180 – 1.999 nW

Terminators (Yx)

Function Selects the characters that follow the end of a data string. Set x to:

- “T” for two terminators; a carriage return(CR) and a line feed(LF).
- “O” for one terminator; a carriage return(CR).
- “N” for no terminator.

Remarks Many controllers use the terminator sequence to recognize the end of an input string. Using incorrect terminators can lock the bus.

Prefixes (Px)

- Function** Turns the prefix mode on or off. Set x to:
- “Y” to enable prefixes.
 - “N” to disable prefixes.
- Remarks** Prefixes are sent over the bus with the measurement, and indicate the status of the current measurement (see Figure 30 for examples):
- “FC”, “FD”, “RC”, “RD”, “SW”, “RL”, “MN”, “MX” indicates the measurement type.
 - “U” indicates underflow; the value sent is “.000”.
 - “O” indicates overflow; the value sent is “199.9”.
 - “N” indicates normal; the value sent is a normal on-scale reading.
 - “4421” indicates the Bird model number.

Figure 30
Prefix Examples

Data String	Description
NFC.0.123W(CR) (LF)	Normal (N) forward carrier wave (FC), prefixes on
OFC 199.9W(CR) (LF)	Overflowed (O) forward carrier wave (FC), prefixes on
199.9W(CR) (LF)	Overflowed forward carrier wave, prefixes off
URD .000W(CR) (LF)	Underflowed (U) reflected dBm (RD), prefixes on

Triggers (Tx)

- Function** Selects the condition which will trigger a reading (see Figure 31).
- Remarks** Failure to trigger device before requesting a reading will lock the bus. Fastest reading rate is 2.4 readings/second; slowest is 1 reading/sec.

Figure 31
Trigger Conditions

Command	Trigger Condition
T0	Continuous on ENT
T1	One shot on ENT
T3	One shot on TRG
T5	One shot on measurement command (FC, FD, RC, RD, SW, RL, MN, MX)

Status (Ux)

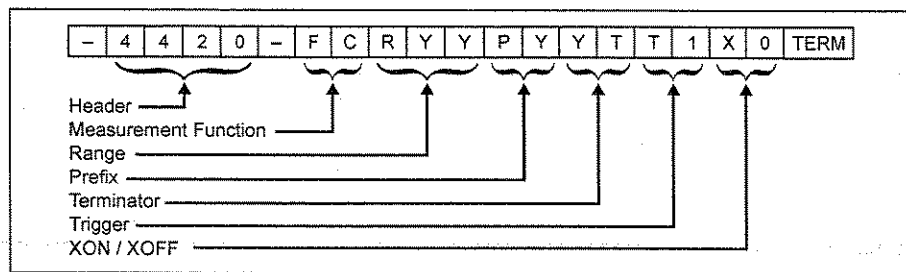
Function Reads a status word and returns the information as a string. Set x to:

- “0” for machine status.
- “1” for error status.
- “2” for revision history.

Remarks After sending the status command, a status word is sent the next time the unit is addressed to talk. To ensure the correct status is transmitted, the status word should be requested as soon as possible after the command is sent.

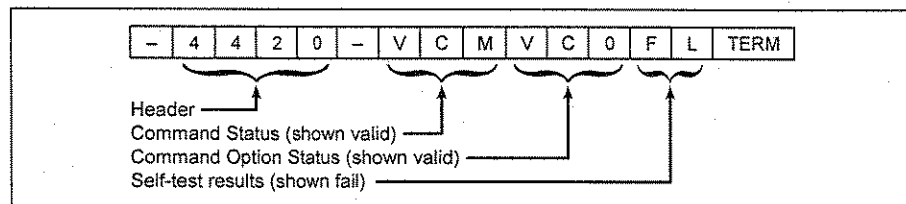
Machine Status Word (U0): The format of the machine status word is shown in Figure 32. The default values are also shown.

Figure 32
Machine Status
Word Format



Error Status Word (U1): The format of the error status word and the possible error messages are shown in Figure 33. All flags will revert to their non-error states after the U1 command is sent.

Figure 33
Error Status
Word Format

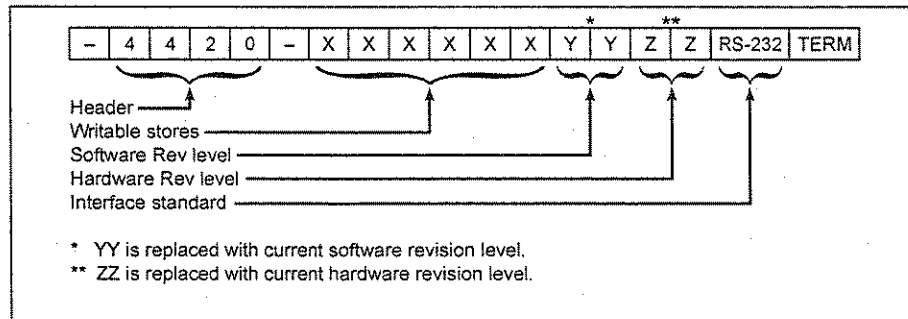


Status	Meaning	Description
ICM	Invalid Command	Set when an illegal device-dependent command (IDDC) such as V2 is received. (V is illegal)
VCM	Valid Command	Set when no IDDC is received.
ICO	Invalid Command Option	Set when an illegal device-dependent command option (IDDCO) such as T6 is received. (6 is illegal)
VCO	Valid Command Option	Set when no IDDCO is received.

PS	Self-test Pass	Set when a self-test has been initiated by the J0 command and the test result is acceptable.
FL	Self-test Fail	Set when the self-test has failed. (This is the default condition.)

Revision History Word (U2): The format of the revision history word is shown in Figure 34.

Figure 34
Revision History
Word Format



Self Test (J0)

Function Initiates a hardware and software test.

Remarks Results are stored in the U1 status word (see "Status" on page 36). "J0" must be sent each time before reading the result.

Writable Store (Wxxxxxx)

Function Storage for six bytes of ASCII data.

Remarks Data stored is lost when the 4421 is turned off.
Data is sent back as part of the U2 status word.