IRPlus Infrared Transmission Sensor

User's Manual

6510020274 (Supersedes 46022800)

IRPlus Infrared Transmission Sensor

May, 2007

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Produced in Canada

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Introduction

This manual provides a description of the operation and maintenance of the IRPlus Transmission Sensor. It applies only to the generic sensor. A “special” must be written to accommodate a specific application. There are no references to specific applications or to specific wavelengths or filters, except as examples.

This manual is applicable to the following sensors (model numbers 094624XX):

- IRPlus Single-Tower Direct Transmission Sensor
- IRPlus Single-Tower Offset Transmission Sensor
- IRPlus Double-Tower Direct and Offset Transmission Sensor

Audience

This manual is intended for use by engineers or process engineers and assumes that the reader has some knowledge of the operation of a paper machine and a basic understanding of mechanical, electrical and computer software concepts.

About This Manual

This manual contains three chapters.

Chapter 1, **Sensor Overview**, describes the main components of the sensor and how they function.

Chapter 2, **Maintenance and Troubleshooting,** describes common maintenance tasks and troubleshooting tips.

Chapter 3, **Principles of Operation,** describes how the sensor operates.

Related Reading

The following documents contain related reading material.

Honeywell P/N	Document Title / Description
MN462402	IRPlus Gauge General Calibration Procedure
	Infrared Sensor Maintenance Procedure
	Sensor Maintenance Common Interface
094624XX	IR Sensor Bill of Materials
PC427501	IR Backplane Functional Specification
PC427601	IR Detector Signal Conditioner

Conventions

The following conventions are used in this manual:

ATTENTION — Text may appear in uppercase or lowercase except as specified in these conventions.

`Boldface` Boldface characters in this special type indicate your input.

`Special Type` Characters in this special type that are not boldfaced indicate system prompts, responses, messages, or characters that appear on displays, keypads, or as menu selections.

Italics In a command line or error message, words and numbers shown in italics represent filenames, words, or numbers that can vary; for example, filename represents any filename.
In text, words shown in italics are manual titles, key terms, notes, cautions, or warnings.

Boldface	Boldface characters in this special type indicate button names, button menus, fields on a display, parameters, or commands that must be entered exactly as they appear.
lowercase	In an error message, words in lowercase are filenames or words that can vary. In a command line, words in lowercase indicate variable input.
Type	Type means to type the text on a keypad or keyboard.
Press	Press means to press a key or a button.
`[ENTER]` or `[RETURN]`	`[ENTER]` is the key you press to enter characters or commands into the system, or to accept a default option. In a command line, square brackets are included; for example: **`SXDEF 1`** `[ENTER]`
`[CTRL]`	`[CTRL]` is the key you press simultaneously with another key. This key is called different names on different systems; for example, `[CONTROL]`, or `[CTL]`.
`[KEY-1]-KEY-2`	Connected keys indicate that you must press the keys simultaneously; for example, `[CTRL]-C`.
Click	Click means to position the mouse pointer on an item, then quickly depress and release the mouse button. This action highlights or "selects," the item clicked.
Double-click	Double-click means to position the mouse pointer on an item, and then click the item twice in rapid succession. This action selects the item "double-clicked."
Drag X	Drag X means to move the mouse pointer to X, then press the mouse button and hold it down, while keeping the button down, move the mouse pointer.
Press X	Press X means to move the mouse pointer to the X button, then press the mouse button and hold it down.
ATTENTION	The attention icon appears beside a note box containing information that is important.
CAUTION	The caution icon appears beside a note box containing information that cautions you about potential equipment or material damage.
WARNING	The warning icon appears beside a note box containing information that warns you about potential bodily harm or catastrophic equipment damage.

Honeywell, Vancouver Operations Part Numbers

Honeywell, Vancouver Operations assigns a part number to every manual. Sample part numbers are as follows:

6510020004

6510020048 Rev 02

The first two digits of the part number are the same for all Honeywell, Vancouver Operations products. The next four digits identify part type. Type numbers 1002 designates technical publications. The next four digits identify the manual. These digits remain the same for all rewrites and revision packages of the manual for a particular product. Revision numbers are indicated after the Rev. If no revision numbers follow the part number, and then it is the first edition of the manual, Rev 00.

1. Sensor Overview

The sensor consists of three main sections:

- A source of modulated IR energy
- A sample cell in which the IR energy is caused to interact with the sample
- A receiver (Analyzer) in which the transmitted energy on all of the selected channels is simultaneously read

1.1. Source

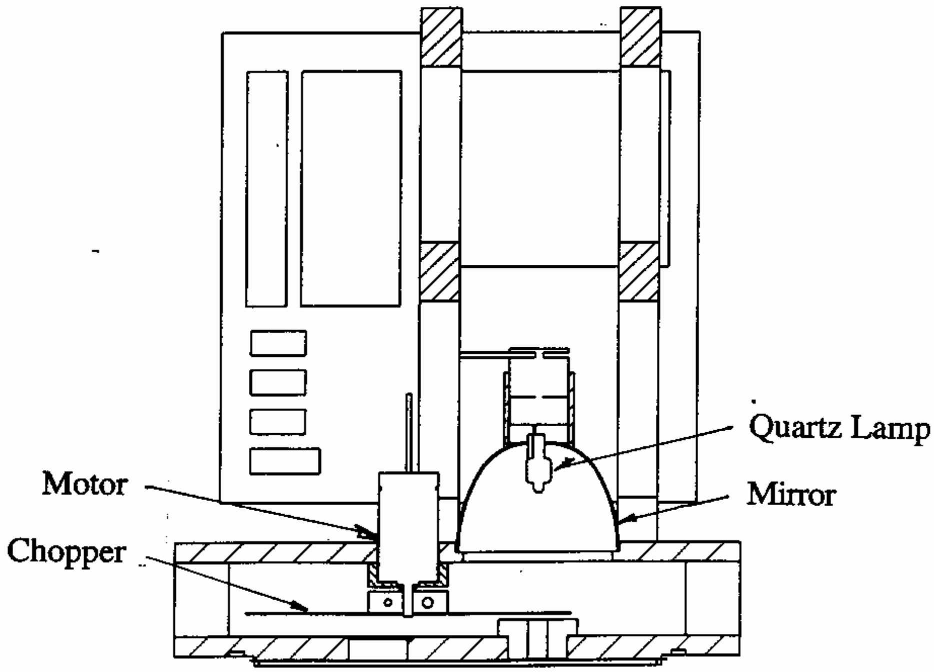

Figure 1-1 Source Assembly

The function of the source is to transmit pulses of wideband IR to the sample between the upper and lower heads.

1.1.1. Source description

The source consists of an incandescent light, a mirror, and supporting hardware for chopping the IR energy.

A Quartz Tungsten Halogen lamp is used because it is small, and the Quartz envelope is transparent to the IR energy in the wavebands of interest in the applications. The small filament of the lamp makes it possible to focus most of the energy onto the window.

Radiation from the Quartz Tungsten Halogen lamp is focused at a light pipe by the mirror. The only adjustment required is the focusing of the lamp by sliding it in the holder to maximize the signal strength at the receiver.

The chopper is a lightweight stainless steel disc with 8 evenly spaced holes. It is driven by a brushless DC motor that chops the radiation at 620 ±25 Hz. Chopping the light serves two purposes:

- The modulated light will prevent the signal received by the detectors in the receiver from being obscured by low frequency noise generated in the detector.
- Modulating the source is necessary to make the sensor insensitive to ambient light.

ATTENTION

If the lamp fails or becomes noisy, *both the lamp and the base must be changed*. Over time, the contacts in the base become burnt. Changing only the lamp (and not the base along with it) can result in poor or intermittent contact between the lamp pins and base, which results in a noisy sensor.

1.1.2. Source PCB

The source has a support PCB with the following functions:

- 5.0V DC/DC converter to power the IR lamp
- 9.0 ±0.3V regulator to drive the chopper motor
- ±15V supply for the onboard electronics
- Support for a Z sensor, if installed
- Ceiling temperature monitor
- Air temperature monitor
- Flag mechanism support
- External phase support

It also has test points:

TP1: +15V

TP2: -15V
TP3: Ground
TP4: Z out
TP5: Head Temp (Air)
TP6: Z Rtn
TP7: Ceiling Temp (Water Cooling)

1.1.3. Source diagnostics

Temperature of the air in the source housing

Motor voltage (9V)

If a second strip is added:

Temperature of the water-cooled ceiling plate

+15V auxiliary power

Lamp voltage (5V)

Lamp failure contact closure

1.2. Sample cell

The sample cell is the space between the source and receiver windows. It is here that the IR energy interacts with the sample. It is very important that the IR energy absorbed be determined only by the sample and not by extraneous effects, such as dirt and head alignment, or separation.

Sample cell may have direct or offset configuration. For double-tower sensors, it is possible to have a combination of both direct and offset for different channels.

1.3. Receiver

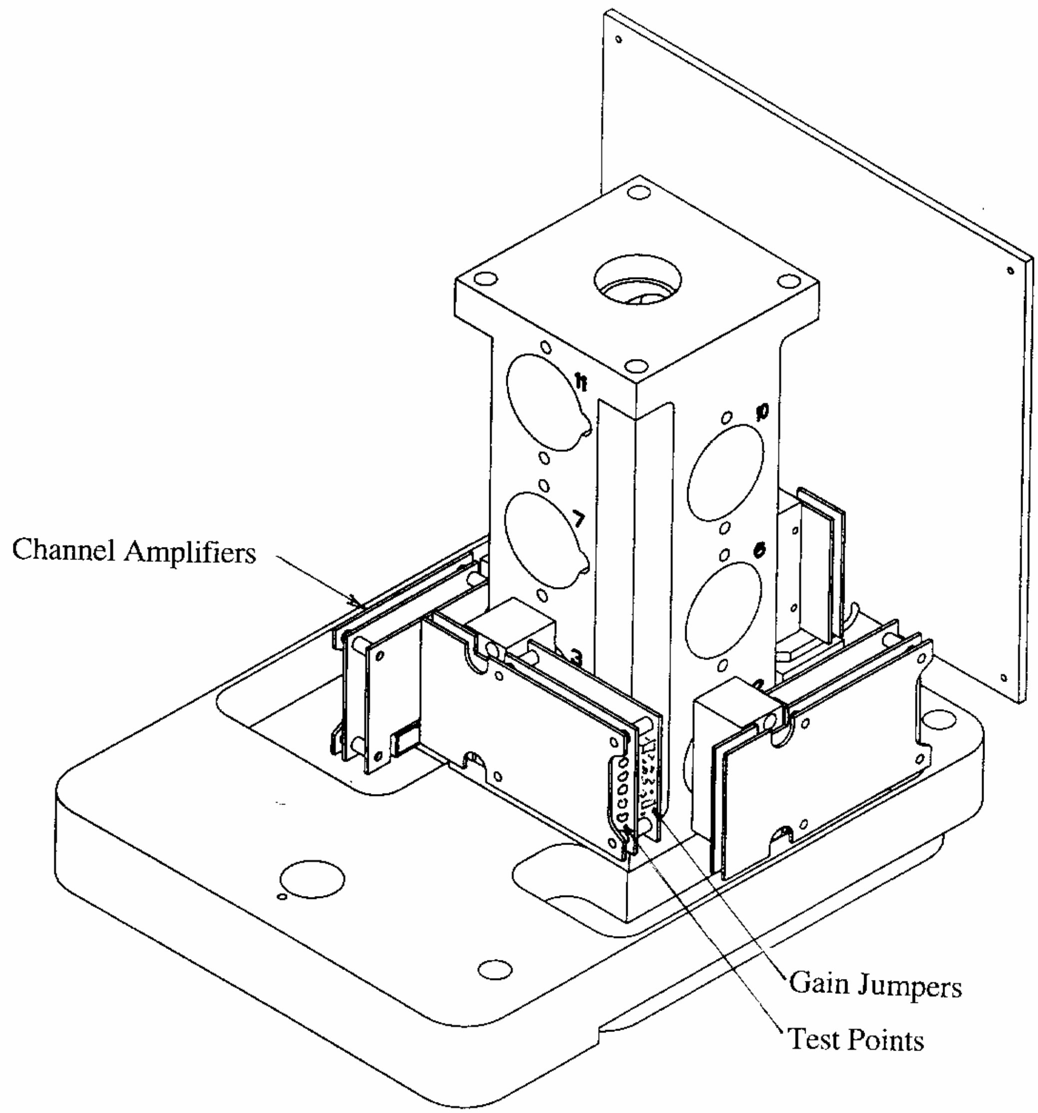

Figure 1-2 Receiver Assembly

The function of the receiver is to simultaneously read the transmitted energy in all of the selected bands. This is done by using beamsplitters to separate the energy into a series of parallel beams. Each beam is then passed through a filter designed to pass a predetermined waveband, and the total energy in that band is detected by a PbS Detector. Each detector has its own electronics that amplify the received signal, convert it to DC, and transmit it to the receiver backplane.

1.3.1. Receiver description

The receiver can support up to 12 channels, but only load as many as needed. The channels can be in the direct mode, in the offset mode, or in a combination of both modes. There is a PCB backplane and a central Aluminum column that supports up to 12 channels. The central Aluminum column is mounted to a water-cooled plate in the ceiling. In the standard configuration, water is allowed to flow "open loop" over the plate to cool the sensor; however, for most applications, temperature control to the heads is recommended.

Channels consisting of an IR band selection filter, a detector, and support electronics are added to the central column as required by the application. Heat from the electronics and Peltier cooling of the detectors is conducted from the detector assemblies through the column to the water-cooled plate. Channels are added sequentially, matching the numbers on the column to those on the backplane. To aid in the matching, both ends of the connecting ribbon cables are marked with the channel number.

1.3.2. Backplane PCB

The backplane provides the power and logic support for the channel support electronics. It also provides test points to monitor the power and the channel outputs.

Table 1-1 Backplane PCB Test Points

Test Point	Value	Comment
1	250 VDC	Bias for PbS or PbSe Cells
2	24 VDC	Power to PCB fused at 3A
3	24 Rtn	Power return line
4	+15 VDC	Supply for channel electronics
5	0V	Signal ground
6	-15 VDC	Supply for channel electronics
7	5 VDC	Power for Peltier coolers
8	250 or 15 VDC	Switched at Std if Gain used
9		Edge Adjust for Digital Output
10	5.5 to 9.2 VDC	TP10 to 32 Even Numbers Ch Out

Test Point		Value	Comment
11*	p/n 08682104, 08682105 & 08682106	0.8 to 1.2 VDC	TP11 to 33 Odd Numbers Cooler V
11*	p/n 08682114, 08682115 & 08682116	2.7 to 3.1 VDC	TP11 to 33 Odd Numbers Cooler V
11*	p/n 08682103 (no cooling)	0 VDC	TP11 to 33 Odd Numbers Cooler V
12		5 to 15 VAC	Master Phase

*Test point #11 value varies dependent on the detector model.

There is a 5A fuse (F2) in the 24V power line, and a spare (F1).

There is an onboard "GAL" (decoder) that takes three logic signals (DS1, DS2, and DS3) and outputs logic signals to **Dark**, **Gain Attenuate**, **Gain 1**, and **Gain 2**. The PCB is intended to be used with a Reflection Sensor so there is a **Tile** output.

The backplane also reads the stack temperature (returned on Power Track Strip #1) and water-cooled platform temperature on Strip #2.

Circuitry is included to support an optical edge detector with a potentiometer to set the level for a digital output.

The normal mode is to take the master reference phase from Channel #1. Channels 2 through 12 can either use the master phase or be self-demodulating (selected using jumpers W2 to W12). The master phase regime is recommended when the signal intensity is low so the detector gain is more than 25. Self-demodulation is preferable when the signal is strong and the detector gain is small. In exceptional circumstances, you can use an external reference phase (selected by using W13).

1.3.3. Detector/Amplifier (one per channel)

Each channel has a detector with support electronics connected to the backplane with an identified ribbon cable. The electronics consist of two boards:

- Peltier cooler board that cools and controls the temperature of the IR detector

- Signal conditioner that amplifies, rectifies, and filters the signal from the detector before transmitting it to the Analog-to-Digital Converter (ADC) in the central processor

Gain is set by two sets of jumpers: W1 to W5 and W6 to W8. There must be a jumper in each group.

W1	X 6	W6	X 100
W2	X 4	W7	X 10
W3	X 2.5	W8	X 1
W4	X 1.5		
W5	X 1		

Table 1-2 Detector Amplifier Test Points

Test Point		Observe	Comment
1		0 Volts	Ground
2		5.5 to 9.2 VDC	Signal Out
3		7 to 12 VAC pk-to-pk	Before Rectification
4		3 to 6V pk	Rectified Sine Wave
5*	p/n 08682103, 08682104, 08682105 & 08682106 only	20 mV to 8 VAC pk-to-pk	Buffered Signal fm Detector
5*	p/n 08682114, 08682115 & 08682116	5 to 15 VAC pk-to-pk	Phase Reference
6*	p/n 08682103, 08682104, 08682105 & 08682106 only	5 to 15 VAC pk-to-pk	Phase Reference
6(hidden)*	p/n 08682114, 08682115 & 08682116	Do not test	Buffered signal from Detector

*Test points #5 and #6 values vary dependent on the model.

The detector amplifiers must be kept clean. If they become contaminated, the buffered signal from the detector will have a DC bias. When amplified (especially by high gain), this can cause the signal to clip. In extreme cases, it can cause saturation so that the signal at test point 3 is observed to clip or to have no signal at all.

2. Maintenance and Troubleshooting

2.1. Maintenance

2.1.1. Equipment required

- Voltmeter
- Oscilloscope
- Repeatability samples (three samples sealed in glass are recommended)
- Sample paddle
- Logbook

In addition, a Personal Computer with spreadsheet and graphics software is helpful.

2.1.2. General preventive maintenance

Preventive maintenance, performed periodically, helps to anticipate possible failures and provides a baseline for sensor performance. Table 2-1 shows a recommended schedule for performing weekly and monthly preventive maintenance routines.

Table 2-1 Preventive Maintenance Task Schedule

Action	Weekly	Monthly
Background and Standardize Data LOG: Dark voltages, channel voltages, stack temperature, upper head temperature, lower head temperature, and ceiling temperature when available It is suggested that you average 5 consecutive readings during the course of a day. Enter the data into a spreadsheet and plot variables vs. date.	X	
Repeatability Data Move heads to standardize position and standardize the sensor Read the repeatability samples (3 recommended) LOG: Channel voltages and readings Enter the data into a spreadsheet and plot variables vs. date.	X	
Dynamic Sample LOG: Sensor readings, lab readings, dynamic constants Enter the data into a spreadsheet and plot variables vs. date.	X	
Reference Test – 30 consecutive repetitions LOG: Average voltages on each channel Standard deviation on each channel Enter the data into a spreadsheet and plot variables vs. date.		X

2.2. Troubleshooting

2.2.1. Basic guidelines

The following are basic sensor troubleshooting tips:

To isolate a potential problem, check these areas:

- Hardware – source, receiver, wiring
- Software – calibration constants

You can also:

- Use standardized values to plot information to help diagnose the problem.

- Refer to logbook data collected and graphed during Preventive Maintenance.

- Record all changes in the logbook dedicated to that system;

  for example:

  - Malfunctions and corrective actions on all hardware changes (filters, PCBs, detector modules, and source and base replacements)

  - Changes to the software or calibration constants, addition or deletion of codes, and profile corrections

Implement changes one at a time, or at least make the changes in a logical sequential order. Clearly label the data collected - that will help to identify what steps or series of steps caused the problem to disappear.

2.2.2. General practices for troubleshooting

The IR sensor is designed to be very reliable, so problems are rare. When a problem is suspected, make sure that the problem really exists.

IR sensor problems fall into three main groups: calibration errors, sensor noise, and drift. It is easy to diagnose a catastrophic failure of the IR lamp, chopper motor, or a channel, and to replace the defective part.

When the cover is off the receiver, measure the outputs on all of the test points on the backplane. See Table 1-1 for all of the Peltier cooler voltages. Compare the channel output voltages with those measured by the system.

ATTENTION	Remember that the system subtracts the dark offset.

This will show up any grounding or wiring problems. If noise is a problem, look at the test points with a scope. Check the grounds (both electronic and platform) for continuity. A bad ground will result in a noisy sensor.

Table 2-2 Symptom-Based Troubleshooting Guide

Symptom	Probable Causes	Solution
There is no light on the source.	Lamp, or poor contact between the base and the lamp	Replace *both the lamp and the base*. When replacing the lamp, do not touch the quartz envelope with your fingers. The grease from your fingers will react with the quartz and will lead to early failure. To clean the lamp, use pure alcohol or lens cleaner. Adjust the lamp position to maximize the signal in the receiver as read at the output of one of the channels.
All channels show increased noise or drift in the same direction.	Lamp flickering or poor contact between the base and the lamp	Replace *both the lamp and the base*.
Noise or drift persists in all channels.	Problem continues after changing the lamp and base, especially if it is drift and the signal strength is not restored.	Split the heads. *Remove the source window*: 1. Inspect the window and light pipe, and clean them if necessary. 2. Inspect the mirror for signs of tarnishing. If it needs cleaning, remove the lamp and base (there is no need to disconnect it). Be very gentle when cleaning it to avoid damaging the Aluminum coating. Use a lens cloth or cotton swab and pure alcohol (not tissue). *Remove the receiver window*: 1. Inspect the window and clean it if necessary. 2. Inspect the base of the optics stack to make sure the lens is in place.
Noise or drift is in one channel.	Detector amplifier unit	Replace the unit after setting the gain to be the same as the old one. If the problem is still there, and it is a moisture channel, look for moisture on the quartz plates and light pipes. Give the sensor a general inspection, looking for condensation or any other source of moisture.

2.2.3. Calibration and dynamic check problems

When a “bad check” is received from the lab, the first thing to do is check the repeatability samples. Perform the complete preventive maintenance procedure.

ATTENTION

Be sure to read the samples *both before and after* cleaning the sensor. If the problem is due to dirt, cleaning the sensor first will destroy the evidence.

If the repeatability samples check out properly, have the lab do another test. Assist the tester, if possible.

Assuming that both the lab and the sensor appear good but do not agree, there is a dynamic problem. These are difficult to find. Some suggestions on how to proceed:

To catch a bad power track or an error in software, such as a bad entry:

1. Scan on a known sample to see if it reads correctly.
2. Watch the on-sheet readings to look for dropouts.
3. Go to single point and check the readings.
4. Do a pass-line test.

   All IR sensors have some pass-line sensitivity that gets worse as the gap is increased.

   This test is important if the position of the sheet in the gap has changed for some reason.

5. Do a sheet temperature test by putting a hot sheet in the gap and letting it cool down while sampling.

   There is almost always some sheet temperature effect. You must determine whether the sheet temperature could have changed enough to cause the effect.

2.2.4. Dynamic constants

There is always a difference between the readings from the sensor and the lab checks. The dynamic constants make it easy to adjust the sensor to give the same readings as the lab.

A common mistake is to adjust the values of the constants too often. The values should only be changed when it is statistically clear that there is a difference between the sensor and the lab. Over time, the log of the dynamic constants, the sensor readings, and the lab readings can provide valuable information. For example, with this information, perhaps the dynamic constants can be removed and the true variation between the sensor and lab observed.

3. Basic Measurement Principles

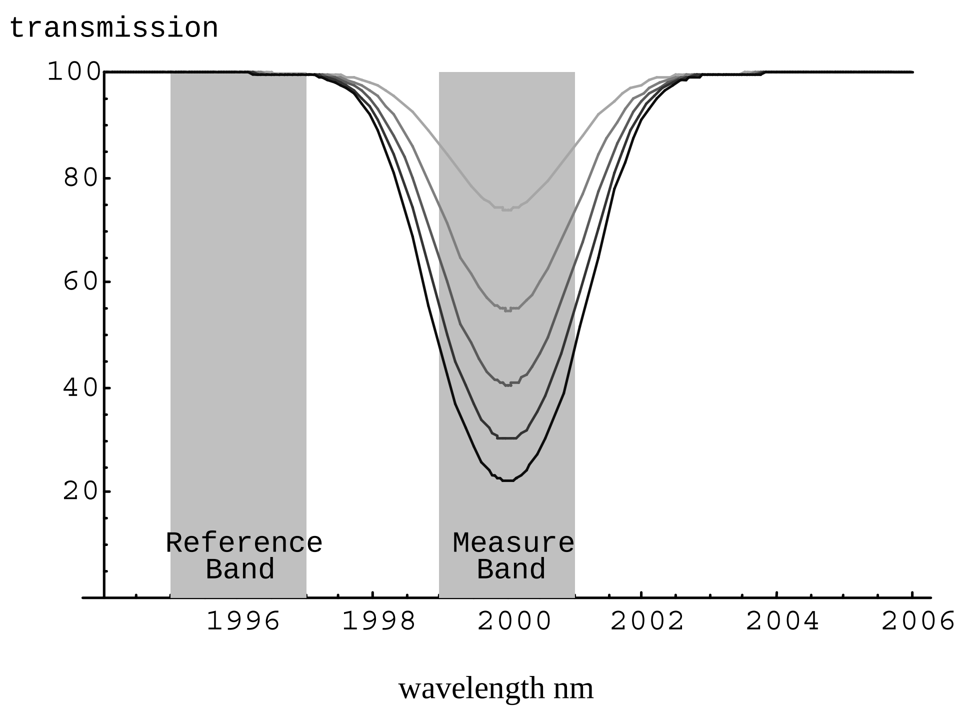

Figure 3-1 Measure Band and Reference Band

The IR gauge works by measuring the relative amount of light absorbed by a sample in two or more wavelength bands of the IR spectrum. In the simplest case, the sensor monitors two bands: a measure band and a reference band.

The measure band is selected to coincide with a strong absorption in the target material. The reference band is selected to match a weakly absorbing region of the target material. In more complicated cases, the measure band for one target may be the reference band for another target.

The measurement is based on Beer's Law:

$I = I_0 * e^{-\mu w}$

or

$w = (\text{Ln } I_0 / I) / \mu$ (1)

where:

I_0 is the Signal with no sample (Signal at Standardize)

I is the Signal with a sample

μ is the Absorption Coefficient

w is the Weight of the sample

This equation holds true for monochromatic energy. In practice, both the absorption band and IR transmission filter encompass a range of wavelengths. The detector sums all the transmitted energy in the pass band, and this optical signal is converted to an electrical signal. This has the effect of making the logarithmic relationship of equation (1) approximately linear. Thus,

$W \cong A_0 + A_1 * (I_0/I)$

where:

A_1 and A_0 are constants.

The slight nonlinearity can be corrected by including higher order terms in the equation:

$W = A_0 + A_1 * (I_0/I) + A_2 * (I_0/I)^2 + A_3 * (I_0/I)^3$ (2)

Equation (2) would give the correct weight if there were no surface reflections or non-spectral attenuation. You cannot measure I_0 at the same time that you read I, so read the value of the signal with no sample (Standardization). The value (I_0/I) is known as the channel ratio and is a way of normalizing the received signal I.

To take account of non-spectral effects, read the transmitted signal at one or both sides of the absorption band, then ratio the measured signal to this reference.

Ratio $R = (I_0/I)_{Mes} / (I_0/I)_{Ref}$

Ratio R is substituted for the value (I_0/I) in equation (2) to yield:

$W = A_0 + A_1{*}R + A_2{*}R^2 + A_3{*}R^3$ (3)

In practice, the absorption bands are rarely as clean as the above example. Usually there are overlapping bands from one or more components. Sometimes you can find a reference band that is absorbed the same amount by the interfering component as the component of interest.

You can then use this band to balance the effect of the interference.

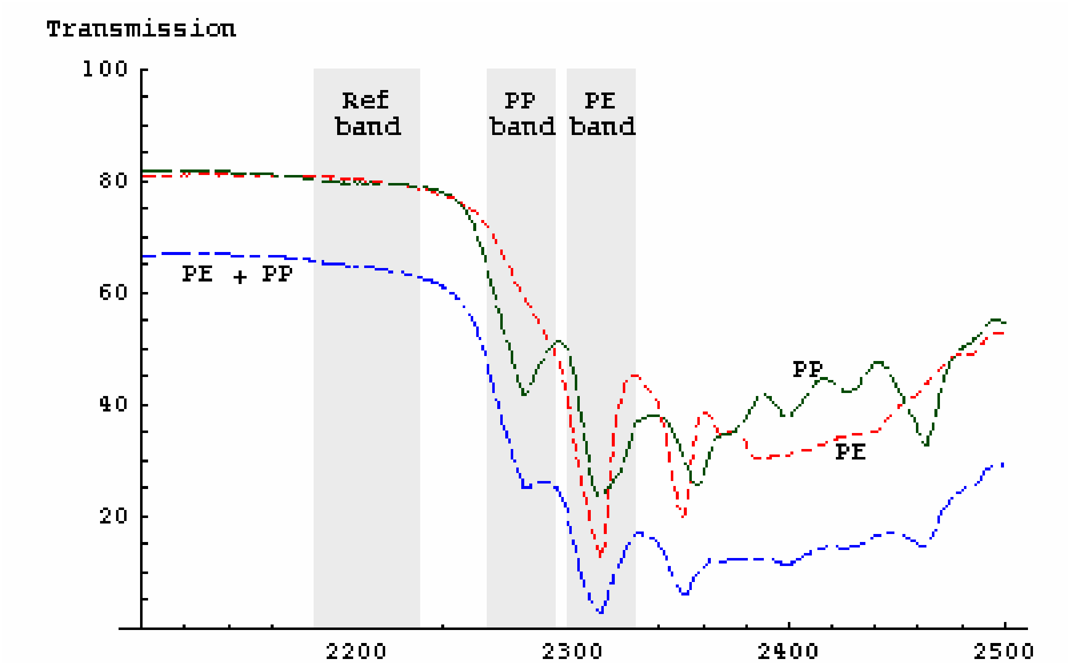

Figure 3-2 wavelength nm

In many applications there are multiple overlapping bands, and it becomes necessary to read them all and to correct for the interference in software. To do this, you need known samples in which each component is varied independently. Once samples are read and all the data entered, the calibration program is able to determine all of the calibration coefficients for an equation that is an expansion of (3) for which you determine ratios for each component.

$$W_i = A_0 \quad + A_{11} \cdot WR_1 + A_{12} \cdot WR_1^2 + \ldots + A_{1j} \cdot WR_1^j$$

$$+ A_{21} \cdot WR_2 + \ldots + A_{2k} \cdot WR_2^k$$

$$+ \ldots$$

$$+ A_{n1} \cdot WR_n + \ldots + A_{nm} \cdot WR_n^m$$

In the equation, **i** is an index for each component, and **Wi** is the weight of the ith component. There is only one $\mathbf{A_0}$ since a separate constant for each ratio polynomial would be redundant. Typically, real world calibrations are limited to either one row of the above or to the first non-constant column.