

Pacemaker Counter and Histogram Operation / Interpretation

BACKGROUND INFORMATION

The information in this article is intended to clarify the operation and interpretation of dual-chamber pace/sense counter totals and A-V histogram bars available in PULSAR MAX II, DISCOVERY II and INSIGNIA pacemakers.

This article was first published as a *Product Update* in May 2003.

COUNTERS

There are three basic sets of pace/sense event counters, as depicted in Figure 1 below:

1. Combination A-V events
2. Atrial-only events
3. Ventricular-only events

	<u>Percent of total count</u>	<u>Total count since last reset</u>	
Paced and Sensed			
A-sensed / V-sensed	38%	7.0M	← 18.5M Total
A-sensed / V-paced	26%	4.8M	
A-paced / V-sensed	5%	939.7K	
A-paced / V-paced	31%	5.8M	
Atrial			
Paced	44%	6.3M	← 14.5M Total
Sensed	56%	8.2M	
Ventricular			
Paced	57%	10.6M	← 18.5M Total
Sensed	43%	7.9M	

Figure 1. Pace/Sense Counters

Counter Data Sources

The data for each of the event counters come from different sources:

1. Combination A-V events are derived from ventricular activity, and then categorized based upon the immediately preceding atrial event:
 - First, the ventricular event is designated as either paced or sensed.
 - Next, the atrial event immediately preceding the ventricular event is classified as either paced or sensed.
 - Finally, the overall A-V combination is assigned to one of four possible A-V pace/sense bins (refer to Figure 1).
2. Atrial-only events are derived solely from the atrial channel and assigned to either the paced or sensed bin.
3. Ventricular-only events are derived solely from the ventricular channel and assigned to either the paced or sensed bin.

Comparing Counter Data

Counter totals can be analyzed as follows:

- The total of the combination A-V event counters will always match the total of the ventricular-only event counters, as both sets of counters are derived from the same ventricular events (refer to Figure 1).

CRM PRODUCTS REFERENCED*
PULSAR MAX II, DISCOVERY II, and INSIGNIA

*Products referenced herein may not be approved in all geographies.

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- The total of the **combination A-V event counters** will only match the total of the **atrial-only event counters** in situations of 1:1 A-V conduction in dual-chamber mode. In this scenario, every ventricular event is preceded by one and only one atrial event, so all counters will be equal.
- The total of the **combination A-V event counters** will often not match the total of the **atrial-only counters** because the atrium and the ventricle often work independent of each other (as seen in Figure 1). Examples of common situations resulting in dissociation of the counters include:
 - Atrial arrhythmias (more than one A event for each V event)
 - Ventricular arrhythmias (more than one V event for each A event)
(Note that PVCs are not included in the ventricular pace/sense counters; instead, they have their own separate counters.)
 - Programming the device to a single-chamber mode--AAI(R) or VVI(R)

Counter Examples in Various Modes

Below are more examples of counter data that may be observed in the clinical setting:

Example 1: A dual-chamber device programmed in DDI(R) mode in a patient with frequent atrial fibrillation (refer to Figure 2)

Note that because of the A-Fib, a large number of atrial-sensed events are recorded in the atrial-only event counter. This data is not represented in the combination A-V event counters, since the combination A-V event counter recognizes only the single atrial event immediately preceding the associated ventricular event.

Paced and Sensed		
A- sensed / V-sensed	0%	0
A- sensed / V-paced	16%	190,0K
A- paced / V-sensed	0%	0
A- paced / V-paced	84%	990,0K
Atrial		
Paced	35%	990,0K
Sensed	65%	3.8M
Ventricular		
Paced	100%	1.2M
Sensed	0%	0

Difference due to atrial fibrillation

Figure 2. DDI(R) Counter Example

Example 2: A dual-chamber device programmed to VVI(R) mode (refer to Figure 3)

Note that in VVI mode, the A-V event counters are populated even though a lack of atrial sensing prevents classification of combination A-V events. This is because the source data is the same for both fields (ventricular-only events). As a default, the ventricular events are binned as having been preceded by atrial sensed events, even though no atrial data has been collected. Nevertheless, both totals are fully accurate. In addition, note that the totals are also equal.

Paced and Sensed		
A- sensed / V-sensed	38%	141.8K
A- sensed / V-paced	62%	231.4K
A- paced / V-sensed	0%	0
A- paced / V-paced	0%	0
Atrial		
Paced	0%	0
Sensed	0%	0
Ventricular		
Paced	62%	231.4K
Sensed	38%	141.8K

Figure 3. VVI(R) Counter Example

Example 3: A dual-chamber device programmed to AAI(R) mode (refer to Figure 4)

Note that in AAI mode, the A-V event counters are not populated, because the source data for these counters are derived from ventricular activity.

Paced and Sensed		
A-sensed / V-sensed	0%	0
A-sensed / V-paced	0%	0
A-paced / V-sensed	0%	0
A-paced / V-paced	0%	0
Atrial		
Paced	91%	182K
Sensed	9%	18K
Ventricular		
Paced	0%	0
Sensed	0%	0

Figure 4. AAI(R) Counter Example

HISTOGRAMS

Histograms provide a graphical representation of counter data. While counters provide pace and sense totals, histograms display the amount of time spent pacing and sensing at various rates. This information may facilitate diagnostic interpretation of cardiac activity, which can then be used to program devices in a way that maximizes therapeutic benefits for the patient.

Although the histogram bar chart has the ability to scale the vertical axis to 50% or 100%, depending upon the maximum values in specific event counters, it is possible to see an atrial sensed histogram bar extend beyond the chart boundaries when the histogram is printed, as depicted in Figure 5 below:

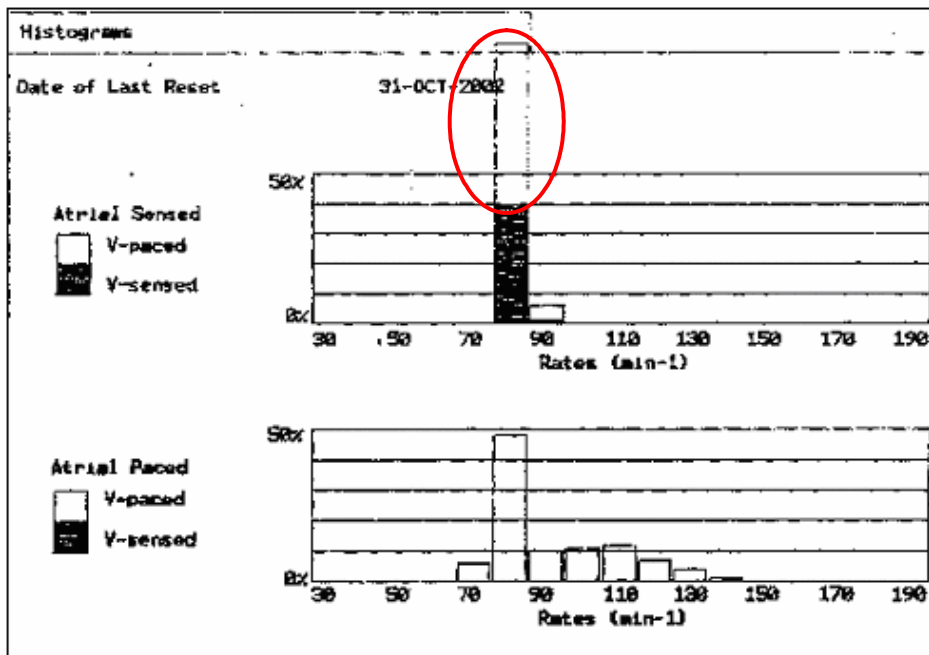


Figure 5. A-V Histogram Printout

When plotting A-V histograms, the decision to display either 50% or 100% as the maximum Y-axis scale value is determined by the highest percentage of either the ventricular-paced/sensed events or atrial-paced events (i.e., if the percentage at any given rate exceeds 50%, then the scale will be displayed at 100%). Even though the maximum values in the atrial-sensed bins may exceed 50%, they are not considered in the scale selection process.

Based upon this logic, the condition seen in Figure 5 will occur **only if**:

1. The highest frequency of ventricular-paced/sensed or atrial-paced events at any given rate is less than 50%, setting the maximum Y-axis scale value to 50% (rather than 100%), **AND**
2. Atrial-sensed events occur with a frequency greater than 50% at any given rate. Because this value is greater than the set Y-axis scale value of 50%, the histogram bar will appear above the previously scaled Y-axis.

It is important to note that in this situation, the printed histogram differs from the histogram displayed on the programmer. On the programmer screen, the bar noted above is automatically truncated and will not extend beyond the top of the grid; this means that the graphical display will differ, but the printed version will correctly display the appropriate pacing percentage.

Note that unusual Y-axis scaling will not occur with the atrial or ventricular (Pace/Sense) histograms because scale selection is based solely on a single maximum count (no combinations).