Tech Corner

Automatic refractory periods

in MicroPort pacemakers

NOTE: PLEASE NOTE THAT THE FOLLOWING INFORMATION IS A GENERAL DESCRIPTION OF THE FUNCTION. DETAILS AND PARTICULAR CASES ARE NOT DESCRIBED IN THE ARTICLE. FOR ADDITIONAL EXPLANATION PLEASE CONTACT YOUR SALES REPRESENTATIVE.

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MicroPort

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AVAILABILITY

The refractory periods described below are available for all MicroPort pacemakers.

DEFINITION

The refractory period is a time interval starting after pacing or sensing an event in the ventricular and/or atrial cavity. There are two types of refractory periods:

1. The **absolute refractory period (or blanking)**: This is the time interval during which there is no detection. The aim of this period is to protect the device from multiple detections of the same contraction or post-potential detection of the spike, as well as farfield sensing[1] or crosstalk[2]. **During this period, the device is not allowed to sense, nor to pace**.

2. The **relative refractory period:** This is the time interval during which sensed events are taken into account for the arrhythmia diagnosis and the functioning of some algorithms (for ex: Anti-PMT algorithm), but do not initiate any synchronisation intervals. The aim of this period is to avoid triggering synchronisation intervals on "incorrect" events such as retrograde P waves, farfield R waves, interferences, etc. **During this period, the device senses but is not allowed to pace**.

GENERAL CONCEPT

In MicroPort pacemakers, the absolute refractory periods are fully automatic, *i.e.* they are managed automatically by the device, except for:

- two refractory periods in ALIZEA BOREA CELEA: the Post V[3] Atrial Blanking and the Post R[4] Atrial Blanking
- one refractory period in ENO TEO OTO and previous generations: the Post Ventricular Atrial Blanking (PVAB).

[1] Farfield sensing: the intrinsic signal (P wave or R wave) is detected by the lead implanted in the other cavity.

[2] Crosstalk: the spike is detected by the lead implanted in the other cavity.

[3] Ventricular pacing

[4] R wave sensing

The total duration of the refractory period is a fixed minimum value, which is prolonged automatically by the device hardware, in the event of a sensed signal within the last part of the period.

Each absolute refractory period is made of 2 periods: one fixed and one retriggerable period.

Refractory periods are made of 2 periods: one fixed (1st period, in blue here), one retriggerable (2nd period, in grey here)

1. **One fixed absolute refractory period:** during this interval the pacemaker cannot sense any events
2. **One retriggerable period:** this second period shall be considered as "absolute" for the user but is "relative" for the hardware (*i.e.* sensing circuits are able to sense the cavity). If a signal is sensed by the pacemaker during this period, the hardware will prolong ("retrigger") the interval by 50 ms, as any signal sensed during this interval cannot be physiologic and therefore shall not be considered as an intrinsic cardiac signal (and should not initiate a new escape interval). The aim of this period is to protect the device from noise detection, such as EMI or myopotentials.

	1st period	2nd period
Hardware	Absolute	Relative retriggerable
Software/User	Absolute	Absolute

REFRACTORY PERIODS IN A SINGLE CHAMBER PACEMAKER

VVI mode

In VVI mode, a ventricular absolute refractory period is triggered after any paced and sensed ventricular event. The aim of this ventricular refractory period (VRP) is to avoid:

- post-potential detection of the ventricular spike
- double counting of the R wave

Notes:

1. If the ventricular refractory period is too short, there is a risk of R wave oversensing, which could result in pacing inhibition.
2. If the ventricular refractory period is too long, there is a risk of undersensing of premature events, which could result in pacing on the T-wave of the premature events.

VENTRICULAR REFRACTORY PERIOD POST R WAVE

On R wave detection, the VVI mode triggers a non-programmable absolute ventricular refractory period of **100 ms**. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The maximum total duration of the prolonged refractory period is equal to the basic ventricular escape interval.

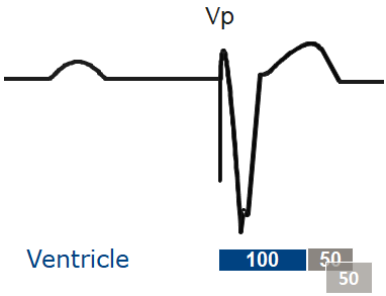
Note: If a signal is sensed within the last 50 ms of the refractory period, it cannot be the T wave since it is already filtered by the device.

On R wave detection, VVI mode triggers a non-programmable absolute refractory period of 100 ms.

VENTRICULAR REFRACTORY PERIOD POST V PACING

On a paced ventricular event, the VVI mode triggers a non-programmable absolute ventricular refractory period of **150 ms**. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The maximum total duration of the prolonged refractory period is equal to the basic ventricular escape interval.



On a ventricular pacing, the VVI mode triggers a non-programmable absolute refractory period of 150 ms.

AAI mode

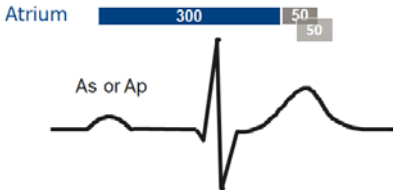
In AAI mode, an atrial absolute refractory period, is triggered after any paced or sensed atrial event. The aim of this atrial refractory period (ARP) is to avoid:

- double counting of the P wave,
- R wave farfield sensing, *i.e.* sensing in the atrial channel of the spontaneous ventricular depolarization, which would trigger an inappropriate escape interval.

ATRIAL REFRACTORY PERIOD POST P WAVE DETECTION OR POST ATRIAL PACING

On P wave detection or a paced atrial event, the AAI mode triggers a non-programmable absolute atrial refractory period of **350 ms**. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The maximum total duration of the prolonged refractory period is equal to the basic atrial escape interval.



On P wave detection or atrial pacing, the AAI mode triggers a non programmable absolute refractory period of 350 ms.

REFRACTORY PERIODS IN A DUAL CHAMBER PACEMAKER

In dual-chamber pacing mode, atrial and ventricular absolute refractory periods are triggered after any paced or sensed event in the considered cavity, but also in the other cavity (the so-called "blanking" period):

- in the cavity where the depolarization occurs, in order to avoid multiple detections of the same complex
- in the cavity where the spike is triggered, in order to protect the device against the post-potential detection
- in the other cavity, in order to protect the device against farfield sensing or crosstalk

Refractory periods post atrial events

Absolute atrial and ventricular refractory periods are triggered after any paced and sensed atrial event.

Note: In MicroPort pacemakers, after any sensed or paced atrial event, a relative and dynamic atrial refractory period (WARAD: Window of Atrial Rate Acceleration Detection) is also triggered (except in DDI mode), which duration depends on the ongoing atrial rhythm. This dynamic window is effective only once the atrial refractory period is over. The aim is to detect atrial premature contraction (see the Tech Corner article on the WARAD and Fallback Mode Switch for more details).

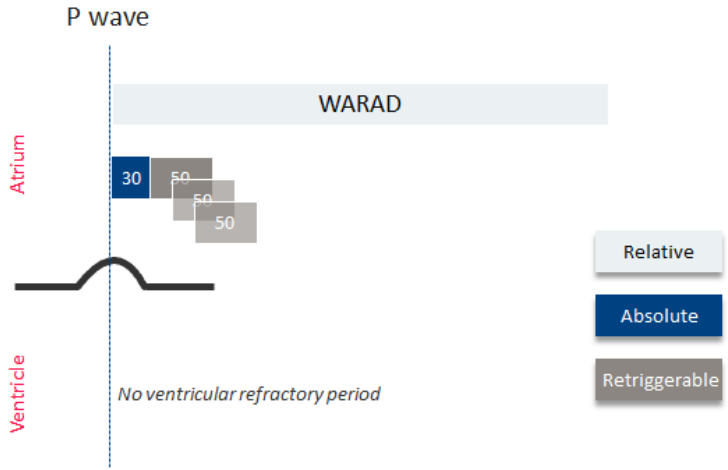
POST P WAVE

Atrial refractory period post P wave: On P wave detection, a non-programmable absolute atrial refractory period of **80 ms** is triggered. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The aim is to avoid double counting of the P wave.

The maximum total duration of the prolonged refractory period is equal to the AV delay (atrial escape interval in AAI mode of SafeR).

Ventricular refractory period post P wave: There is no ventricular refractory period post atrial sensed event.



Refractory periods post P wave

POST ATRIAL PACING

Atrial refractory period post atrial pacing: On a paced atrial event, an absolute atrial refractory period is triggered. Its duration is equal to the programmed AV delay + paced/sensed offset (except in AAI mode of SafeR, see below).

The aim is to avoid post-potential detection of the atrial spike.

Atrial refractory period post atrial pacing in Safer: In AAI mode of SafeR, on a paced atrial event, a non-programmable absolute atrial refractory period of **150 ms** is triggered. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The maximum total duration of the prolonged refractory period is equal to the atrial escape interval.

Note: in AAI mode of SafeR, all other atrial refractory periods are the same as in DDD mode.

Ventricular refractory periods post atrial pacing

- **Ventricular blanking:** On a paced atrial event, a non-programmable absolute ventricular refractory period (blanking) of **30 ms** is triggered. This period is automatically prolonged by 15 ms if a signal is sensed in the last 15 ms of the period.

  The aim of this ventricular blanking is to avoid AV crosstalk (detection of the atrial spike by the ventricular channel), which would inhibit the ventricular pacing (available in DDD(R), DDI(R) and SafeR(R) pacing modes). The maximum total duration of the prolonged refractory period is equal to 50 ms.

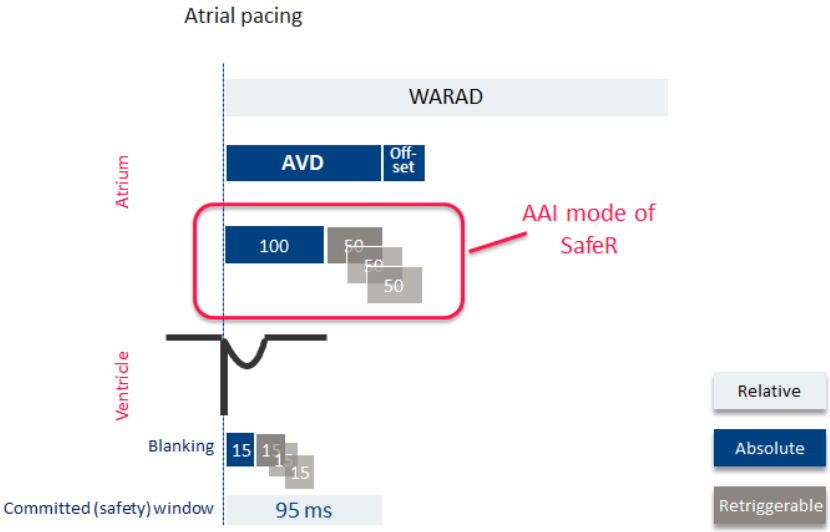
- **Committed window (or Safety window):** On a paced atrial event, a non-programmable relative ventricular refractory period (committed window) of **95 ms** is triggered. It is effective at the end of the ventricular blanking (see above paragraph).

  The committed window is a ventricular sensing window, which has a "complementary role" to the ventricular blanking post atrial pacing. The aim is to avoid inappropriate inhibition of the ventricular pacing when the atrial spike is sensed by the ventricular channel (available in DDD, DDI and SafeR).

  If ventricular sensing occurs between the end of the ventricular blanking and the end of the committed window, it is considered as a non-physiological event by the device. Therefore it triggers ventricular pacing at the end of the committed window.

  - If the ventricular oversensed signal is the result of AV crosstalk, the ventricular spike at the end of the committed window captures the ventricle safely
  - If the sensed signal is the result of a late premature ventricular contraction, the ventricular spike at the end of the committed window occurs during the natural refractory period of the cardiac cells, and not on the T-wave.

Note: **When SafeR is programmed**, and the device works in AAI (ADI), if sensing occurs within the committed window, the device does not pace the ventricle at the end of the committed window. The atrial event is considered as a blocked atrial event and the device switches into DDD after two consecutive blocked atrial events ("3rd AV Block criterion") or on the Pause criterion: the switch will be labelled "safety criterion". The second degree AV block criterion is suspended for 12 cycles after sensing in the committed window (see the Tech Corner article on SafeR here for more details).



Refractory periods post atrial pacing

Refractory periods post ventricular events

Absolute atrial and ventricular refractory periods are triggered after any paced and sensed ventricular event.

POST R WAVE

Ventricular refractory period post R wave: On R wave detection, a non-programmable absolute ventricular refractory period of **100 ms** is triggered. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The aim is to avoid double counting of the R wave.

The maximum total duration of the prolonged refractory period is equal to the basic ventricular escape interval.

Atrial refractory period post R wave: On R wave detection, a programmable absolute atrial refractory period of **95 ms** (as-shipped value) is triggered. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The aim is to avoid R wave farfield sensing, *i.e.* sensing in the atrial channel of the spontaneous ventricular depolarization.

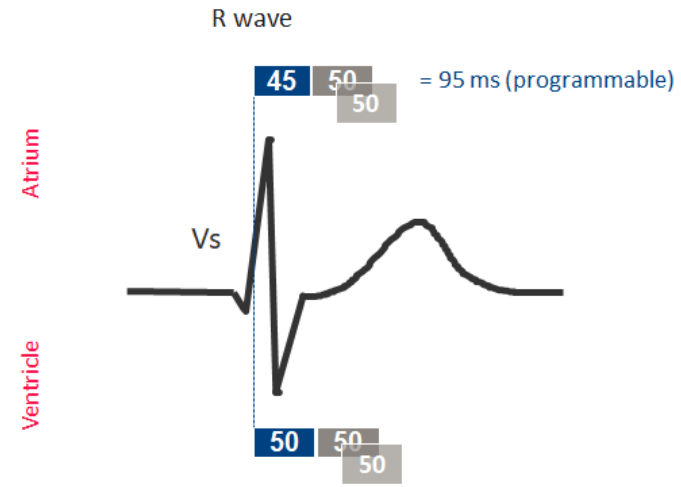
The maximum total duration of the prolonged refractory period is equal to the VA escape interval.

This value is programmable through:

- The parameter "Post R Atrial Blanking" in ALIZEA, BOREA and CELEA
- The parameter "PVAB" in ENO, TEO, OTO and previous generations: the post R wave refractory period will be equal to the programmed PVAB – 55 ms.

Notes:

1. The as-shipped value is the shortest value that can be programmed (95 ms).
2. In the event of VA farfield sensing, the "Post R Atrial Blanking" or the "PVAB" shall be reprogrammed to a longer value.
3. For ENO, TEO, OTO and previous generations, when the PVAB parameter (post V pacing) is reprogrammed, it also changes the value of the PVAB post V sensing.



Refractory periods post R wave

POST VENTRICUAL PACING

Ventricular refractory periods post ventricular pacing: On a paced ventricular event, a non-programmable absolute ventricular refractory period of **150 ms** is triggered. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The aim is to avoid the post potential detection of the ventricular spike.

The maximum total duration of the prolonged refractory period is equal to the basic ventricular escape interval.

Atrial refractory periods post ventricular pacing: On a paced ventricular event, a programmable absolute atrial refractory period of **150 ms** (as-shipped value) is triggered. This period is automatically prolonged by 50 ms if a signal is sensed in the last 50 ms of the period.

The aim is to avoid VA crosstalk, *i.e.* sensing in the atrial channel of post potentials of the ventricular spike or the ventricular depolarization of the paced ventricle.

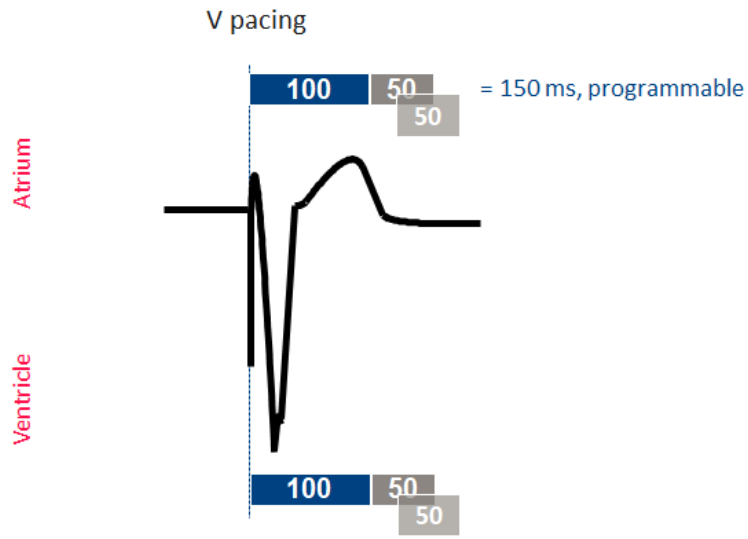
The maximum total duration of the prolonged refractory period is equal to the VA escape interval.

This value is programmable through:

- The parameter “Post V Atrial Blanking” in ALIZEA, BOREA and CELEA (as-shipped: 150 ms)
- The parameter “PVAB” (Post Ventricular Atrial Blanking) in ENO, TEO, OTO and previous generations (as-shipped: 150 ms).

Notes:

1. The as-shipped value is the shortest value that can be programmed (150 ms).
2. In the event of VA crosstalk, the “Post V Atrial Blanking” or the “PVAB” shall be reprogrammed to a longer value.
3. For ENO, TEO, OTO and previous generations, when the PVAB parameter (post V pacing) is reprogrammed, it also changes the value of the PVAB post V sensing.



Refractory periods post ventricular pacing

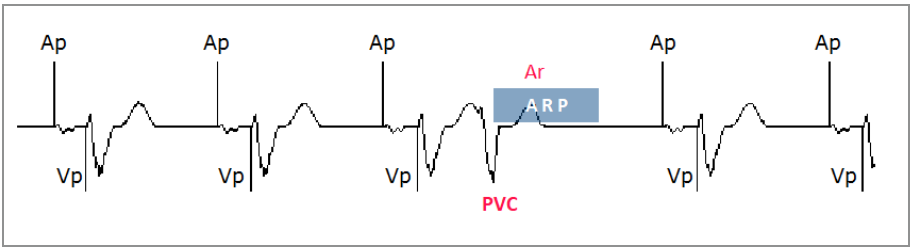
POST PREMATURE VENTRICULAR COMPLEX (PVC)

Definition of a PVC in MicroPort dual chamber pacemakers:

- In DDD and Dplus: A ventricular event is considered as a PVC if it is not preceded by an atrial event within the 313 ms before the considered ventricular event.
- In SafeR: A ventricular event is considered as a PVC if there is no atrial event within the ventricular cycle.

In a dual chamber device, when a premature ventricular complex (PVC) is detected, the device triggers a relative post-ventricular atrial refractory period (ARP). The ARP is fixed at 500 ms (not programmable).

The aim is to avoid a PMT: refer to the Tech Corner "Anti-Pacemaker Mediated Tachycardia algorithm" for more information.



ARP is applied in the atrium for one cycle after any asynchronous ventricle (PVC) in order to avoid PMT: the P wave sensed inside the ARP (Ar) is "blocked", i.e. no AV delay is triggered and the PMT cannot start.

PROGRAMMABLE PARAMETERS

ALIZEA BOREA CELEA[5]

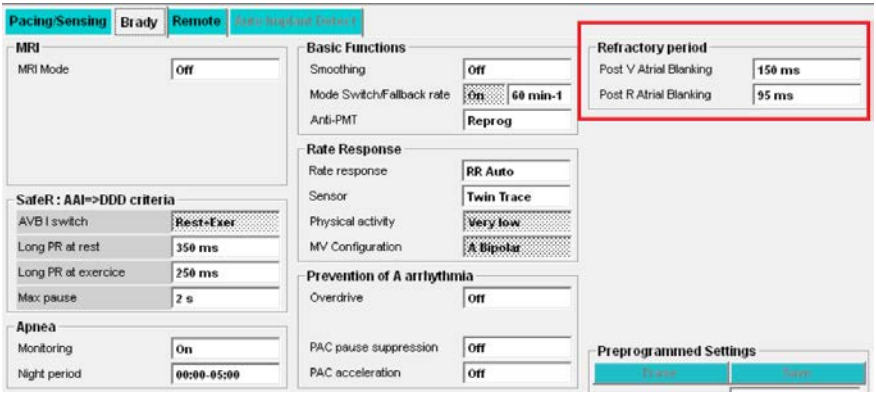
POST V ATRIAL BLANKING

The **Post V Atrial Blanking** is the absolute refractory period (blanking) triggered in the atrium after a paced ventricular event. The aim of this refractory period is to avoid VA crosstalk, *i.e.* sensing in the atrial channel of post potentials of the ventricular spike or the ventricular depolarization of the paced ventricle.

POST R ATRIAL BLANKING

The **Post R Atrial Blanking** is the absolute refractory period (blanking) triggered in the atrium after a sensed ventricular event. The aim of this refractory period is to avoid VA farfield, *i.e.* sensing in the atrial channel of the spontaneous ventricular depolarization.

[5] *ALIZEA BOREA CELEA dual chamber only*



Refractory periods: Post V Atrial Blanking and Post R Atrial Blanking (Param. screen, Brady tab)

Notes:

1. The Post R Atrial Blanking is always shorter than Post V Atrial Blanking.
2. In ALIZEA BOREA CELEA, the 2 atrial blanking periods are programmable to let the user better manage the VA oversensing (VA crosstalk and R wave farfield sensing).
3. When changing the programming, the total duration of the absolute refractory period is changed.

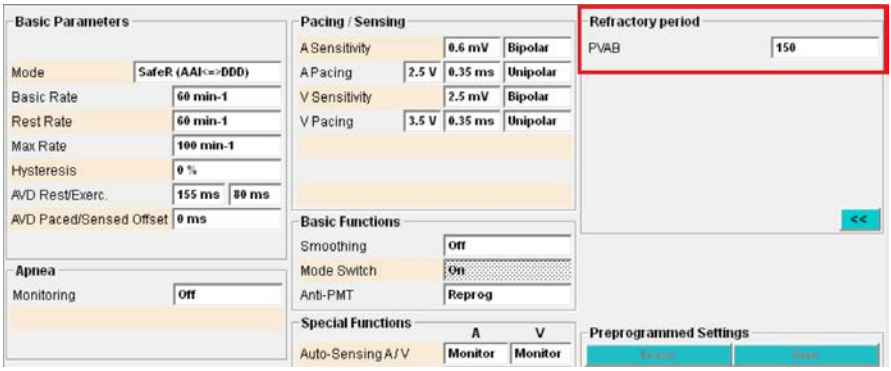
ENO TEO OTO and previous generations[6]

POST VENTRICULAR ATRIAL BLANKING (PVAB)

The **Post Ventricular Atrial Blanking (PVAB)** is the absolute refractory period (blanking) triggered in the atrium after a paced ventricular event (PVAB) and a sensed ventricular event (PVAB - 55 ms). The aim of this refractory period is to avoid:

- VA crosstalk, *i.e.* sensing in the atrial channel of post potentials of the ventricular spike or the ventricular depolarization of the paced ventricle
- R wave farfield sensing, *i.e.* sensing in the atrial channel of the spontaneous ventricular depolarization.

[6] *In dual chamber pacemakers only*



Refractory period: PVAB (Param. screen, Advanced parameters)

Example: When changing the PVAB parameter from 150 ms (as-shipped value) to 210 ms, the total duration of the absolute atrial refractory period post ventricular event is changed:

- Post R wave: the atrial refractory period will be 155 ms (210 ms - 55 ms): the first 105 ms are “absolute” (for the hardware only), the next 50 ms are retriggerable in the event of atrial sensing within this period.
- Post ventricular pacing: the atrial refractory period will be 210 ms: the first 160 ms are “absolute” (for the hardware only), the next 50 ms are retriggerable in the event of atrial sensing within this period.

WHAT YOU MUST REMEMBER

Thanks to the auto-functioning of MicroPort refractory periods, the pacemakers manage their durations automatically.

Refractory periods are designed to suppress sensing and pacing after any cardiac contractions, in order to avoid:

- Double counting of the same event in the sensed cavity
- Farfield sensing or crosstalk oversensing of the event occurring in the other cavity

In single chamber pacemakers, none of the refractory periods is programmable.

ALIZEA BOREA CELEA dual chamber pacemakers

Two refractory periods are independently programmable to let the user better manage the VA oversensing:

- Atrial absolute refractory period post V pacing = Post V Atrial Blanking (as-shipped: 150 ms)
- Atrial absolute refractory period post V sensing = Post R Atrial Blanking (as-shipped: 95 ms)

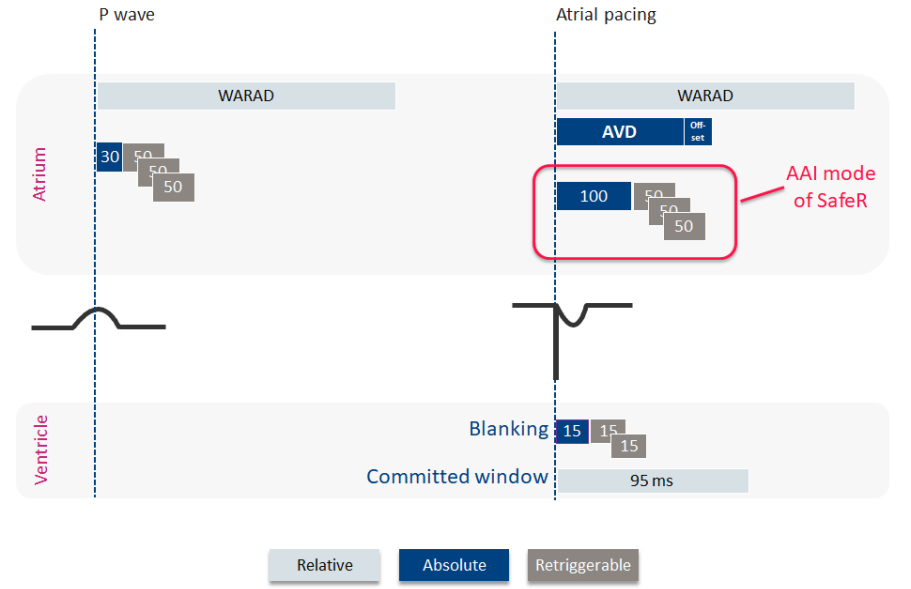
ENO TEO OTO and previous dual chamber pacemaker generations

Two refractory periods are programmable via one single parameter to manage VA oversensing: Post Ventricular Atrial Blanking (PVAB):

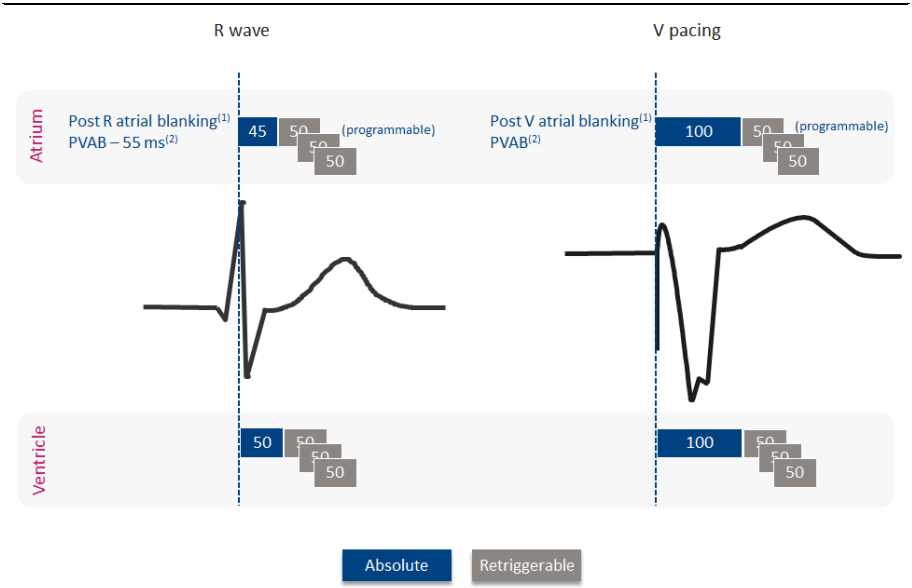
- Atrial absolute refractory period post V pacing: PVAB (as-shipped: 150 ms)
- Atrial absolute refractory period post V sensing: programmed PVAB - 55 ms (as-shipped: 95 ms)

OVERVIEW OF ALL MICROPORT REFRACTORY PERIODS

Automatic refractory periods post atrial events in dual chamber pacemakers



Automatic refractory periods post ventricular events in dual chamber pacemakers



(1) in ALIZEA BOREA CELEA dual chamber pacemakers

(2) in ENO TEO OTO and previous generations of dual chamber pacemakers.

Refer to user's manual furnished with the device for complete instructions for use. (www.microportmanuals.com)