12-Lead ECG
For Monitoring and Diagnostic Use
Application Note
For IntelliVue Patient Monitors Rev. J.xx.xx and IntelliVue Information Center iX Rev. A.xx.xx

About This Paper
The goal of this application note is to support the clinician in the proper use of the 12-Lead ECGs modalities provided by IntelliVue Patient Monitors and IntelliVue Information Center iX.

The application note:
• Describes the system capability and its components.
• Explains how to acquire a 12-Lead ECG.
• Reviews the conventional 12-Lead electrode placement and describes how to check that the electrodes are correctly placed.
• Reviews the modified electrode placement (Mason-Likar) and summarizes its benefits and limitations.
• Discusses signal quality and filter use.
• Explains common problems seen in waveforms for both conventional and modified electrode placement.
• Explains the format of 12-Lead ECG reports.

Introduction
Philips provides a comprehensive ECG solution to meet both the diagnostic and monitoring needs of patients in critical care. In addition to the standard 3 or 5-lead monitoring, there are three types of 12-Lead ECGs: directly acquired using a 10-electrode cable set, Hexad partially derived from 6-electrode cable set or EASI fully derived from a 5-electrode cable set.

This solution offers both continuous 12-Lead ECG monitoring and diagnostic 12-Lead ECG capture at the Patient Monitor. The 10 seconds of captured 12-Lead ECG is analyzed using the Philips 12-Lead Analysis Algorithm at the Information Center iX. For the directly acquired 12-Lead ECG, the time-based interval measurements, axis measurements and the interpretation statements are provided. For the EASI and Hexad derived 12-Lead ECG only the time-based interval measurements are provided. The captured 12-Lead ECGs can be reviewed at the Information Center iX as well as at the Patient Monitor.
12-Lead ECG at the IntelliVue Patient Monitor

At the IntelliVue Patient Monitor, 12 leads of ECG can be viewed, recorded or printed. In addition, any two of the 12 leads of ECG can be selected for multi-lead arrhythmia analysis and all 12 leads of ECG can be used for ST segment analysis.

![Figure 1: 12-Lead ECG Screen with ST Snippets and ST Map](image1.jpg)

Figure 1: 12-Lead ECG Screen with ST Snippets and ST Map

At the Patient Monitor, the user can review the 12-Lead ECG prior to sending it to the Information Center iX for analysis (Release J.0x.xx and higher). The 12-Lead ECG Application window allows the user to capture 10 seconds of ECG data, print a diagnostic ECG report, send the data to the Information Center iX, and store the data locally at the IntelliVue Patient Monitor.

The captured 12-Lead ECGs at the Patient Monitor can be viewed or printed with different filters, speeds and layouts. When stored and sent, the Information Center iX receives 10 seconds of ECG waveforms at 0.05-150 Hz at 500 samples/second and the settings for filters, speeds and layouts. When received by the Information Center iX, the 12-lead ECG is analyzed and the results of the analysis are sent back to the Patient Monitor for review by the clinician.

![Figure 2: IntelliVue Patient Monitor with 12-lead ECG Application Window open displaying a captured 12-lead Preview](image2.jpg)

Figure 2: IntelliVue Patient Monitor with 12-lead ECG Application Window open displaying a captured 12-lead Preview
12-Lead ECG at the Information Center iX

At the IntelliVue Information Center iX, the captured 12-Lead ECG can be viewed by selecting the 12-Lead Review button from the Patient Window after completion of the ECG analysis. The Information Center iX can store up to 30 captured 12-Lead ECGs.

In addition, the Information Center iX has the capability of 24 hours 12-lead ECG full disclosure if EASI lead placement is used at the Patient Monitor or with a telemetry transmitter. All 12-lead ECGs stored at the Information Center iX can be viewed at the Patient Monitor for review by the clinician.

Obtaining 12-Lead ECGs

Figure 4 demonstrates how 12-Lead ECGs are obtained and transmitted across the monitoring system. Traditionally, diagnostic 12-lead ECGs are acquired using a cardiograph. The cardiograph uses a 12-Lead interpretation algorithm to analyze the ECG waveforms.

The IntelliVue Patient Monitor provides the capability of monitoring up to 12-leads of ECG.

When the Capture 12 Lead Smartkey or Capture 12 Lead entry from the patient monitor’s Main Setup menu are selected, at the Patient Monitor, the 12-Lead ECG Application window is opened and up to 12 leads of ECG are displayed. The user can capture 10 seconds of waveform in a preview window prior to sending the data to the Information Center iX. Selecting Store & Send saves the 12-Lead at the bedside monitor and sends 10 seconds of the diagnostic waveform to the Information Center iX. At the Information Center iX, the diagnostic 12-Lead ECG waveform is analyzed and stored. The Information Center iX can save up to 30 12-lead ECGs. The Information Center iX uses the same 12-Lead interpretation algorithm as the Philips PageWriter TC series cardiographs with the DXL (PH100B) algorithm. The analyzed 12-lead ECG is sent back to the IntelliVue Monitor for review. The 12-Lead ECG can then be reviewed, printed and/or exported to TraceMasterVue or an alternative ECG management system for storage and validation by a qualified clinician.
12-Lead ECG Data Flow in the IntelliVue Monitoring System

The following figure provides an overview of the flow of 12-Lead ECG data in the IntelliVue Monitoring System:

![Diagram of 12-Lead ECG Data Flow]

**Figure 4: 12-Lead ECG Data Flow**
12-Lead ECG Electrode Placement

Conventional Lead Placement

**Limb Electrodes**

- Place arm electrodes on the inside of each arm, between the wrist and the elbow.
- Place leg electrodes inside of each calf, between the knee and the ankle.
- To minimize muscle artifact, place the electrodes on the fleshy part of the limb, avoiding large bones and muscles.

*Note:* Bone is a poorer conductor but may produce less muscle interference. Muscle is a better conductor but may produce more interference.

**Chest Electrodes**

Table 1 lists the placement of the chest (precordial) electrodes. Place them in the following order:

- V1, V2, V4
- V3
- V6
- V5

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>on the 4th intercostal space at the right sternal border</td>
</tr>
<tr>
<td>V2</td>
<td>on the 4th intercostal space at the left sternal border</td>
</tr>
<tr>
<td>V3</td>
<td>midway between the V2 and V4 electrode positions</td>
</tr>
<tr>
<td>V4</td>
<td>on the 5th intercostal space at the left midclavicular line</td>
</tr>
<tr>
<td>V5</td>
<td>on the left anterior axillary line, horizontal with the V4 electrode position</td>
</tr>
<tr>
<td>V6</td>
<td>on the left midaxillary line, horizontal with the V4 electrode position</td>
</tr>
</tbody>
</table>

*Table 1: Placement of Chest Electrodes*
Modified Lead Placement (Mason-Likar)

- In the modified (Mason-Likar) electrode configuration, the limb electrodes are placed on the torso in the same locations as used for standard continuous ECG monitoring.
- The arm electrodes are placed below the clavicle near the shoulders.
- The leg electrodes are placed on the lower abdomen.
- The chest (precordial) electrodes are placed in the same positions as conventional 12-Lead ECG placement.

As with conventional 12-Lead ECG placement, accurate electrode placement is required for quality 12-Lead ECG measurements.

This lead placement should not be used for diagnostic interpretation using the Philips 12-Lead ECG Algorithm.

Advantages of Modified Electrode Placement

One advantage of the Mason-Likar configuration is that it is less susceptible to movement artifact than the conventional 12-Lead ECG placement (because the limb electrodes are on the torso).

Also, because the electrodes are on the torso, the modified placement is more comfortable for the patient than the conventional placement.

Hexad 12-Lead Placement using 6-wire lead set

Hexad lead placement is available for MX40 telemetry with a 6-wire lead set and can be selected at the Information Center iX in the Telemetry Setup window. To use Hexad derivation, select the pair of chest leads where the Va and Vb electrodes will be placed. The Hexad algorithm will derive the four additional leads.

![Telemetry Setup Window on Information Center iX](image)

The label **Hexad** is shown beside the 1 mV calibration bar on the ECG wave on the display, and **Hexad** derived leads are marked on any recorder strip and printout.

Electrodes are placed in Mason-Likar limb position with two chest leads placed in standard position.

![Modified Lead Placement (Mason-Likar)](image)

![6-Electrode Lead Placement with V2 and V4](image)
**EASI™ Lead Placement**

EASI monitoring is available on all IntelliVue Patient Monitors. To monitor with EASI lead placement, you must enable EASI in the Setup ECG menu under **Lead Placement**.

EASI derived 12-Lead ECGs and their measurements are approximations to conventional 12-Lead ECGs and should not be used for diagnostic interpretations.

- The Label EASI is shown beside the 1 mV calibration bar on the ECG wave on the display, and EASI is marked on any recorder strip and printout.

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>on the lower sternum at the level of the 5th intercostal space</td>
</tr>
<tr>
<td>A</td>
<td>on the left midaxillary line at the same level as the E electrode</td>
</tr>
<tr>
<td>S</td>
<td>on the upper sternum</td>
</tr>
<tr>
<td>I</td>
<td>on the right midaxillary line at the same level as the E electrode</td>
</tr>
<tr>
<td>Ref</td>
<td>reference electrode - can be anywhere, usually below the 6th rib on the right hip</td>
</tr>
</tbody>
</table>

**Table 2: Placement of EASI Electrodes**

![Figure 7: EASI Lead Placement](image)
Differences between Conventional and Modified Electrode Placement

To properly record a 12-Lead ECG, it is important to have the patient lying comfortably with the wrist close to but not touching the torso. The limb electrodes should be placed on the right and left wrists and the right and left ankle. The outer aspect of the wrist should be used to ensure that the arm does not need to be rotated. The leg electrodes should be placed on the outer aspect of each ankle.

In continuous 12-Lead ECG monitoring, electrodes placed in conventional lead placement, may cause excessive noise due to muscle activity and electrode artifact due to electrode movement. The signal noise caused by muscle activity can be reduced by placing the electrodes on the shoulders and hips instead of the wrists and ankle as suggested by R. E. Mason and I. Likar in 1966. The Mason-Likar modification of the 12-Lead ECG system is used in exercise ECG and continuous Patient Monitor monitoring of the 12-Lead ECG.

If the limb electrodes are placed on the torso (Mason-Likar Placement), the recording will be different from that obtained using the conventional electrode placement (see figure 9). These variations include a rightward shift of the mean QRS axis due to a reduction in R wave amplitude in I and aVL, and increase in R wave in Lead II, III and aVF. Chest leads are also affected because of the altered potential of the central terminal.

There are occasions when limb electrodes need to be shifted to obtain 12-Lead ECGs. For example, a cast on a limb, a partially or entirely missing limb, or to minimize noise in the ECG signal.

Any change in electrode placement from the conventional electrode placement must be clearly noted on the ECG recording or printout. The IntelliVue Patient Monitors allows the user to mark the printouts and captured 12-Leads ECGs as a modified lead placement. In the ECG setup window, setting Mod.LeadPlacement to On, will label all 12-Lead ECG reports and captured 12-Lead ECGs from the Patient Monitor to the Information Center iX as Mason-Likar (see figure 9).

Be sure to mark ECGs as modified (Mason-Likar) to prevent misdiagnosis and use caution when comparing 12-Lead ECGs acquired using different electrode placements.

The 12-Lead ECGs displayed on the following page demonstrate the changes that occur when placing the limb electrodes in different positions. Both 12-Lead ECGs were obtained from the same individual.

In figure 8, the limb electrodes were placed on the outer aspect of the wrist and ankles. In figure 9, the limb electrodes were moved to the torso which is typically the position of the limb electrodes during continuous monitoring. This 12-Lead ECG shows significant changes in the limb leads particularly in Leads II, III and aVF. The P-wave, QRS and T-wave axis measurements also demonstrate large differences from the 12-Lead ECG performed with the limb electrodes on the wrists/arms and ankles/leg. In addition, the 12-Lead ECG interpretative algorithm based on these measurements interpreted this 12-Lead ECG as a “borderline right axis deviation.”

These differences that the modified lead placement creates may lead to misdiagnosis and may mask inferior infarction due to calculated axis, R-, P-, and T-wave magnitudes shifts, and ST slope.
Examples of Lead Placement

Figure 8: Conventional Lead Placement - Limb electrodes on the wrists and the ankles

Figure 9: Modified Lead Placement (Mason-Likar)
Checking for Correct Placement

To ensure quality 12-Lead ECG monitoring, it is important to check that the electrodes are correctly placed.

If they are, you should see these landmarks:
- Positive P-wave in Lead II.
- Negative QRS in Lead aVR.
- R-wave progression in the precordial leads.
- Normal R-wave progression is as follows:
  - Negative R-wave in Lead V1 and Lead V2.
  - Biphasic R-wave in Lead V3.
  - Positive R-wave in Lead V4 - Lead V6.

Figure 10: Correct Lead Placement

In this figure, the right and left arm electrodes have been reversed - all other lead placement is correct.
- By noting that aVR is positive, the 12-Lead ECG analysis algorithm was able to detect this error and alert the clinician to repeat the 12-Lead ECG.

Figure 11: Incorrect Lead Placement - Reversed right and left arm electrodes
**Signal Processing**

The ECG signal at the body surface is transmitted via the ECG leadset and cable. The ECG measurement device then digitizes the analog signal at a sample rate of 500 samples per second in the frequency range of 0.05 Hz to 150 Hz.

**Filter Settings Used for Real-time ECG Monitor at the Patient Monitor**

These filters suppress ECG signals at the high and low frequency range to allow the user to view a clearer ECG signal when noise is present.

The following table lists the different bandwidths that result from applying the different filter modes available in the IntelliVue Patient Monitors.

<table>
<thead>
<tr>
<th>Patient Category</th>
<th>Filter Mode</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td>Diagnostic</td>
<td>0.05 Hz - 150 Hz</td>
</tr>
<tr>
<td></td>
<td>Extended Monitoring</td>
<td>0.5 Hz - 150 Hz</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>0.5 Hz - 40 Hz</td>
</tr>
<tr>
<td></td>
<td>Filter</td>
<td>0.5 Hz - 20 Hz</td>
</tr>
<tr>
<td>Pediatric/Neonatal</td>
<td>Diagnostic</td>
<td>0.05 Hz - 150 Hz</td>
</tr>
<tr>
<td></td>
<td>Extended Monitoring</td>
<td>0.5 Hz - 150 Hz</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>0.5 Hz - 55 Hz</td>
</tr>
<tr>
<td></td>
<td>Filter</td>
<td>0.5 Hz - 20 Hz</td>
</tr>
</tbody>
</table>

*Table 3: Filter Settings*

- For adult patients, use the Diagnostic Filter Mode to obtain an ECG signal with the highest fidelity for viewing and recording.
- For pediatric or neonatal patients, consider using the Extended Monitoring Filter Mode to reduce motion artifacts.

**Using Filters**

There is a trade off between clarity and fidelity of the ECG trace when a filter is applied. The more filtering applied, the greater the possibility of removing ECG signal details.

Changing the high frequency filter to 20 Hz, 40 Hz or 55 Hz results in a smoother looking ECG waveform while eliminating some fine detail in the signal. Small deflection, notches, slurs may be distorted or may disappear if one of these filters is applied.

Changing the low frequency filter to 0.5 Hz can be used to reduce baseline noise such as baseline wander. Baseline wander is the slow (typically 0.1 Hz - 0.2 Hz) drifting of the ECG baseline up or down.

Baseline wander may result from patient respiration or from other sources such as dried electrodes. Severe baseline wander may make it difficult to determine the true wave shapes in the ECG.

Changing the low frequency filter to 0.5 Hz might result in distortion of the ST segment in real-time ECG waves.

Real-time ECG waves are used on the Patient Monitor’s main screen and the Information Center iX’s patient sector, on strip recordings, and on the real-time ECG reports (ECG Report A/B).

Diagnostic 12-Lead ECGs shown on and printed from the 12-Lead ECG application at the Patient Monitor and the Information Center iX will not result in ST segment distortion, regardless of the filter mode settings.

Filter settings used for ST Segment Analysis

The ST/AR ST analysis algorithm receives the ECG signal at the highest fidelity 0.05 Hz regardless of the patient category or filter mode setting. ST/AR applies a special 0.67 Hz filter for analysis. This filter type does not distort the ST segments.
The ST waveforms captured by the ST/AR analysis algorithm can be used for assessment of ST segment changes (figure 14). The ST waveforms can be displayed at the Patient Monitor as well as recorded. The ST waveforms are also stored at the Information Center iX for the ST Review application.

Filters used for 12-Lead ECG Application

The 12-Lead ECG signal sent from the Patient Monitor is at a sample rate of 500 samples per second in the frequency range 0.05 Hz to 150 Hz. This signal is used for the 12-Lead ECG analysis performed by the Philips 12-Lead ECG Algorithm.

For viewing and printing, when the 12-Lead ECG is sent to the Information Center iX the filter settings from the bedside are sent and will be viewed and printed using these settings. After capture the settings may be changed at either the IntelliVue Patient Monitor or at the Information Center iX. The changes, however, are local to the device.

The type of filter used by cardiographs and the 12-Lead ECG Application is a filter that does not cause distortion of the ST segment when using 0.5 Hz filter. However it requires delayed processing and cannot be used when real-time viewing and recording is required.

Figure 14: ST snippets available on the IntelliVue Patient Monitor can be used for assessment

Figure 15: Filters used for 12-Lead ECGs
Common 12-Lead ECG Monitoring Problems

Obtaining a 12-Lead ECG with computer-assisted ECG analysis begins by obtaining accurate and noise-free ECG waveforms. Improving the electrode to skin interface by preparing the skin and using fresh electrodes helps eliminate most noise quality problems.

This section describes common problems that can be encountered when using both conventional and modified electrode placement.

**Electrical Interference**

Possible cause: Presence nearby from an electrical device (e.g., IV pump, microwave oven, cellular phone).

Solution: Check the environment for possible electrical devices that can cause interference and unplug if possible or switch the device to battery power.

**Figure 16: Electrical Interference**

**Wandering Baseline**

Possible cause: Patient movement, respirations, dry electrodes or loose electrode.

Solution: Instruct the patient to lie quietly. Apply fresh electrodes

**Figure 17: Wandering Baseline**

**Somatic Tremors**

Possible cause: Involuntary movement (shivering).

Solution: Warm/cover the patient and assist with limiting patient movement.

**Figure 18: Somatic Tremors**

**Loose Electrode**

Possible cause: Electrode is not adhering adequately to the skin.

Solution: Check electrodes and re-apply if needed.

**Figure 19: Loose Electrode**
The Philips 12-Lead ECG Analysis Algorithm

For the conventional 12-Lead ECG waveforms provided by the IntelliVue Patient Monitor, the Philips 12-Lead ECG algorithm provides an analysis of the amplitudes, durations and morphologies of the ECG waveforms and the associated rhythm. For the Hexad 12-Lead ECG and the EASI 12-Lead ECG, the Philips 12-Lead ECG algorithm provides only time-based interval measurements. The ECG analysis is based on standard criteria for interpretation of these parameters, calculation of the electrical axis and the relationship between leads. The 12-Lead analysis algorithm is highly age and gender specific. Patient age and gender are used throughout the program to define normal limits for heart rate, axis deviation, time intervals, and voltage values for interpretation accuracy in tachycardia, bradycardia, prolongation or shortening of PR and QT intervals, hypertrophy, early repolarization, and myocardial infarction.

Adult criteria apply if the patient age entered is 16 years old or older or if no age is specified. Pediatric criteria apply if the patient age entered is younger than 16 years of age.

Keep in mind that a computer-interpreted ECG report is not intended to be a substitute for interpretation by a qualified clinician. The interpreted ECG is a tool to assist the clinician in making a clinical diagnosis in conjunction with the clinician’s knowledge of the patient, the results of physical examination, and other findings. The algorithm helps to identify problem areas for the clinician and saves time for the clinician or editing technician who may need only to add, delete or modify a few statements.

The 12-Lead ECG Analysis Algorithm Process

The following is a brief review of the Philips 12-Lead ECG Algorithm. For a detailed description of the 12-Lead ECG Algorithm, review the Philips 12-Lead Algorithm Physician’s Guide (Part number 4535 641 06411).

**Step 1: Signal Quality Check**

The algorithm examines the signal quality of each ECG Lead to ensure that good ECG measurements can be made. The ECG is analyzed for muscle artifact, AC noise, baseline wander, and leads off. In addition, a check for correct placement of right arm and left arm leads is also performed. Any problems that are not corrected by the operator are described in the interpretative statements on the ECG report.

**Step 2: Waveform Recognition**

This step involves beat detection and waveform recognition. If paced mode is on, pacing spikes detected at the Patient Monitor are used for analysis. Pacer spikes are then removed and the resulting waveforms are analyzed with a boundary indicator derived from all leads. Subsequently approximate P wave, QRS complex and T wave regions are then determined for each beat in the ECG.

**Step 3: Measurements**

Once the final onsets and offsets are determined, the amplitude, duration, area and shape are calculated for every P-wave, QRS complex, ST segment and T-wave in each lead. Waveform irregularities such as notches, slurs, delta waves and pacemaker spikes are also noted for every beat. Measurements for each of the 12 leads are calculated from the predominant beat type. Only if all beats in the ECG are classified as ventricularly paced will the measurements be performed on the paced beats. If an ECG contains both paced and non-paced beats, only non-paced beats will be measured. Atrial Rhythm analysis is determined by examining leads V1, aVF, II and III in succession until the algorithm can determine the number of P waves per QRS complex. If the determination fails, no atrial rhythm parameter is calculated.

**Axis Measurements**

Instead of using the waveform amplitudes, the waveform areas are used to calculate P, QRS and T axis measurements for more accurate results. The sum of the ST onset, middle and end amplitudes is used in calculating the ST axis. The frontal plane axis measurements use the six limb leads to estimate the axis. The horizontal plane axis measurements are calculated from leads V1- V6.

**Step 4: Interpretation**

Based on waveforms and measurements the final diagnostic interpretation is performed. Each diagnostic category may be represented by only one statement in the final report. This statement is the most specific one encountered whose medical criteria were true based on the measurements, earlier decisions, and patient information (gender and age).

**Overall Severity**

Each interpretative statement selected for the ECG report has an associated severity. The severities associated with these statements are then combined to determine the overall severity for the 12-Lead ECG report.
12-Lead ECG Reports

Report Types
There are three types of 12-Lead ECG reports available:
• Diagnostic (captured) 12-Lead ECG reports from the 12-Lead ECG Application at the Patient Monitor
• Diagnostic (captured) 12-Lead ECG reports printed from the Information Center iX 12-Lead Review application
• Real-time 12-Lead ECG reports requested at the Patient Monitor (ECG Report A, ECG Report B)

Report Formats
The following 12-Lead ECG report formats are available:

<table>
<thead>
<tr>
<th>Diagnostic ECG Report at Patient Monitor</th>
<th>Diagnostic ECG Report at Information Center iX</th>
<th>Real-Time ECG Reports A/B at Patient Monitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x4</td>
<td>3x4 (figure 26)</td>
<td>ECG3x4 (figure 22)</td>
</tr>
<tr>
<td>6x2</td>
<td>6x2</td>
<td>ECG6x2 (figure 23)</td>
</tr>
<tr>
<td>12x1</td>
<td>12x1 (figure 27)</td>
<td>ECG12x1</td>
</tr>
<tr>
<td>3x4 1R (figure 24)</td>
<td>3x4 1R</td>
<td>ECG4x2</td>
</tr>
<tr>
<td>3x4 3R (figure 25)</td>
<td>3x4 3R</td>
<td>ECG8x1a</td>
</tr>
<tr>
<td>3x4 ST (figure 25)</td>
<td>3x4 ST MAP</td>
<td>ECG12x1 (2P)a</td>
</tr>
<tr>
<td>3x4 1R ST (figure 28)</td>
<td>3x4 1R ST MAP</td>
<td>ECG12x1 (2P)a</td>
</tr>
</tbody>
</table>

Table 4: 12-Lead ECG Report Formats

- For the Patient Monitors, the orientation of the 12-Lead ECG report is by default Landscape. For some formats, it can be changed to Portrait (see footnote above).
- For the Information Center iX, Landscape or Portrait orientation can be chosen for each 12-Lead ECG report.
- The 6 x 2 format and 12 x 1 formats show longer waveform segments in multiple leads that may be more suitable for reviewing arrhythmias.

Report Layouts
There are two configurable limb lead layouts for printed 12-Lead ECG reports: International: I, II, III, aVR, aVL, aVF, and Cabrera: aVL, I, -aVR, II, aVF, III.

Time Sequence
• The 12-Lead ECG Application at the Patient Monitors lets you define the time sequence for all leads, when displaying or printing two or more columns. Choices are Sequential or Simultaneous.
  - Sequential: All ECG signals start at 0 seconds in the first column, 2.5 seconds in the second column, 5.0 seconds in the third column, and 7.5 seconds in the fourth column. The ECG sequences are separated by single bars.

<table>
<thead>
<tr>
<th>ECG part 1</th>
<th>ECG part 2</th>
<th>ECG part 3</th>
<th>ECG part 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>aVR</td>
<td>V1</td>
<td>V4</td>
</tr>
<tr>
<td>II</td>
<td>aVL</td>
<td>V2</td>
<td>V5</td>
</tr>
<tr>
<td>III</td>
<td>aVF</td>
<td>V3</td>
<td>V6</td>
</tr>
</tbody>
</table>

Table 4: 12-Lead ECG Report Formats

- Simultaneous: The ECG starting point of each lead is the same time even though they may appear to start at different times on the ECG. The ECG sequences are separated by double bars.

<table>
<thead>
<tr>
<th>ECG part 1</th>
<th>ECG part 2</th>
<th>ECG part 3</th>
<th>ECG part 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>aVR</td>
<td>V1</td>
<td>V4</td>
</tr>
<tr>
<td>II</td>
<td>aVL</td>
<td>V2</td>
<td>V5</td>
</tr>
<tr>
<td>III</td>
<td>aVF</td>
<td>V3</td>
<td>V6</td>
</tr>
</tbody>
</table>

Table 4: 12-Lead ECG Report Formats

- At the Information Center iX the 3 x 4 format, the most commonly selected format, shows consecutive 2.5 second segments of the 12-lead, three leads at a time with a 10 second continuous rhythm strip displayed at the bottom of the report.
- Bedside monitor real-time 12-Lead ECG reports are formatted in the same way except that the 2.5 second segments are simultaneously obtained.
Lead Placement

- A 12-Lead ECG report obtained using EASI lead placement and setup at the IntelliVue Patient Monitor as EASI Lead placement will be labelled on the report as EASI. The 12-Lead ECG capture labelled as EASI will only contain time based basic measurements.
- If the user has placed the electrodes in modified electrode placement (Mason-Likar) and has set the Patient Monitor setting Mod.LeadPlacement to On, the 12-lead ECG report will be marked “Mason Likar”.
- A 12-Lead ECG report obtained using Hexad 12-lead with 6-wire lead set will be labelled on the report as Hexad. The 12-Lead ECG captured from the Wave Review will have time-based measurements only.
IntelliVue Patient Monitor Diagnostic 12-Lead ECG Report

A typical IntelliVue Patient Monitor diagnostic 12-Lead ECG report is shown below (figure 22). This report is generated by selecting Print Report in the 12-Lead ECG Application and represents the 10 seconds of captured ECG. This report has not been sent to the PIIC iX for analysis.

Figure 22: Patient Monitor 12-Lead ECG Report
<table>
<thead>
<tr>
<th>Field</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Information, MRN, and Paced Mode</td>
<td>The Patient Name, date of birth, gender, and Medical Record Number (MRN) will appear on the report only if this information has been entered in the Patient Demographics Window. Paced mode can be changed in the Setup ECG menu, Patient Demographics window, or Profiles menu, and is stored with capture.</td>
</tr>
<tr>
<td>ST Measurements</td>
<td>ST measurements will appear on the 12-Lead ECG report if the ST analysis is turned on. These measurements are generated from the ST/AR ST analysis.</td>
</tr>
<tr>
<td>Date and Time</td>
<td>Capture Date and Time will always appear on the report.</td>
</tr>
<tr>
<td>Height and Weight</td>
<td>Height and weight will appear on the report only if this information has been entered in the Patient Demographics Window</td>
</tr>
<tr>
<td>Page Count</td>
<td>Page count will always appear on the report.</td>
</tr>
<tr>
<td>Hospital Name, Order Number, Encounter Id</td>
<td>Hospital name, Order number and Encounter Id will appear on the report only if this information has been entered in the Patient Demographics Window</td>
</tr>
<tr>
<td>1 milliVolt Bar</td>
<td>The 1 milliVolt bar is the rectangular waveform shown at the end of the ECG trace. It shows for both limb and chest leads, how much the cardiograph deflected the trace in response to a 1 milliVolt pulse applied to the acquisition circuitry. The 1 milliVolt bar is a visual indicator of size. For half chest gain, the 1 milliVolt bar is stepped (see figure 25 on page 20).</td>
</tr>
<tr>
<td>Filter Bandwidth</td>
<td>The bandwidth is adjusted in Main Setup → Measurements → ECG → Setup ECG → 12 Lead → Filter. The bandwidth settings are applied to the 12-Lead ECG not as a real-time filter but in a manner which minimizes the distortion of the ST segment.</td>
</tr>
<tr>
<td>Paper Speed, Gain, and Chest Gain</td>
<td>Paper Speed, Gain and Chest Gain are adjusted in Main Setup → Measurements → ECG → Setup ECG → 12 Lead.</td>
</tr>
<tr>
<td>Bed Label</td>
<td>This is identical to the label displayed in the Monitor Info Line on the Patient Monitor. If the monitor is connected to an Information Center iX, the label is controlled by the Information Center iX. If the Patient Monitor is not connected to an Information Center iX, the label is the configured equipment label.</td>
</tr>
<tr>
<td>Report Title</td>
<td>The title of the captured report.</td>
</tr>
<tr>
<td>HR, PVC, QT, QTc</td>
<td>These are the HR, PVC, QT, QTc values which are displayed at the time of the capture.</td>
</tr>
<tr>
<td>1-second Marks</td>
<td>Short vertical lines at the top of the grid, marking one second.</td>
</tr>
</tbody>
</table>

Table 5: Fields of an IntelliVue Patient Monitor Diagnostic 12-Lead ECG Report
Examples of IntelliVue Patient Monitor Diagnostic 12-Lead ECG Reports

Figure 23: Diagnostic 12-Lead ECG Report at Patient Monitor ‘3x4 1R’; Time Sequential; Full Chest Gain
Figure 24: Diagnostic 12-Lead ECG Report at Patient Monitor ‘3x4 1R’; Time Simultaneous In; Half Chest Gain
IntelliVue Information Center iX Diagnostic 12-Lead ECG Report

A typical 12-Lead ECG report using conventional lead placement generated at the Patient Monitor and printed from either the Information Center iX or printed from the IntelliVue Patient Monitor 12-Lead ECG Application window after capture and interpretation is shown below (figure 25). It contains basic measurements, interpretative and severity statements, and status information.

Figure 25: IntelliVue Information Center iX Diagnostic 12-Lead ECG Report

Table 6: Fields of an IntelliVue Information Center iX Diagnostic 12-Lead ECG Report
<table>
<thead>
<tr>
<th>Field</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page Count</td>
<td>Page count will always appear on the report.</td>
</tr>
<tr>
<td>Severity Statement</td>
<td>The severity statement represents the overall severity of the ECG.</td>
</tr>
<tr>
<td>Status of Report</td>
<td>The status of the report from the Information Center iX will be unconfirmed. This indicates that the ECG report has not been over read by a qualified physician. The 12-Lead ECG status can be changed once the ECG has been exported to a 12-Lead ECG Management system.</td>
</tr>
<tr>
<td>1 milliVolt Bar</td>
<td>The 1 milliVolt bar is the symbol shown on the first line of the ECG trace. It shows how much the cardiograph deflected the trace in response to a 1 milliVolt bar applied to the acquisition circuitry.</td>
</tr>
<tr>
<td>12-Lead Analysis Algorithm</td>
<td>Algorithm version used for analysis</td>
</tr>
<tr>
<td>Bandwidth Information</td>
<td>The 12-Lead ECG capture is transmitted to Information Center iX in diagnostic bandwidth (0.05 - 150 Hz). The 12-Lead ECG is analyzed using this bandwidth. It is displayed using the bandwidth settings from the 12-Lead ECG Review Application. The bandwidth settings are applied to the 12-Lead ECG not as a real-time filter but in a manner which minimizes the distortion of the ST segment.</td>
</tr>
<tr>
<td>Gain</td>
<td>Size of limb and chest leads.</td>
</tr>
<tr>
<td>Paper Speed</td>
<td>Paper Speed is changeable.</td>
</tr>
<tr>
<td>Axis Measurements</td>
<td>This section provides the P, QRS, and T axis measurements.</td>
</tr>
<tr>
<td>Basic Measurements</td>
<td>This section provides the heart rate, the standard interval and duration measurements, and limb lead axis measurements. These are representative values for the dominant beat pattern in the ECG.</td>
</tr>
</tbody>
</table>
Examples of IntelliVue Information Center iX Diagnostic 12-Lead ECG Reports

Figure 26: Diagnostic 12-Lead ECG Report at Information Center iX; ‘3x4 1R ST MAP’
IntelliVue Patient Monitor Real-Time 12-Lead ECG Report

A typical IntelliVue Patient Monitor real-time 12-Lead ECG report is shown below (figure 28).

![ECG Report Diagram]

**Figure 27: IntelliVue Patient Monitor Real-Time 12-Lead ECG Report, 3 x 4 format**

<table>
<thead>
<tr>
<th>Field</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Name</td>
<td>The unit name if configured in the IntelliVue Patient Monitor.</td>
</tr>
<tr>
<td>ST Measurements</td>
<td>ST measurements will appear on the 12-Lead ECG report if the ST analysis is turned on. These measurements are generated from the ST/AR ST analysis.</td>
</tr>
<tr>
<td>Patient Name</td>
<td>The Patient Name will appear on the report only if this information has been entered in the Patient Demographics Window.</td>
</tr>
<tr>
<td>Medical Record Number and Encounter Id</td>
<td>The MRN and Encounter ID will appear on the report only if this information has been entered in the Patient Demographics Window.</td>
</tr>
</tbody>
</table>

Table 7: Fields of an IntelliVue Patient Monitor Real-Time 12-Lead ECG Report
<table>
<thead>
<tr>
<th>Field</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed Label</td>
<td>This is identical to the label displayed in the Monitor Info Line on the Patient Monitor. If the monitor is connected to an Information Center iX, the label is controlled by the Information Center iX. If the Patient Monitor is not connected to an Information Center iX, the label is the configured equipment label.</td>
</tr>
<tr>
<td>Printing Time</td>
<td>Printing date and time will always appear on the report.</td>
</tr>
<tr>
<td>Page Count</td>
<td>Page count will always appear on the report.</td>
</tr>
<tr>
<td>Hospital Name</td>
<td>The hospital or institution name if configured in the IntelliVue Patient Monitor.</td>
</tr>
<tr>
<td>Wave Speed</td>
<td>The actual wave speed of the real-time report.</td>
</tr>
<tr>
<td>Gain</td>
<td>The actual set gain of the real-time report.</td>
</tr>
<tr>
<td>Paced Mode</td>
<td>Paced mode can be changed in the Setup ECG menu, Patient Demographics window, or Profiles menu.</td>
</tr>
<tr>
<td>Filter Bandwidth</td>
<td>The bandwidth is set in the Main Setup → Measurements → ECG → Filter. If contour analysis is important use Diagnostic mode which minimizes the ST Segment distortion.</td>
</tr>
<tr>
<td>1 milliVolt Bar</td>
<td>The 1 milliVolt bar is shown under each lead name. It shows how much the cardiograph deflected the trace in response to a 1 mV calibration pulse applied to the acquisition circuitry. The 1 milliVolt bar is a visual indicator of size.</td>
</tr>
<tr>
<td>HR and PVC per minute</td>
<td>This is the HR and PVC count which is displayed at the time of the report.</td>
</tr>
<tr>
<td>Report Title</td>
<td>The title of the real-time report.</td>
</tr>
</tbody>
</table>

Table 7: Fields of an IntelliVue Patient Monitor Real-Time 12-Lead ECG Report
Examples of IntelliVue Patient Monitor Real-Time 12-Lead ECG Reports

Figure 29: IntelliVue Patient Monitor Real-Time 12-Lead ECG Report; ‘ECG 3x4’
Figure 30: IntelliVue Patient Monitor Real-Time 12-Lead ECG Report; ‘ECG 6x2’
Summary

The IntelliVue Patient Monitor provides a comprehensive ECG solution to meet both the diagnostic and monitoring needs of patients in critical care.

**Monitoring (real-time) ECG**
- Support for various ECG cable sets and lead placements
- Support for Hexad lead placement to generate derived 12-Lead ECG
- Support for EASI lead placement to generate derived 12-Lead ECG from a 5-electrode cable set
- Tailored monitor screens to view up to 12 leads of ECG as real-time waves
- ECG filters for both monitoring use
- Real-time ST analysis on all 12 ECG leads
- ST Map - a graphical display of ST segment data, providing a focused view that can help clinicians more easily recognize ST changes and location
- Real-time arrhythmia analysis and trending on one or multiple ECG leads using the Philips ST/AR algorithm
- Real-time ECG reports for documentation
- Real-time ECG recordings for documentation.

**Diagnostic (captured) ECG**

The dedicated 12-Lead Application on the IntelliVue Patient Monitor provides:
- Capture of 12-Lead ECGs in diagnostic quality
- ECG filters tailored for diagnostic use
- Entry of an ECG order number to facilitate order reconciliation
- Review of captured 12-Lead ECGs before they are stored and sent to the IntelliVue Information Center iX
- Storage of 12-Lead ECG data locally at the monitor
- Display results of 12-lead analysis received from the Information Center iX
- Review all 12-lead ECGs stored at the Information Center iX at the bedside
- Trigger export of captured 12-lead ECGs via the Information Center iX for long-term storage to an ECG management system, such as TraceMasterVue
- Print out of diagnostic 12-Lead ECG reports in various formats for documentation.

Captured 12-Lead ECGs can be sent to the IntelliVue Information Center iX, where:
- Up to 30 diagnostic 12-Lead ECGs can be stored per patient
- Captured 12-lead ECGs can be viewed in a dedicated 12-Lead Review application
- Captured 12-lead ECGs can be analyzed and interpreted using the Philips DXL ECG Algorithm
- Captured 12-lead ECGs can be exported for long-term storage to an ECG management system, such as Philips TraceMasterVue.