# Modus 3 RF Network Emulator User Guide

# Modus 3 RF Network Emulator - Quick Start Guide

### Introduction

Modus 3 is a transport stream player, COFDM modulator and RF up converter in one integrated system.  It is designed to emulate the signals from terrestrial and mobile TV transmission network and currently support DAB derived systems like T-DMB and DVB-T derived systems like DVB-H.

Modus 3 has a highly configurable software defined radio architecture and can act as a I/Q RF signal generator for emulation of DAB/T-DMB systems or as a channel modulator for DVB-T and DVB-H.

Modus 3 can store I/Q files and transport stream files on either a removable Compact Flash card or an optional internal hard disk drive.

RF output can be in the range 100MHz to 2.2GHz in a continuous range with levels between 0dBm and -110 dBm in 0.5dB steps, set using the internal electronic attenuator.

All channel settings are stored in a XML meta data file which resides with the I/Q and Transport Stream files on either of the two storage media.

Modus 3 has a USB  interfaces, which provides mass storage class connectivity.  The unit also has differential I/Q RF outputs which can be used to drive a external I/Q Vector Signal Generator like the Agilent ESG-C to provide a reference quality RF output with 0.1db resolution and very low phase noise.  Modus 3 support hierarchical ASI inputs and outputs, together with SPI inputs and outputs.

For support issues not covered in this manual please email or phone CellMetric.  The dedicated support email is support@cellmetric.co.uk

### DVB Composer

CellMetric's DVB Composer application is an optional software package designed to work with the Modus 3.  Composer emulates on  PC a complete TV head end to either the DVB-T or DVB-H standard, generating test streams and patterns for transmission.  Functionality includes Multiplexing, SI Insertion, time slicing, MPE FEC, and IP encapsulation.

### DVB - H , DAB & DAB+ Test streams

CellMetric can provide a library of DVB-H, DAB and DAB+ standard test streams for the Modus 3.

# Getting Started

## Objectives

The objectives of this guide are as follows:

- To provide an overview of Modus 3 Local Operation, outlining the major applications incorporated.
- To explain how to install and use the Modus 3 in Local Operation mode for correct and safe operation.
- To describe the physical and electrical features of the Modus 3 in Local Operation to a level necessary for routine maintenance.
- To describe the functions available in Modus 3 Local Operation and how to access and use them via the software graphical user interface (GUI).

## Layout and Content

The user guide has a hierarchical structure of sections and sub-sections. It is suggested that after taking note of the safety advice, sections on the Modus 3 Unit, Power Supply, Front and Rear Panel and DVB-H operation are read before attempting to operate the unit.

## Documentation Conventions
## Safety advice

### Warning or Caution

This caution symbol is used to mark procedural information that could prevent damage to equipment or personnel or which is important to the equipment's correct operation. Failure to understand and implement the information given may result in equipment failure or injury to personnel.

### Electric Shock

This sign indicates safety procedures or advice relating to the presence of high voltages.

### Advice & Suggestions

This information direction symbol is used to mark important non-safety critical advice and suggestions for operation of the Modus 3 Local Operation.

## Modus 3 Kit

Modus 3 kits will have the following equipment supplied:

- ❐ Modus 3 RF Vector Signal Generator
- ❐ Auto Switching IEC Mains Power Supply Unit
- ❐ IEC Mains Lead
- ❐ Wideband Antenna
- ❐ 2GByte Ultra 3 Compact Flash Card
- ❐ Compact Flash Reader

- USB Lead

- RS232 9 Way D Software/Firmware Upgrade cable

- Peli 1500 Transport Case
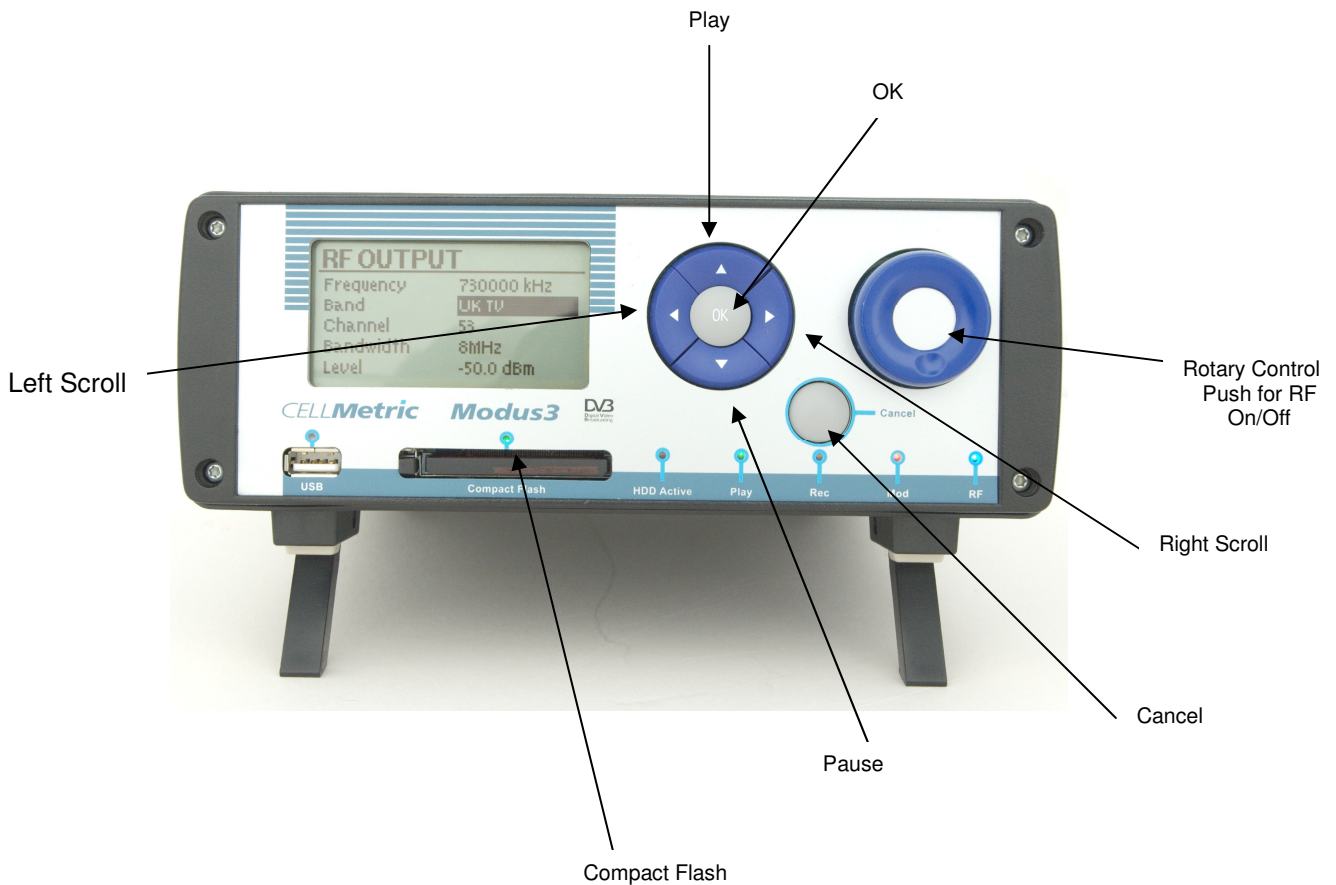
- Getting started user guide

## Power Supply

⚠️ The mains power supply provided with the Modus 3 units is auto switching 100v to 240v AC. Output is 12V DC and is overload protected.

Modus 3 can be powered from a 12v car battery with terminal voltage in the range 12 to 15V at 3A.

## Front Panel

The Modus 3 has the following front panel controls and connectors:



## Rear Panel

The Modus 3 has the following rear panel connectors:

- RF Out 100 MHz to 2.2 GHz
- I/Q Differential out
- 10MHz Reference in

- 1PPS timing reference in
- ASI 1 & 2 in
- ASI 1& 2 out
- LVDS SPI In
- LVDS SPI Out
- USB
- 10/100 LAN (Not currently enabled and not part of released 1.0)
- RS232 Serial Port – Only used for software upgrade and remote control
- 12 V DC Power in
- Earth stud
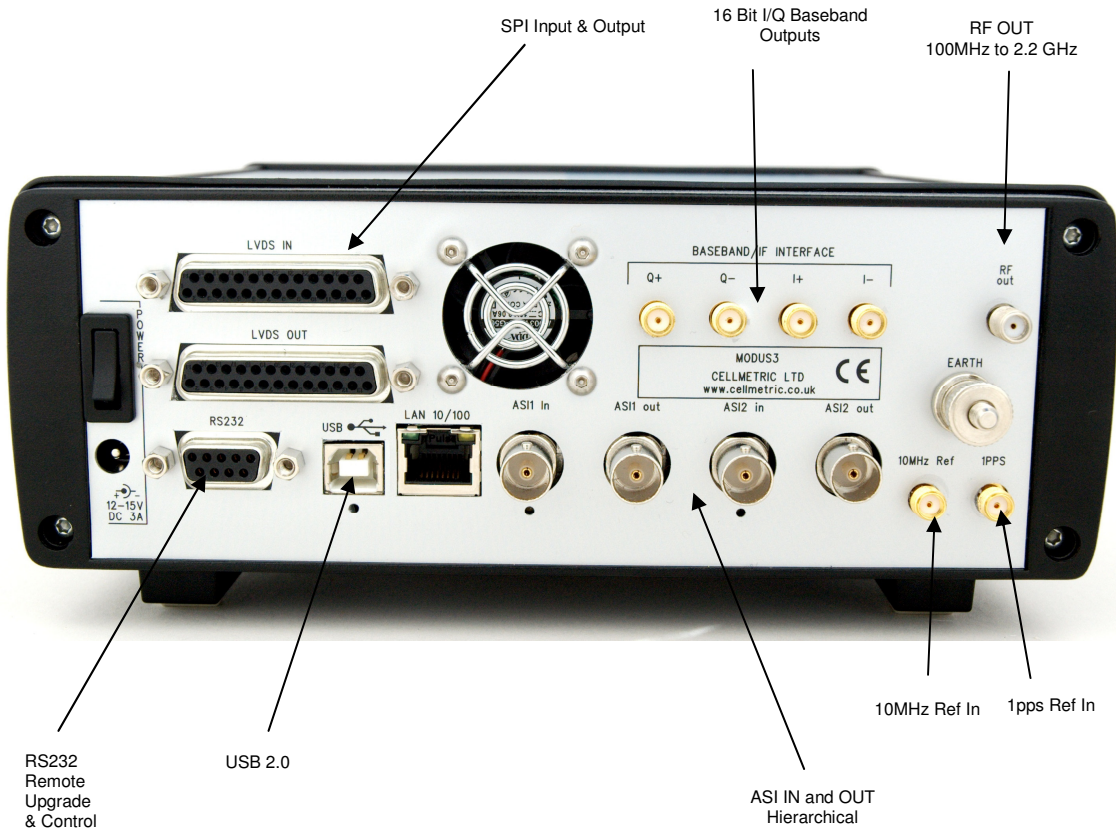


## RF Antenna

The Modus 3 Demo Kit is supplied with a 50Ω wideband antenna. In many countries it is illegal to transmit RF signals without an appropriate broadcast transmission licence. CellMetric strongly recommend that before undertaking any free to air transmission you obtain an appropriate experimental broadcast licence.

## RF Connector

Damage may occur to the RF Out SMA connector if the antenna is over tightened when still attached to the connector.

## RF On/Off

RF output can be switched on and off by pressing the front panel rotary control knob, the blue RF LED will switch on when the RF output is enabled.

# Signal Source Overview

Modus 3 can be considered as a series of integrated functional blocks:

- ❐ Play out source
    - ○ Mobile video data from Compact Flash card
    - ○ Mobile video data from internal hard disk
    - ○ Mobile video data from ASI hierarchical interface
    - ○ Mobile video data from SPI interface
    - ○ PRBS from internal data generator
- ❐ Modulator
    - ○ DVB-T Real Time Modulator
    - ○ DVB-H Real Time Modulator
    - ○ I/Q Streaming Engine
- ❐ Upconverter
    - ○ Converting base band modulator signals to RF signals in the range 100MHz to 2.2 GHz with 1KHz step size
- ❐ Amplifier
    - ○ Generating a level controlled 0 dBm signal across the 100MHz to 2.2 GHz band
- ❐ Attenuator
    - ○ Attenuating the RF level from 0 dBm to -110dBm in 0.5dB steps
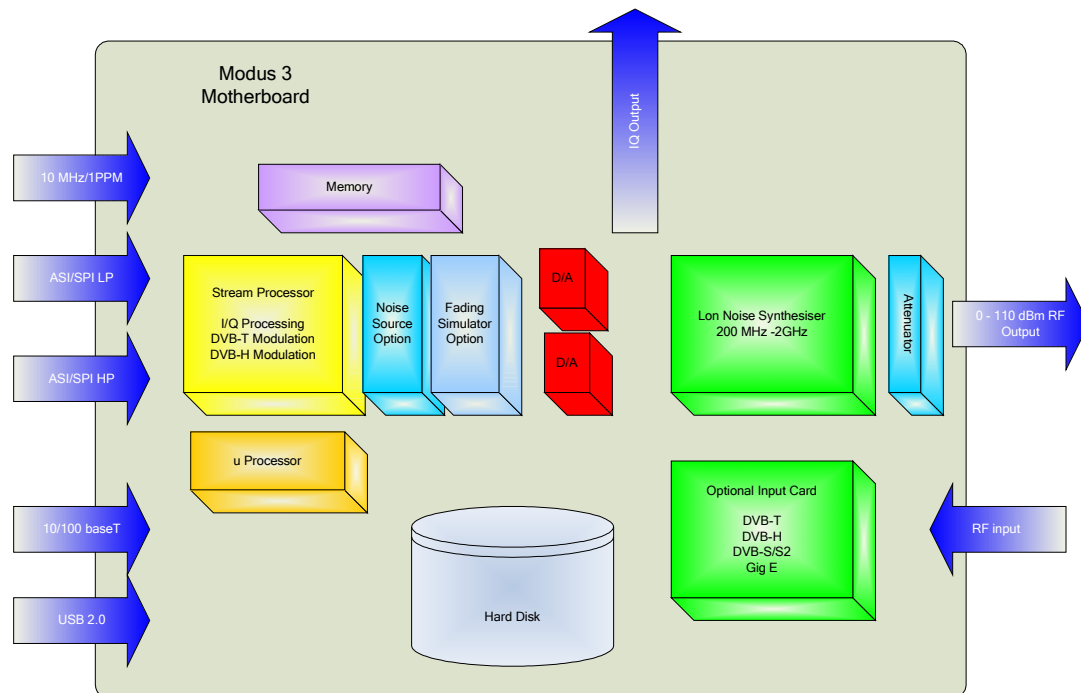


Interfaces for these functional blocks are as follows:

- ❐ ASI Interface

    Asynchronous Serial Interface (ASI)
    - ○ ASI1 In        Hierarchical High Priority Input
    - ○ ASI2 In        Hierarchical Low Priority Input
    - ○ ASI1 Out       Hierarchical High Priority Output
    - ○ ASI2 Out       Hierarchical Low Priority Output

❒ SPI Interface

Synchronous Parallel Interface
- LVDS IN
- LVDS OUT

❒ I/Q interface

I/Q Baseband Interface 50Ω output Impedance
- Q+
- Q-
- I+
- I-

❒ RF Interface

Main RF output 0 dBm to -110 dBm 50Ohm

❒ USB  Interface

USB Type B Connector supporting mass storage class

❒ Ethernet 10/100Base T Interface

This Interface is not enabled on Modus 3 and is reserved for future use by CellMetric

❒ RS 232 Interface

9 Way D RS232 with full handshake used for firmware and software upgrade of the Modus 3 and remote control
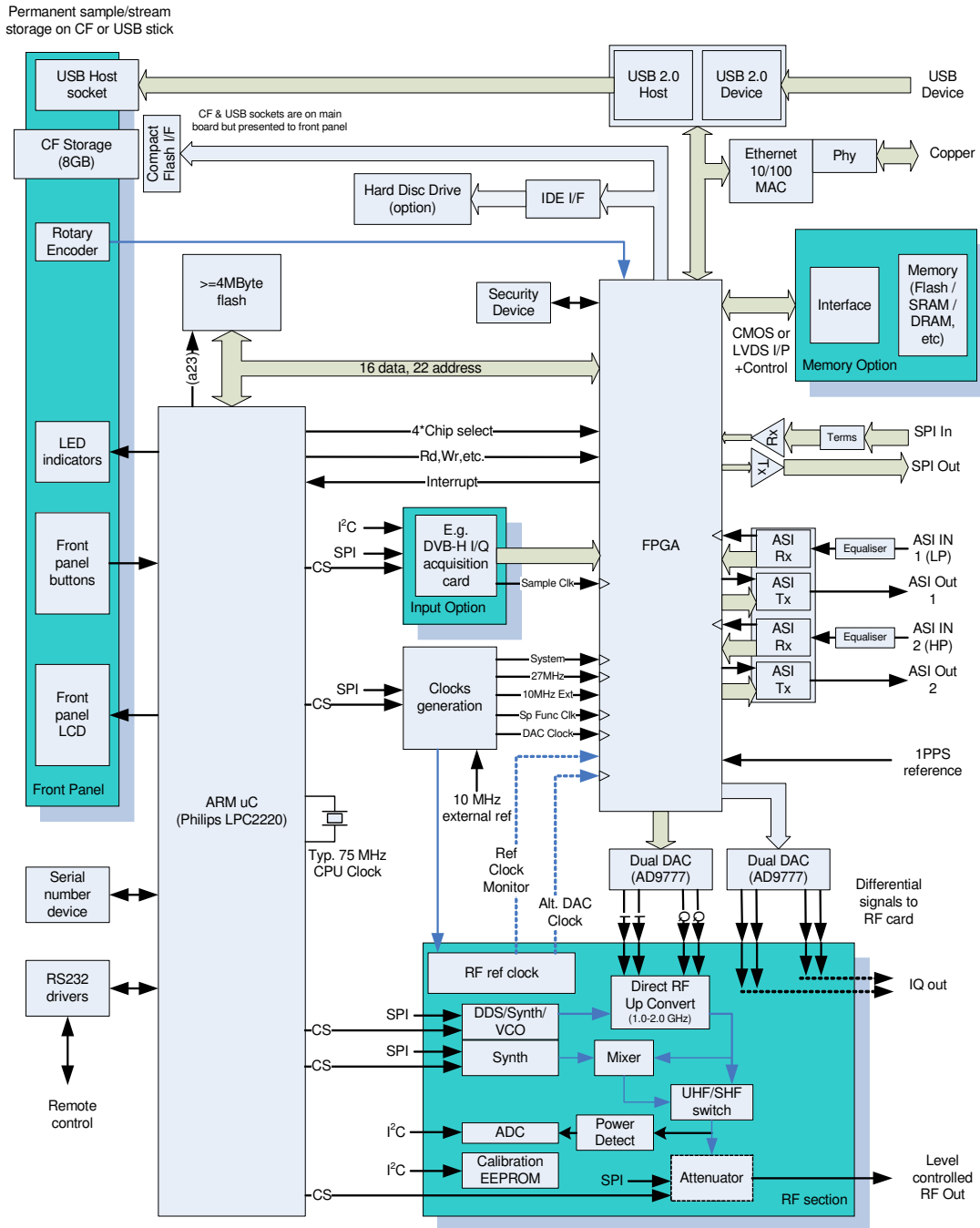
❒ 10 MHz Reference input

External frequency reference input.  If selected from the Modus 3 user interface the Modus will lock its internal operational clocks to a precision 10 MHz reference clock.

❒ 1PPS Input

One Pulse Per Second input used to lock the output RF transmission to Single Frequency Network (SFN) transmission if the SFN adaptor option is fitted and enabled.

A detailed system diagram of the functional hardware of modus 3 is shown below.

Modus Project
System Architecture
Rev 2.0

Permanent sample/stream storage on CF or USB stick

USB Host socket

CF Storage (8GB)

Compact Flash I/F

CF & USB sockets are on main board but presented to front panel

Rotary Encoder

>=4MByte flash

(a23)

LED indicators

Front panel buttons

Front panel LCD

Front Panel

ARM uC (Philips LPC2220)

Typ. 75 MHz CPU Clock

Serial number device

RS232 drivers

Remote control

Hard Disc Drive (option)

IDE I/F

Security Device

16 data, 22 address

4*Chip select

Rd,Wr,etc.

Interrupt

I²C
SPI
CS

E.g. DVB-H I/Q acquisition card

Input Option

Sample Clk

SPI
CS

Clocks generation

System
27MHz
10MHz Ext
Sp Func Clk
DAC Clock

10 MHz external ref

Ref Clock Monitor

Alt. DAC Clock

USB 2.0 Host

USB 2.0 Device

USB Device

Ethernet 10/100 MAC

Phy

Copper

Interface

Memory (Flash / SRAM / DRAM, etc)

Memory Option

CMOS or LVDS I/P +Control

FPGA

Rx
Tx

Terms

SPI In

SPI Out

ASI Rx

Equaliser

ASI IN 1 (LP)

ASI Tx

ASI Out 1

ASI Rx

Equaliser

ASI IN 2 (HP)

ASI Tx

ASI Out 2

1PPS reference

Dual DAC (AD9777)

Dual DAC (AD9777)

Differential signals to RF card

IQ out

RF ref clock

SPI
CS

DDS/Synth/ VCO

Direct RF Up Convert (1.0-2.0 GHz)

SPI
CS

Synth

Mixer

UHF/SHF switch

I²C

ADC

Power Detect

I²C

Calibration EEPROM

SPI

Attenuator

RF section

Level controlled RF Out

CS

RF Card shown provides continuous output from 0.1 to 2.2 GHz.
Other RF cards may be developed for alternative needs.

## Operational Mode and Transmit Data File Formats

Modus 3 support two storage file formats depending on its mode of operation:

### Transport Stream

❒ DVB-T and DVB- H mode

In DVB mode the Modus accepts DVB Transport Streams of either 188 or 204 Byte format. These can be fed as live streams into the hierarchal ASI inputs or stored on the hard disk or compact flash disk and played from these storage devices. Modus 3 auto detects whether a transport stream is 188 or 204 byte format.

### IQ Files

❒ DAB and DMB-T mode

In DAB and T-DMB mode the Modus accepts pre stored streams of 8 or 16 bit I and Q data at a clock rate of 2.048 Mbit/s. For continuous looping it is advisable to terminate data files on an integer increment of 188 Bytes.

### File Directory and Selection

A file selection dialog is provided for loading the XML config settings file (see below) and selecting stream files. This presents the Compact Flash card and the Hard Disk in a tree structure, and it is possible to select the correct file by moving up and down the tree and expanding nodes where necessary.

Both the settings file and stream files may reside anywhere on either disk. The following keys are used to navigate:

OK: Press this to enter the file selection dialog. When a directory is highlighted, pressing OK will expand or compact the display of that directory. When a file is highlighted, pressing OK will select that file.

LEFT ARROW: Pressed from within a directory, this collapses the display of its contents.

RIGHT ARROW: Expands a directory.

CANCEL: Returns to the previous menu without making any changes.

UP and DOWN ARROWS: Moves up and down the list of files and directories.

### Compact Flash Card Types and File Sizes

Modus 3 is qualified for use with SanDisk Extreme III Compact Flash cards. Other makes of Compact Flash card may work with the unit but have not been qualified by CellMetric. Access speeds of at least X133 are required to enable full bandwidth streaming of transport stream or I/Q files.

Modus 3 supports individual file sizes of up to 4GByte (limit is set by its FAT32 filing system). The maximum Compact Flash card size supported is 16GByte.

### Hard Disk File Systems

⚠ If the optional 100GByte hard disk is fitted to the Modus 3 8 bit I/Q files and DVB Transport stream files can be stored and played from the disk up to a maximum individual file size of 4 G Byte.  Maximum data rate for I/Q and transport stream playout from the hard disk is:

❒ 8 bit I/Q files at up to 2MSPS
❒ 16 bit I/Q files at up to 1MSPS
❒ DVB-T and H (with 188 byte packets) at all legal rates
❒ DVB-T and H (with 204 byte packets) at up to 20Mbits/s

## XML File Systems

Modus 3 uses XML files for a number of configuration tasks.  These include:

❒ Auto configuration of transport stream and I/Q files to preset the Modus 3 modulator parameters.

This config XML file stored on the compact flash card or hard disk and is associated with an individual transport stream or I/Q data file.  Its function is to preset the modulation parameters required to correctly play and modulate the associated data file.

The config XML files is parsed by the Modus 3 when the unit powers up or the compact flash card is inserted into the compact flash slot at the front of the Modus 3, or the file to be played is selected.  Appendix A contains the syntax for XML programming.  The simplest way to generate the file is to use the Modus 3 to generate it by setting the desired modulation parameters from the local UI and then going to the Housekeeping Screen. Save settings will write an XML file to the compact flash disk.  This can then be edited on a PC using a commercially available XML editor.

⚠ Please Note that up to software release 1.11.6 only the XML Auto Configuration file on the Compact Flash card is parsed.  XML files stored on the hard disk will not be parsed at startup.  From Software Release 1.14.0 multiple XML cofig files can exist on both compact flash and hard disk and are associated with individual transport stream or I/Q files.

❒ Setting the frequency raster of the modulator.

This data can be stored on the compact flash card and will be parsed at start up.  The frequency data on the compact flash card will override the frequency raster stored in the Modus 3.

❒ Calibration data to linearise the digital RF radio.

This data is programmed into $E^2$ memory on the radio module during manufacture and is not accessible to the user.

# DVB-T and DVB-H Operation Mode

Modus 3 has a intuitive LCD based graphical user interface that allows setting of all play out and modulation parameters.  Individual control screens are context sensitive and will only be displayed if appropriate to the modulation mode chosen for the unit.

Scrolling the control screen right **Right Arrow,**  directly follows the logical signal flow / modulation processing from data source to modulation, to RF up conversion.

All settings on the Modus 3 are accessible from the front panel control keys and the rotary control.
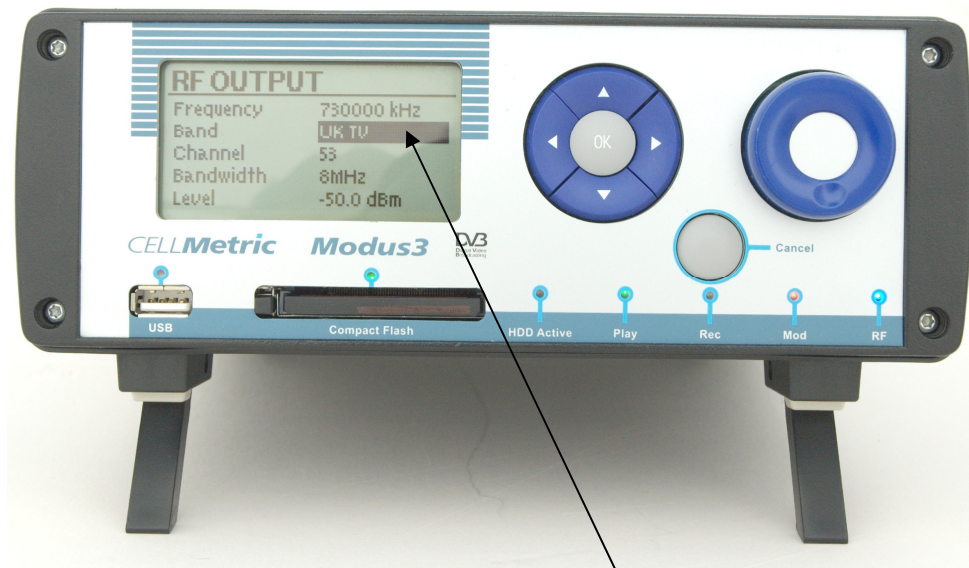


Highlight using down arrow
Modify with L or R arrow or Knob
OK to Set

❐  Modus 3 always defaults to the player screen on power up.  To quit this screen hit Cancel, this takes you to the control menus which are scrolled left or right

- Modus 3 control screens scroll left or right across the LCD display and are selected by the right or left hand control buttons of the 4 way round switch.

-  Quitting any screen is actioned by pressing the Cancel button.

-  Accepting any setting is actioned by pressing the central OK button of the 4 way switch

- Once on a settings screen individual settings are accessed by scrolling down the menu using the up/down buttons.  Selected menu items are in reversed graphics.

- Settings are changed by scrolling fields or digits using the left/right buttons of the 4 way switch or the rotary knob, then pressing OK to confirm

- Stream play out can only be activated once an appropriate file has been selected for play from the stream control panel, you need to manually enter the stream bitrate into the UI

-  Play out is activated by pressing the up key of the 4 way switch from the player (default) menu.  Pause is the down key.

- You can always get to the play menu by pressing Cancel twice

- Once you have selected appropriate modulation settings they can be saved by scrolling to the Housekeeping screen and selecting save settings.

**DVB-H & DVB-T Control Screens are:**

**System**



❑ Allows selection of the mode of operation of the unit. Select from:

    o DVB-H

    o DVB-T

    o I/Q streaming

    o TS Player

❑ Hierarchy

    o None

    o Alpha 1

    o Alpha 2

    o Alpha 4

**TS Source**



❑ Allows selection of data source. Select from:

    o Compact Flash memory card

    o Hard Disk (If option fitted)

    o ASI#1 in

    o ASI#2 in

    o SPI (LVDS) in

    o PRBS

N23 Pseudo Random Binary Sequence generated internally by the Modus 3 which is then modulated and transmitted

❒ Filename

The filename of the data file to be transmitted

❒ Select data rate for play out

Data rate for play out in Kbits/s.  If the selected data rate is above that of the stored Transport Stream the modulator will automatically stuff null packets.

## Modulation



❒ Sets all modulation parameters

❒ Mode

  o QPSK

  o QAM-16

  o QAM-64

❒ Guard

  o 1/32

  o ¼

  o 1/8

  o 1/16

❒ FFT

  o 2K

  o 4K DVB-H Only

  o 8K

❒ Code Rate

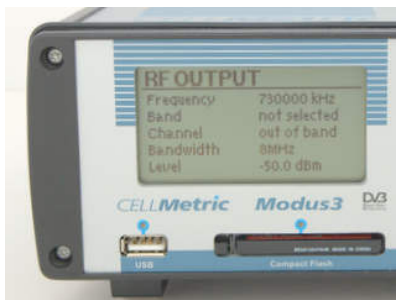  o ½

  o 2/3

  o ¾

- o 5/6
- o 7/8
- ❐ Deep Interleaving – DVB-H Mode Only

## TPS DVB-H Mode Only
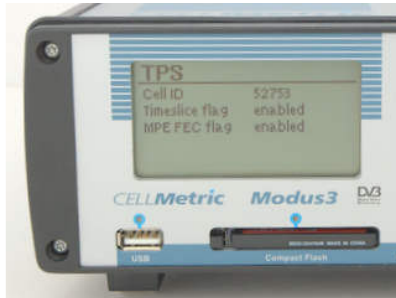


- ❐ Sets TPS processing parameters
- ❐ Cell ID       Any numeric from 0 to 65535 set using scroll knob
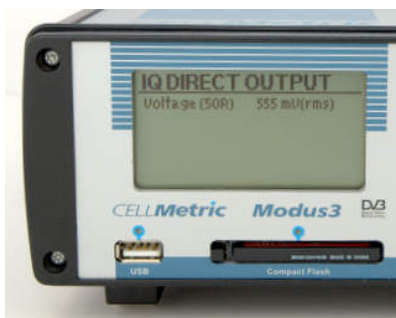- ❐ Time Slice
- ❐ MPE FEC

## RF Output



- ❐ Sets Frequency, channel and level for play out
- ❐ Frequency
- ❐ Band
- ❐ Channel
- ❐ Bandwidth
- ❐ Level

## RF Processing



- ❒ Sets FEC and interleaving parameters
- ❒ Spectrum

  Normal or inverted spectrum

- ❒ Auto Level

  An Automatic Gain Control (AGC) function not normally required for DVB-T/H operation

## IQ Direct Output



- ❒ Differential I/Q base band output to feed external up converter
- ❒ Voltage (50R)        555mv(rms)

## Housekeeping



- ❒  Save Settings - Allows user setting to be stored to a XML file on the mass storage device

❒ Ref Clock

Default is internal clock but the external 10MHz reference input can be selected

❒ Auto Play

If selected allows Modus 3 to automatically start playing the preferred file on the storage media at power up

❒ LCD Contrast

Allows adjustment of the LCD contrast

# DAB and T- DMB I/Q Operation Mode

Modus 3 supports Digital Audio Broadcast (DAB) derived multimedia broadcast standards by I/Q streaming, that is playing pre recorded I and Q RF digital samples through it's A/D converters and RF up converter.

I/Q samples can be 8 or 16 bit at a clock rate of 2.048 Mbit/s.

To enter I/Q mode the **System** screen should be entered and the **System mode** selected, this should be set to **I/Q player** and then **OK**



The right scroll button should then be selected to move to the **I/Q Stream** screen.  This gives access to the I/Q streaming controls:



❐   Source

Source of the stored I/Q data

❐   Filename

Name of the stored I/Q data file

❐   Sample rate

The clock sample data, this is user selectable with the rotary knob but is usually 2.048 Mbit/s

❐   Bit Depth

8 or 16 bit samples

❐   Headroom

The headroom required to prevent RF clipping of the transmitted signal.  For DAB this is usually 16dB

## Modus 3 I/Q Test Patterns

The IQ mode allows simple predefined test patterns to be output. These are activated by choosing the "Pattern" source and selecting a pattern type. Currently a "Carrier wave" pattern type is available, which consists of a full scale tone at the centre frequency.

## Modus 3 I/Q file format

The Modus I/Q file format is a binary file, with each 4 bytes representing one I/Q pair, which may be repeated as many times as necessary:

{ I LSB } { I MSB } {Q LSB } {Q MSB }

Together, the LSB and the MSB make a 16 bit signed value.

The sample rate of the IQ stream should be 2.048MSPS, and cannot be significantly changed on the Modus 3 units for DAB based systems.

The file should have the suffix ".IQ". The compact flash should be formatted using FAT32, with a sector size of 512 bytes and a minimum cluster size of 8 sectors (more would be better).

## sincos.exe

This utility can be supplied by CellMetric and creates an IQ test file, such that:
$I = 16383.5*\cos(2.PI.Fm.t)$
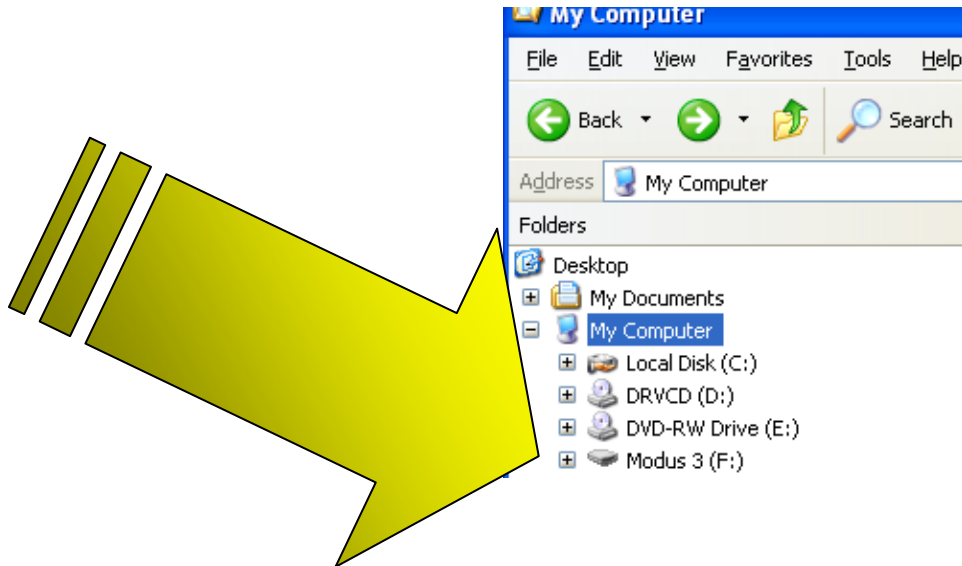$Q = 16383.5*\sin(2.PI.Fm.t)$
Where Fm is 200kHz.

When modulated to RF, such an IQ file will generate a single peak at the carrier frequency PLUS Fm, assuming that the sampling frequency is set for 2.048MSPS.

The output file is always called SINCOS.IQ

# USB  Mass Storage Class Device

Modus 3 Implements a USB  complaint plug and play slave device.  This interface makes the Modus 3 look like an external mass storage device when connected to a host PC.  Both the internal hard disk and the Compact Flash card will look like storage devices on the host PC and will support drag and drop of transport stream or I/Q files from the host PC to the Modus storage devices.

When the Modus 3 is connected to a host PC via the USB interface playout is disabled to prevent memory contention issues which may occur if the Modus 3 and host PC attempt to access a stored file.  This is indicated by the RED Rec LED flashing on the front panel.  To play a file disconnect the USB interface.

# Remote Upgrade



Modus 3 can be upgraded remotely using the 9 way RS232 port on its rear panel.  Upgrade instructions are as follows:

## Required

Modus 3 unit with power supply

The "Modus Burner" application and image to be downloaded. These are normally supplied zipped, and therefore will need to be unzipped and copied to a clean directory on the PC. The image will have a .MOT extension (Motorola S record file format).

A fully-wired straight-through serial cable (sometimes called a "modem" cable). 9 pin socket to 9 pin plug with each pin connected to the same numbered pin at the other end.

A PC with a 9 pin serial connector and running Microsoft Windows XP (the tool should work with other versions of Windows, but has not been tested).

However, some PCs no longer come with serial ports. We have found that it is possible to use some of the USB to serial converter cables that are on the market, although some of them will not work because they do not correctly control the extra signals that Modus expects (i.e. DTR and RTS). One USB adapter we have successfully used is this available here:

http://www.directusbstore.com/cnb/shop/directusbstore?productID=490&op=catalogue-product_info-null

When installed, this product will typically make the serial port appear as COM6.

## Procedure

Connect the serial cable from COM1 (or COM2) on the PC to the rear serial port connector on Modus.

Open a DOS box on the PC and navigate to the directory that the Modus Burner application and download image have been placed. Type the following:

**burner   COM1   <image name>**

Where:
    COM1 is the serial port on the PC which is connected to Modus. Other COM ports may be

also be used.

    <image name> is the name of the image to be burnt into Modus. For example, modus_1x8x1.mot

This will programme the flash, which takes around 5 minutes. As it is programming, it displays the number of bytes successfully burnt.
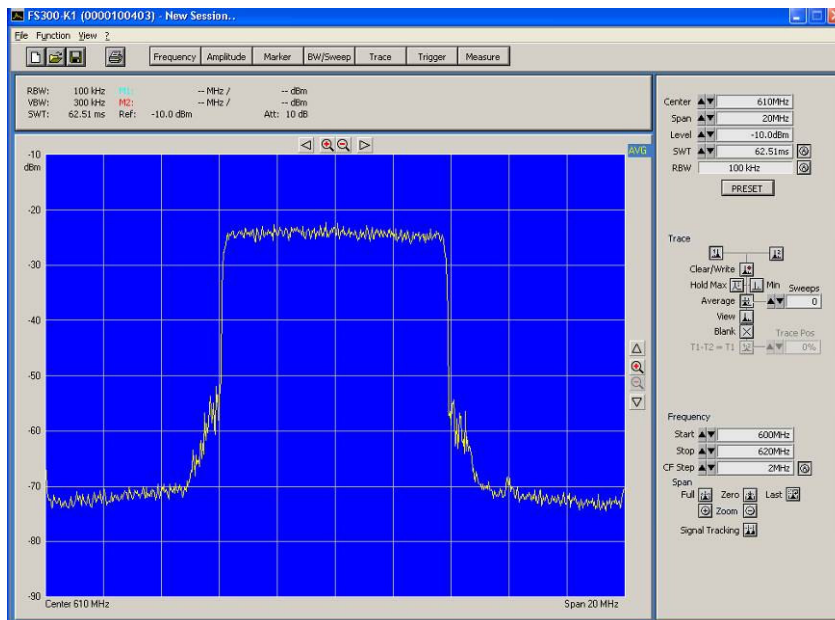
# Modus 3 Typical RF Performance

The following plots give indicative results of the RF performance that can be expected from the Modus 3 modulator
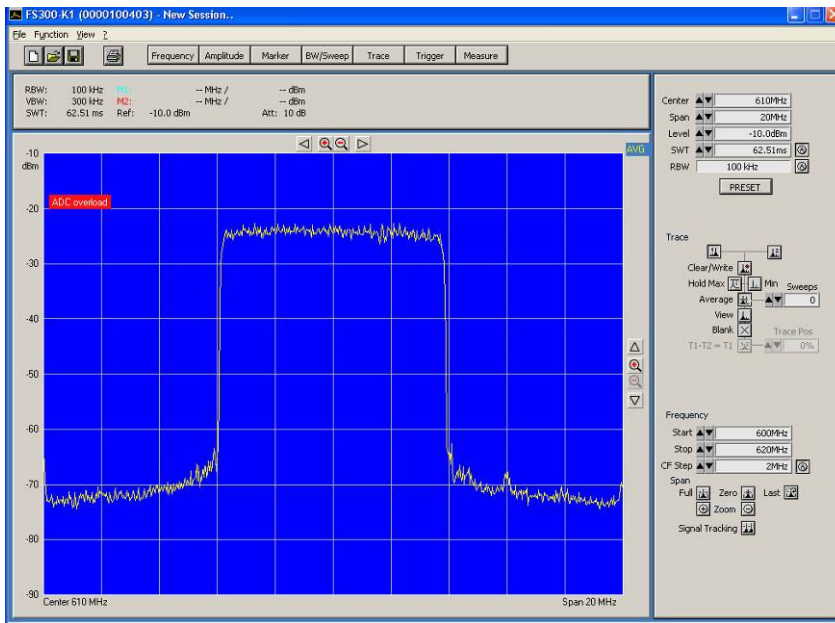
## Modulated Broadband Spectrum
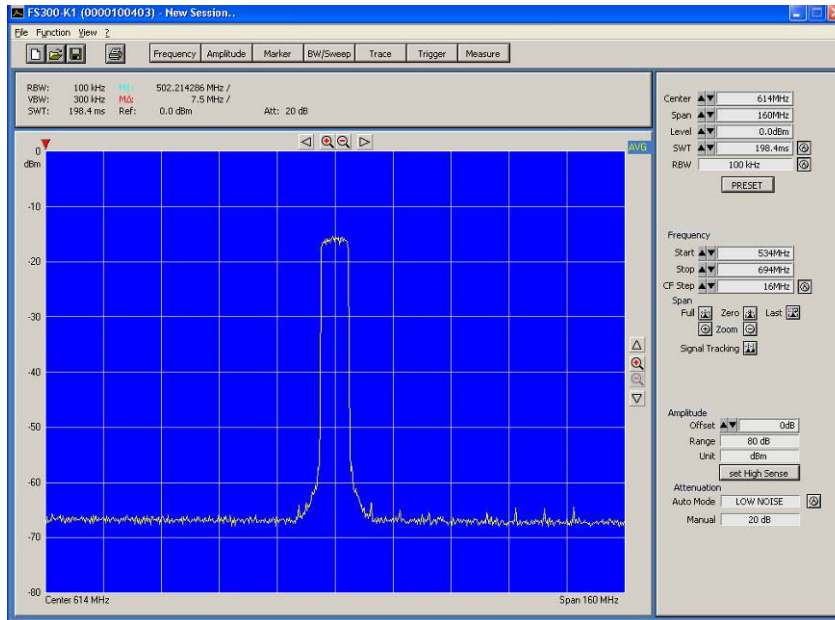


## 2K Modulated DVB COFDM

## 8K Modulated DVB COFDM

# Appendix A – Serial Port Remote Control
# XML Config Files
# XML Band Files

Information contained in this document is based on version 1.9.5 of the Modus 3 software. It is likely to be extended, and possibly changed, in future releases.

## Serial Port

The Modus serial port is used for three purposes:

- Upload of new firmware, using CellMetric's "burner" tool.
- CellMetric internal debugging, diagnostic and calibration purposes.
- Configuring and controlling Modus using simple text commands.

## Configuring and controlling Modus using simple text commands

### Pin out

Connect Modus to a PC using a 9 pin socket to 9 pin plug, straight through cable. It should be sufficient to connect pin 2, 3 and 5 in the socket to the corresponding pin in the plug. If a fully wired cable is used (as used by the Cell Metric Burner application), then it will be necessary to ensure that pin 4 and pin 7 are driven low by the PC – this is not normally the default.

| Modus 9 pin D type socket | Function |
| --- | --- |
| Shield | GND |
| Pin 1 | |
| Pin 2 | Modus Tx (output from Modus) |
| Pin 3 | Modus Rx (input to Modus) |
| Pin 4 | System reset when high (input to Modus). Normally kept low or not connected. |
| Pin 5 | GND |
| Pin 6 | |
| Pin 7 | Must be low or not connected (input to Modus) |
| Pin 8 | |
| Pin 9 | |

### Settings

Baud rate:     115200
Partiy:        None
Databits:      8
Stop bits:     1
Handshake:     none

### Protocol

The Modus 3 remote control protocol is text based. The host PC sends a REQUEST message (REQ), and Modus always sends a CONFIRM message (CFM) in reply.

REQs and CFMs are always shorter than 256 bytes and terminated with ASCII LF (10) or ASCII CR (13) or both. Complete messages should be transmitted within 0.5 seconds. The host should expect a CFM message to begin within 2 seconds of the REQ message being completely sent. If it is not received, then it may be assumed that Modus has not received the message and it should be sent again.

CFM messages always begin with a dollar symbol ("$"). Text that does not begin with this should be discarded. Modus may send a response starting with "$ERR" to indicate an error.

| REQ message (sent by PC) | CFM message sent by Modus in reply |
| --- | --- |
| SET <xml> | $OK |

This sets the internal configuration. The <xml> part of the text is the same as specified for the CONFIG.XML file within the <Configuration> element. For example, the following message will set the output frequency:
SET <RfOutput Frequency="506000000" />
Note that the Element should be properly closed and note that not all the attributes need to be specified. Incorrect XML will be ignored.

| REQ message (sent by PC) | CFM message sent by Modus in reply |
| --- | --- |
| PLAY | $OK |

This tells Modus to begin playing the stream that has been previously selected.

## BANDS.XML

Modus supports Bands and Channels. This means that rather than the user having to painstakingly select a particular frequency in the RF Output menu, by using the knob, the user can select a band (eg UK UHF") and then select a particular channel in the band by name (eg "Ch 21").

A number of Bands are built into Modus, but is possible for the user to create a customised list of Bands and Channels instead. This is achieved by creating an XML file called BANDS.XML and ensuring it is placed on a Compact Flash card that has been inserted before Modus is turned on.

Strict adherence to XML standards is necessary, so for example, inverted commas around attribute values are always needed. All Elements must be closed (eg </Bands>). Note that everything in the file is case sensitive. In general, all Elements and Attributes start with a capital letter, whereas most attribute values start with a lower case letter.

## Example

This example file shows how to make a band called "UHF" which has presents two channels: "Ch21" (at 474MHz) and "Ch22" (at "482MHz"):

```
<?xml version="1.0" ?>
<Configuration Version="1">
  <Bands>
    <Band Name="UHF" BandBottom="466000000" BandTop="866000000"
ChannelFrom="-4000000" ChannelTo="3999999">
      <Channel Name="Ch21" Frequency="474000000" />
      <Channel Name="Ch22" Frequency="482000000" />
    </Band>
  </Bands>
</Configuration>
```

## Description

**<?xml version="1.0" ?>**
This must be present, unchanged.

**<Configuration Version="1">**
The <Configuration> element encloses all the configuration data.
Version: This should be set to "1"

**<Bands>**
The <Bands> element encloses one or more frequency band descriptions.

**<Band Name="UK UHF" BandBottom="466000000" BandTop="866000000" ChannelFrom="-4000000" ChannelTo="4000000">**

The <Band> element provides the description of a particular band, including the list of Channels within that band. There may be specifications for as many bands as needed(subject to Modus memory constraints).
Name: This text identifies the name of the band

BandBottom, BandTop: These values (in Hz) define the range of the band. If the frequency that Modus is currently tuned to falls within these limits, Modus considers the frequency to be within the particular band.
ChannelFrom, ChannelTo: Modus is normally tuned to the centre of a channel – these values indicate the extend of the channel below and above the actual tuned frequency (in Hz).

**<Channel Name="Ch21" Frequency="474000000" Offset="-166666"/>**

This is the definition of an individual channel. There may be as many channels within a band as necessary (subject to Modus memory constraints).

Name: This text identifies the name of the channel.
Frequency: This is the centre frequency of the channel, in Hz.
Offset: This is an optional attribute, not normally needed. It specifies an offset to be applied from the centre frequency. In the case shown, the channel will be displayed as "Ch21 - 167kHz", and the frequency will be 473.833334MHz.

## CONFIG.XML

If a file called CONFIG.XML is found on the Compact Flash when Modus3 is turned on, it will be read and used to set the initial configuration of the unit. Any parameters missing or badly formed will be set to their default values. Strict adherence to XML standards is necessary, so for example, inverted commas around attribute values are always needed. All Elements must be closed (eg </Configuration>).

Note that everything in this file is case sensitive. In general, all Elements and Attributes start with a capital letter, whereas most attribute values start with a lower case letter.

Numbers may only be expressed in decimal (hexadecimal is not supported).

## Example

```
<?xml version="1.0" ?>
<Configuration Product="Modus" Version="1">
  <Device SoftwareVersion="1.0.10" SerialNumber="0000-0E9D-24A9" />
  <System Mode="DVB-H player" AutoPlay="1" />
  <Sources>
    <IqSource Channel="0" Input="CF" Filename="STREAM.IQ"
SampleRate="2048000" Headroom="6.000000" BitDepth="16" />
    <TsSource Channel="0" Input="CF" Filename="N92.TRP" BitRate="4970000"/>
    <TsSource Channel="1" Input="CF" Filename="HD12SD.LP"
BitRate="17564000"/>
  </Sources>
  <Modulators>
    <DvbthModulator Mode="64QAM" GuardInterval="1/16" Bandwidth="8MHz"
Hierarchy="alpha1" FFT="8k" CellId="204" DeepInterleaving="0">
      <Channel Name="HP" CodeRate="1/2" MpeFecFlag="1" TimesliceFlag="1"/>
      <Channel Name="LP" CodeRate="3/4" MpeFecFlag="0" TimesliceFlag="0"/>
    </DvbthModulator>
    <IqModulator/>
    <TsModulator/>
  </Modulators>
  <RfOutput Power="-24.5" RfOn="1" Frequency="506000000" Band="UK UHF"
Spectrum="normal" Alc="0" />
<IqOutput Vrms="0.555" />
</Configuration>
```

## Description

### <?xml version="1.0" ?>
This must be present, unchanged.

### <Configuration Product="Modus" Version="1">
The <Configuration> element encloses all the configuration data.

Product: This is always set to "Modus".
Version: This should be set to "1"

### <Device SoftwareVersion="1.0.10" SerialNumber="0000-0E9D-24A9" />
This is present for information purposes, but is currently not used.

### <System Mode="DVB-H player" AutoPlay="1" />
This element controls the overall functionality of the unit, which sources are connected to which modulator, and determines the legal values any of the following elements may take.

Mode: "IQ player", "TS player", "DVB-T player", "DVB-H player"
AutoPlay: When set to "1", means that the stream will automatically play (if present) when the CONFIG.XML file has completed loading.

### <Sources>
Lists the sources for the modulators. The SystemMode determines whether IqSource or TsSource parameters are used.

**`<IqSource Channel="0" Input="CF" Filename="STREAM.IQ" SampleRate="2048000" Headroom="6.000000" BitDepth="16" />`**

An IQ source. Currently there may only be one IQ source and it must be on channel 0.
Channel: Must be "0"

Input: "CF"
Filename: The 8.3 DOS style filename of the file to be played
SampleRate: The sample rate required to be used for this stream (in Hz) as a decimal integer.
Headroom: The digital headroom of the IQ stream, in dB and between 0 and 20 inclusive.
BitDepth: Modus is capable of playing both 8 bit ("8") and 16 bit ("16") IQ streams.

**`<TsSource Channel="0" Input="CF" Filename="N92.TRP" BitRate="4970000"/>`**

An MPEG2 transport stream source. There may be up to two TS sources. When using DVB-T/H modulator, channel 0 is connected to the HP input of the modulator, channel 1 is connected to the LP input of the modulator.

Channel: "0", "1"
Input: "CF", "ASI1", "ASI2", "SPI"
Filename: The 8.3 DOS style filename of the file to be played
BitRate: The bitrate that the stream should be played out at (in bits/second).

**`<Modulators>`**

This section contains a list of the modulators supported.

**`<DvbthModulator Mode="64QAM" GuardInterval="1/16" Bandwidth="8MHz" Hierarchy="alpha1" FFT="8k" CellId="204">`**

The DVB T/H modulator.

Mode: "QPSK", "16QAM", "64QAM"  (QPSK not allowed in hierarchical modes)
GuardInterval: "1/4", "1/8", "1/16", "1/32"
Bandwidth: "5MHz", "6MHz", "7MHz", "8MHz"
Hierarchy: "none", "alpha1", "alpha2", "alpha4"
FFT: "2k", "4k", "8k" (4k only for DVB-H mode)
CellId: decimal integer (only used in DVB-H mode)
DeepInterleaving: "0" (DVB-H deep interleaving off) or "1" (DVB-H deep interleaving on. FFT mode must be 2k or 4k)

**`<Channel Name="HP" CodeRate="1/2" MpeFecFlag="1" TimesliceFlag="1"/>`**

The DVB-T/H modulator is fed with two channels, "HP" and "LP". When not performing hierarchical modulation, only the "HP" channel is used.

Name: "HP", "LP"
CodeRate: "1/2", "2/3", "3/4", "5/6", "7/8"
MpeFecFlag: "0", "1" (only used in DVB-H mode)
TimesliceFlag: "0", "1" (only used in DVB-H mode)

**`<IqModulator/>`**

The (pseudo) modulator for raw IQ playout. Currently there are no settings here, so this element is not used.

**`<TsModulator/>`**

The (pseudo) modulator for raw transport stream output. Currently there are no settings here, so this element is not used.

**`<RfOutput Power="-24.5" RfOn="1" Frequency="506000000" Band="UK UHF" Spectrum="normal" Alc="0" />`**

The RF Output card configuration

Power: The desired output level (in dBm), between "-110" and "0"
RfOn: "0" (output off), "1" (output on)
Frequency: An integer between 40000 and 2000000000 representing the output frequency in Hz.
Band: The name of the frequency band that the user is currently using. This affects the display of the channel on the UI only.
Spectrum: "normal" or "invert"
Alc: "0" (automatic level control is off – recommended), "1" (automatic level control is on – in IQ mode, this requires that the digital headroom is set appropriately for the signal being played)

`<IqOutput Vrms="0.555" />`
The configuration for the baseband IQ output connectors on the back of Modus.

Vrms: The desired rms output voltage, in volts.

# Appendix C – RF Specification

**Technical Specification**

**Operating Conditions:**

| | |
|---|---|
| Power Supply voltage | 100 to 260V   47-400 Hz AC |
| Operating Temperature range | 0 to +40$^o$C |

**Outputs:**

| | |
|---|---|
| RF Output | 100MHz to 2.2GHz resolution 1KHz |
| Output channels UHF | 470 to 862 MHz |
| Output Offset kHz offset | 62.5kHz minimum (with +/- 166.66 capability) |
| Output frequency accuracy temperature range | better than +/- 3ppm over |
| Output Band III & L Band | 174 to 240 MHz  1452 to 1492MHz and  1675 MHz |
| Signal output level | 0dBm nominal to -110dBm |
| Output Impedance 50 Ώ | |
| Resolution | 0.5dB typ. |
| Repeatability | ±1dB typ. |
| Output RLR | Better than 10dB typ. |
| Spectral flatness | Better than +/- 0.5dB typ. Across any 8MHz channel |
| Gain Taper | Better than +/- 2dB typ. Across the UHF band |
| Intermodulation products | Better than -45dBc typ. In channel, -60dBc typ. Out of channel |

**Modulation:**

| | |
|---|---|
| DVB-T/H | EN 300 744 |
| DAB | EN 300 401 (I/Q Streaming Mode) |
| FFT Mode | 2k 4k 8k |
| Modulation | QPSK, 16 QAM, 64 QAM |
| Guard  Interval | ¼,1/8,1/16,1/32 |
| FEC | ½, 2/3, ¾, 5/6, 7/8 |
| Bandwidth | 1.7, 5, 6, 7, 8 MHz |
| Hierarchical Code support | Hierarchy  1, 2, 4 16 QAM 64 QAM |
| Spectral Polarity | Normal or inverted |
| Transport Stream Max Bitrate rate | 31.67Mbits/sec maximum usable |

**Interfaces:**

| | |
|---|---|
| External Frequency Ref.In | 10MHz SMA Connector |
| Timing Ref. | 1PPS SMA Connector |
| RF Out | SMA Connector 50Ώ |
| I/Q Out | 8/16 Bit Differential ±I / ±Q Output 50Ώ |
| Serial | USB 2.0 (Slave) |
| Transport Stream In | Dual DVB ASI BNC connectors supporting Hierarchical modulation (Optional) |
| Transport Stream In | Synchronous Parallel Interface (SPI) 25way D connector |
| Removable Memory | Compact Flash Memory Card |

**Installation:**

| | |
|---|---|
| Desk top case | 210 W x 74mm H x 220mm D |
| Weight | 2.5Kg |

# Appendix D – Use of the Agilent ESG Vector Signal Source as an external RF precision up converter
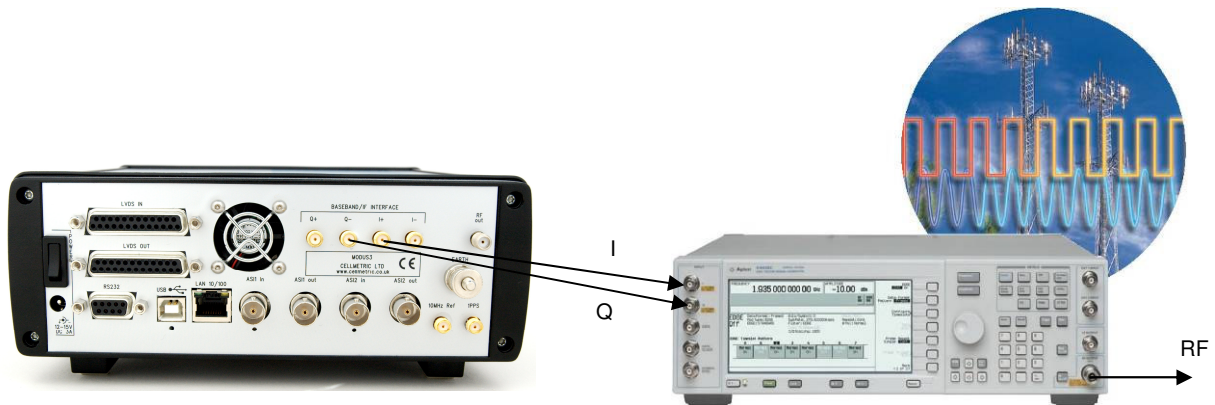


Modus 3 has differential I/Q analogue base band RF outputs which can be used to drive a external I/Q Vector Signal Generator like the Agilent ESG-C to provide a reference quality RF output with 0.1db resolution and very low phase noise.  The I/Q outputs from the Modus 3 are of 16 bit resolution and are the same I/Q data used internally by the Modus 3 up converter stage.

The I/Q outputs are 50Ω output impedance DC coupled and will drive up to 555mV rms into a 50Ω load.  This I/Q level is controllable from the Modus 3 **I/Q Direct Output** screen by scrolling down to highlight the RMS voltage range and adjusting using the front panel rotary control.



To drive the ESG-C the Q- and I+ outputs should be directly coupled to the ESG-C analogue I/Q inputs with the ESG set to external analogue I/Q modulation mode.

## Modus 3: Software Release Note

NB This build is only suitable for Modus products that contain the 4000 series FPGA. These will currently be running version 1.x.x of the software. If in doubt please contact Cell Metric.

| Released Build | Major new features |
|---|---|
| 1.26.0<br>(14 October 2009) | Fix to display of directory structure on CF card and Hard Disk. It is now possible to navigate directory structures.<br>Known issues:<br>Occasionally when playing from mechanical hard disk at high bitrates, the playout stops. This problem does not occur when playing from SSD (solid state hard disks). |
| 1.25.0<br>(3 July 2009) | Additional serial port commands.<br>Known issues:<br>Occasionally when playing from mechanical hard disk at high bitrates, the playout stops. This problem does not occur when playing from SSD (solid state hard disks). |
| 1.24.2<br>(10 June 2009) | Fix to occasional issues when Modus would fail to mount an internal harddisk. Australian VHF and UHF frequency bands added.<br>Burner application now supports serial ports from COM1 through to COM19.<br>Known issues:<br>Occasionally when playing from mechanical hard disk at high bitrates, the playout stops. This problem does not occur when playing from SSD (solid state hard disks). |
| 1.24.0<br>(14 May 2009) | Minor fix to calibration procedures.<br>DVB-TH code rate now defaults to 3/4 (previously 5/6).<br>Known issues:<br>Occasionally when playing from mechanical hard disk at high bitrates, the playout stops. This problem does not occur when playing from SSD (solid state hard disks). |
| 1.23.0<br>(10 April 2009) | Fix to USB problem introduced in build 1.20.0<br>Fix to ASI problem introduced in build 1.14.0.<br>Fix to DVB hierarchical modes, which were broken in build 1.14.0.<br>Various other minor bugs resolved.<br>Known issues:<br>Occasionally when playing from mechanical hard disk at high bitrates, the playout stops. This problem does not occur when playing from SSD (solid state hard disks). |
| 1.20.0<br>(23 October 2008) | Modus now supports playing of both very long (>4GBytes) and concatenated streams. If you wish to use this feature, please contact CellMetric.<br>When a file on the compact flash or hard disk was fragmented, sometimes Modus would stream bad data at the fragmentation point. When playing a DVB-TH stream, this might have resulted in brief visual or audio disturbances. This problem has now been fixed.<br>In the previous release, when loading config information from compact flash or hard disk at start up, the name of the frequency band selected was not loaded. This has now been fixed.<br>Various other minor bugs resolved.<br>Known issues:<br>Occasionally when playing from mechanical hard disk at high bitrates, the playout stops. This problem does not occur when playing from SSD (solid state hard disks).<br>ASI input is broken in this release (and in release 1.14.0).<br>DVB hierarchical modes may be broken in this release (and in release 1.14.0). |
| 1.14.0 | Playout rate from hard disk has been improved.<br>DVB hierarchical modes are now re-enabled.<br>In releases 1.10.7 onwards, the baseband IQ outputs were incorrectly |

| | |
|---|---|
| 18 April 2008 | swapped in some circumstances. This has now been fixed.

The IQ mode now allows simple predefined test patterns to be output. These are activated by choosing the "Pattern" source and selecting a pattern type. Currently a "Carrier wave" pattern type is available, which consists of a full scale tone at the centre frequency.

Minor changes to the UI for selecting PRBS, similar to the IQ Carrier wave selection. Corresponding changes to the config XML and serial port XML commands.

If no bands.xml (frequency bands definition file) is found on the compact flash, modus will now use a bands.xml file on the root of the harddisk, if present. If neither is present, then Modus will use the in-built frequency bands definitions as before.

If no config.xml (settings file) is found on the compact flash, modus will now use a config.xml file on the root of the harddisk, if present.

A new file selection dialog is provided for loading the settings file and selecting stream files. This presents the Compact Flash card and the Hard Disk in a tree structure, and it is possible to select the correct file by moving up and down the tree and expanding nodes where necessary. Both the settings file and stream files may now reside anywhere on either disk. The following keys are used to navigate:
OK: Press this to enter the file selection dialog. When a directory is highlighted, pressing OK will expand or compact the display of that directory. When a file is highlighted, pressing OK will select that file.
LEFT ARROW: Pressed from within a directory, this collapses the display of its contents.
RIGHT ARROW: Expands a directory.
CANCEL: Returns to the previous menu without making any changes.
UP and DOWN ARROWS: Moves up and down the list of files and directories.

Fix to allow the Source parameters (including the filename) to be reliably selected using the serial port XML commands.

Various other minor bugs resolved.

Known issues:
Occasionally when playing from hard disk at high bitrates, the playout stops. This is now much rarer than before, but has still been seen. |
| 1.11.6
(30 October 2007) | Modus no longer requires that stored transport streams begin with a sync byte (hex 47). The stored transport stream may contain a part-packet at the start or end of the file and Modus will automatically regain synchronisation.
Hard disk playback bitrate increased. Now suitable for:
- 8 bit IQ files at up to 2MSPS (DAB and DMB)
- 16 bit IQ files at up to 1MSPS
- DVB-T and H (with 188 byte packets) at all legal rates
- DVB-T and H (with 204 byte packets) at up to 29Mbits
Detection of more hard disk types.
IQ Player mode: A new option in the "RF Processing" menu has been added to enable or disable IQ interpolation processing in the FPGA. (Note that interpolation is still being performed in the DACs). This is a temporary option added because FPGA interpolation seemed to be causing some degradation of the IQ waveform in some circumstances.
DVB-T/H: Improvements to the spectral quality of the DVB-T/H modulation.
DVB-T/H: A new option in the "RF Processing" menu has been added to selectively suppress certain carriers.
Various minor bugs resolved, including a very rare lockup. |

| | Known issues:<br>DVB hierarchical modes are disabled in this release.<br>Occasionally when playing from hard disk, the playout stops. This is more likely to occur at higher bitrates |
|---|---|
| 1.10.7<br>(17 September 2007) | Modus now functions as a USB 1.1 Full-Speed mass storage class device, allowing both the CF card and the internal HDD to be browsed from a Windows XP or Vista PC using a standard USB cable. Includes CellMetric USB vendor ID. (Improvements to the speed of this interface are currently being worked on).<br>Improved MER, especially when using baseband I/Q outputs, due to improvements in clock routing within the FPGA.<br>Transport stream bitrate may now be automatically derived from the modulation parameters when in DVB-T or DVB-H mode, and this is now the default. (Press left or right arrow when the bitrate is highlighted to select or deselect this feature). If setting the bitrate manually, there is now an indication as to whether the bitrate is appropriate for the modulation parameters.<br>Bug that corrupted HDD and CF accesses beyond the first 8GBytes now fixed.<br>Additional frequency bands added.<br>Various minor bugs resolved.<br>Improvements to burner application. |
| 1.9.5<br>(15 May 2007) | Support for simple RS232 control protocol<br>UI enhancements, including messages indicating various events (eg Saving configuration data or unable to play stream)<br>The UI will now only show streams with the correct extension to be selected: Transport streams should have a .TS extension (.MPG, .MPEG and .TRP also permitted). IQ streams should have a .IQ or .IQ8 extension (.BIN also permitted).<br>Additional frequency bands added (for Japan and Korea) |
| 1.9.3<br>(27 April 2007) | Modification to radio software to eliminate problem with radio occasionally failing to start up. |
| 1.9.2<br>(26 March 2007) | Modifications to RF level control algorithms to reduce overloading of intermediate stages in some cases (and hence intermodulation products)<br>Disables DVB-T/H modes if lock chip not fitted |
| 1.9.1<br>(23 March 2007) | New FPGA image fixes intermittent ASI1 output on some boxes.<br>Burner application improvements, including the ability to work with more flash parts<br>Additional built in diagnostics (including flashing LED sequences on fatal errors)<br>RF level control added to main screen<br>IQ signal headroom may now be specified when in IQ playout mode |
| 1.8.1<br>(20 February 2007) | New FPGA image fixes loss of DVB-T/H modulation when continually swapping between modes |
| 1.8.0<br>(9 February 2007) | Direct IQ DAC output enabled<br>Improved RF level control algorithms (to improve MER)<br>Auto-play feature<br>Selection of 10MHz reference source (internal or external)<br>Support for Radio Card #4 |
| 1.6.3<br>(26 January 2007) | Uses Radio calibration data |