# ME1110

## Digital Modulation Techniques Courseware

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~Complete Resources for Lecturers~

KEYSIGHT TECHNOLOGIES
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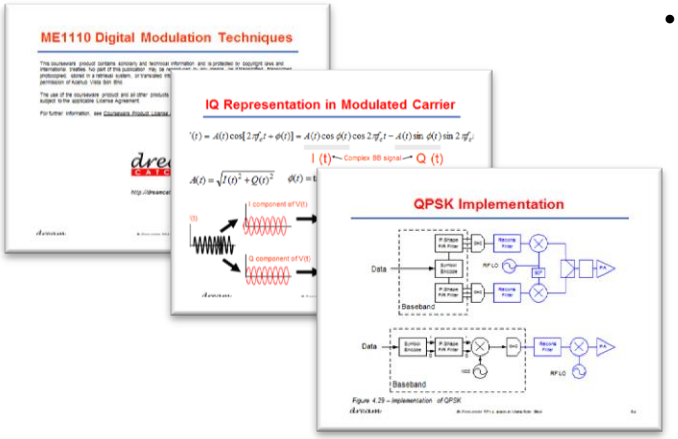
### Teaching slides

- Editable Microsoft® PowerPoint® slides
- Covers 45 hours of teaching




### Training kit

- Digital modulation kit
- Lab sheets and model answers
- Problem-based assignments
- Covers 18 hours of labs


| Target university subject | Target year of study | Prerequisite(s) |
|---|---|---|
| Analog and Digital Communications | Second or third year undergraduate | Basic Electronics |

**The ME1110 serves as a ready-to-teach package in the area of analog and digital modulations. The various modulated communication signals for hands-on lab exercises are implemented using Digital Signal Processing technique. This is a resource for lecturers consisting of teaching slides, training kits, lab sheets, and problem-based assignments.**

## Learning Outcomes

Students would be able to:

- Describe the main features of analog and digital communication systems
- Analyze signals in time and frequency domains
- Analyze IQ modulation technique from digital bits to baseband signal and modulated sinusoidal signal
- Analyze various types of basic analog and digital modulation schemes
- Evaluate modulation signals using industrial grade test and measurement instruments

## Benefits of the ME1110 courseware

- The digital IQ modulator is not a “black box”, students are able to get an insight on the modulation process as the In-phase (I) and Quadri-phase (Q) signals go through each stage of the modulation process from raw serial bit-stream to baseband signal envelopes and finally to modulated sinusoidal signal
- This hardware kit is capable of producing various types of standard analog and digital modulation waveforms such as AM, FM, FSK, BPSK, QPSK, 8-PSK, QAM16, and QAM64
- The raw data bits come from the built-in pseudo-random bit generator at 1 Mbps. Students can also feed in user-specific data from the external bit pattern generator or using the on-board manual on-off push-button for simple serial bit generation
- Students get to experience the usage of industry-grade tool, such as mixed-signal oscilloscope to capture digital and analog signals for verification, and the Keysight Vector Signal Analyzer software for spectrum and baseband signal analysis

# Teaching Slides

More than 400 editable Microsoft PowerPoint teaching slides, covering 45 hours of teaching for one full semester are provided. The slides cover the following topics:

- **Principle of Communications**
- **Analog Modulation Techniques**
- **Baseband Pulse Transmission**
- **Digital Modulation Techniques**
- **Transmitter and Receiver Architectures**

# Training Kit

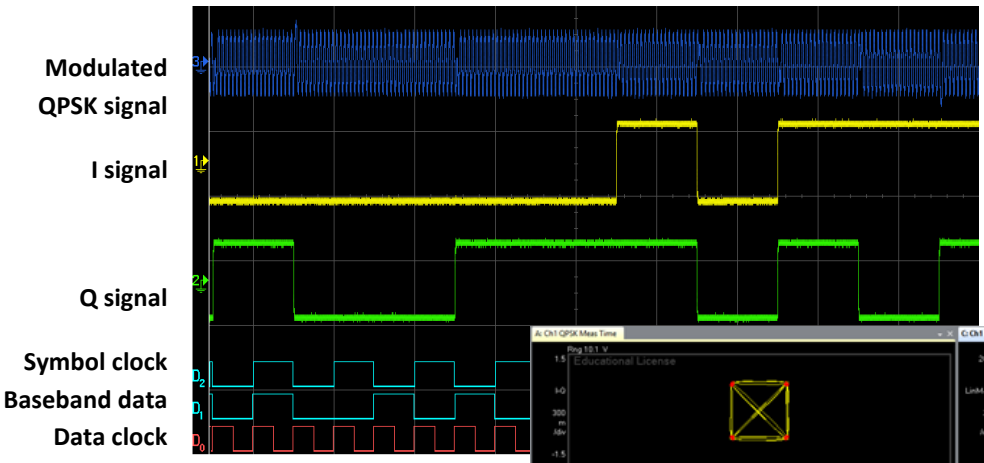
## Digital Modulation Kit

The ME1110 hardware uses a full-digital approach to implement a standard I-Q band-pass modulator system with 10 MHz carrier. It incorporates a FPGA (Field Programmable Gate Array) chip, a high-speed DAC (Digital-to-Analog Converter) chip, and high-frequency analog circuitry such as amplifiers and filters. Various probing points are also available for students to study and analyze the effect of the modulated signal at various stages.

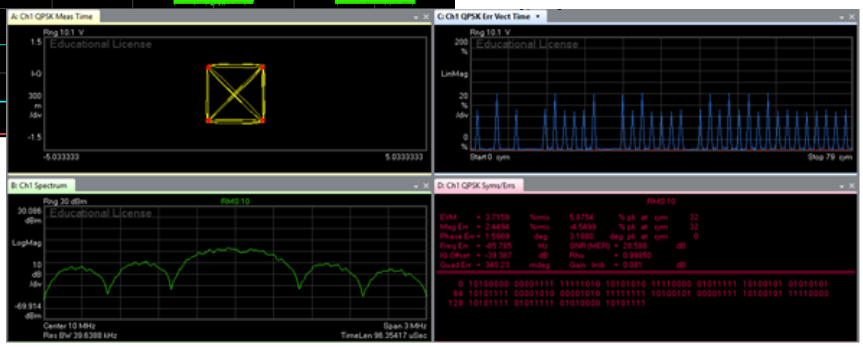

The ME1110 Analog/Digital Modulation Board is a versatile system that can produce a variety of digitally modulated band-pass signals. It is also programmed to produce standard analog modulated signals such as AM and FM signals. The default RF (radio-frequency) carrier used by the system is 10 MHz. One of its special features is the board contains two RF Outputs. This allows the output to be connected to a Vector Signal Analyzer (for demodulation and observing the IQ constellation) and to a low-cost Spectrum Analyzer for observing the real-time spectrum.
In addition to the RF outputs, the ME1110 board has a number of Analog and Digital outputs. For instance, the user can observe the Baseband IQ channels voltage, the Baseband digital data, data-clock, symbol-clock, etc. to understand how a digital transmitter operates.

This hardware kit is capable of producing various types of standard analog and digital modulation waveforms such as sine wave, AM, FM, BASK, FSK, BPSK, QPSK, 8PSK, 16-QAM, 64-QAM, as well as other arbitrarily generated signals.

**Example: Measured IQ and Modulated QPSK**




**Example: Keysight VSA Analysis**



## Accessories

The following accessories are provided with the training kit.

| Item | Quantity |
|---|---|
| SMA(m)-BNC(m) cable assembly – 1 meter | 1 |
| USB cable | 1 |
| Power adapter, 5 Vdc, 2 A | 1 |

## Lab Sheets

The training kit includes six lab sheets in editable Microsoft® Word format. Each lab requires three hours to complete. Model answers are provided with all lab sheets. The required instruments for the labs are listed below.

| Lab Sheet | Required Items |
|---|---|
| | Mixed-Signal Oscilloscope and VSA software |
| 1. Overview of the Digital Modulation Kit | √ |
| 2. BASK Generation and Analysis | √ |
| 3. BPSK Generation and Analysis | √ |
| 4. QPSK and 8-PSK Generation and Analysis | √ |
| 5. AM & FM Generation and Analysis | √ |
| 6. QAM Generation and Analysis | √ |

## Problem-Based Assignments

The problem-based assignments below allow students to enhance their problem-solving skills.

1. Design of analog AM and FM modulator
2. Baseband pulse shaping
3. Using external baseband data

a.

## Instruments

The recommended instruments and software from Keysight Technologies, to be purchased separately, are listed below.

| Instrument / Software[1] | Model |
|---|---|
| Oscilloscope and VSA Software | Minimum 100 MHz Mixed-Signal Oscilloscope, 4 analog and 8 digital channels<br>Recommendation: MSOX3014A[2]<br><br>89601B Vector Signal Analysis Software [with option 200, 300, AYA]<br>or for qualified education customer, 89600EDU-E01 and 89600EDU-E15 |

[1] Refer to the Lab sheets section for the instrument selection.
[2] The 89601B VSA software can only support DSOX/MSOX3000 series model of oscilloscope.

# Training Kit Hardware Specifications

| | Digital Modulation Kit |
|---|---|
| **Digital** | |
| Signal generation method | DDS |
| IQ modulation schemes | AM/FM/BPSK/QPSK/QAM16/QAM32 |
| On-board crystal oscillator | 8 MHz |
| Low-Pass Filter passband (3 dB) | DC to 12 MHz |
| **General** | |
| Input voltage | 4.8 to 5.5 V |
| Input current | 180 mA (typical) |
| External data input | 2.2 to 3.5 V |
| Carrier frequency at CW mode | 9.995 to 10.005 MHz |
| Clock output (for external data input) | 2.5 to 2.6 V |
| RF Out (Main) into 50Ω load at CW mode | 0.30 to 0.70 dBm |
| RF Out (Aux) into 50Ω load at CW mode | 3.00 to 4.2 dBm |
| EMC designed to | IEC61326-1:2005 / EN61326-1:2006<br>CISPR11:2003/EN55011:2007<br>Group 1, Class A |
| Warranty | 1 year |

# Ordering Information

| Description | Package | Product Number |
|---|---|---|
| Teaching Slides | 1 user license | ME1110-100 |
| Training Kit | 1 set | ME1110-200 |
| Teaching Slides + Training Kit | 1 user license + 1 set | ME1110-300 |
| Instruments | Where applicable | Purchase separately from Keysight or its distributor |