

BARC Newsletter – Volume 32, Issue 10, May 2009

## Diary Dates

Sat 9th 2:00PM BARCFest  
Fri 22nd 7:30PM **BARC AGM**

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## Club Net Frequencies

Due to interference to the HF net on 28.450 MHz the following procedure has been adopted.

If 28.450 MHz is not available, the first clear frequency in the following list will be used, 28.445, 28.440, 28.455, 28.460 (i.e. down 5, down 10, up 5, up 10). The starting time is 8:00 pm.

On Wednesday nights the normal frequency of 146.550 MHz will not be used, instead a trial on the Brisbane (Mt. Glorious [VK4RBN](#)) Repeater of 147.000 MHz will be used. The starting time is 8:00 pm.

## Editorial

The AGM is almost here! I will be stepping down as editor for QSP due to time constraints with university. Hope to see a good turnout at this year's AGM.

Hopefully this rather thick newsletter makes up for all the really skinny ones that have been the norm over the last few months. ;-)

## What's New

Not a lot of articles in this release, but still quite a long read.

The Guiana Space Centre has been busy putting a [new satellite into orbit](#), details page [5](#).

More [woes about the solar weather](#) according to NOAA, their assessment is on [6](#).

Finally... I did a little bit of research and compiled some notes on [digital modes](#). This rather lengthy report is on [8](#).

## Committee Members

### PRESIDENT

Michael Cooper VK4MX

### VICE-PRESIDENT

Harry Debnam VK4DFG

### SECRETARY

Kevin Johnston VK4UH

### ASSIST-SECRETARY

To be decided

### TREASURER

Les Parker VK4S0  
Keith Adams VK4XAK

### LIBRARIAN

Peter Holtman VK4C0Z

### PROVIDOR

Jim Kelly VK4HJK

### REPEATER OFFICER

To be decided

### STATION MANAGERS (VK4BA)

HF: Les Parker VK4S0  
VHF: Don Johnman VK4DS

### PROJECTS CO-ORDINATORS

Kevin Dalton VK4WA

### AWARDS & QSL MANAGER

To be Decided

### PUBLICITY & LIASON

Peter Holtham VK4C0Z

### QSP NEWS EDITOR

Stuart Longland VK4MSL

### CLUB EQUIPMENT OFFICER

Frank Barker VK4KFB

### W.I.A. ACCREDITED EXAMINERS

Les Parker VK4S0

### BARCFEST COMMITTEE

Michael Cooper VK4MX  
Les Parker VK4S0

## Club Meetings

Meetings are held on the 2nd Saturday (social) at the Maritime Museum and 4th (business) Friday of each month at the Maritime Museum in Brisbane.

No meetings are held on the 2nd Saturday of January or the 4th Friday of December.

Visitors are most welcome to come along and sample our hospitality.

## Membership Subscriptions

Subscriptions fall due on the last day of August.

Current Standard Membership fee is \$20.00 (Subject to any changes prior to 31st August).

## Correspondence

All correspondence (except for items for the Club newsletter) should be addressed to:

The Secretary  
Brisbane Amateur Radio Club Incorporated  
P.O. Box 605  
Annerley, Qld, 4103.

Club Web Site <http://www.qsl.net/vk4ba>  
Items for the Newsletter may be sent by mail to:

QSP Editor  
P.O. Box 605  
Annerley, Qld, 4103.

or, by Email to:

[qspnews@longlandclan.yi.org](mailto:qspnews@longlandclan.yi.org).

Deadline is 5pm Monday prior to the 2nd Friday Each month except January.

## Club Station Nets (VK4BA)

28.450 MHz SSB Mondays 2000 hrs Local.  
*Trial* 14.170 MHz SSB Mondays 2000 hrs Local – if 10m conditions are bad.  
147.000 MHz FM Wednesdays 2000 hrs Local.

# Brisbane Amateur Radio Club Incorporated

## Club Minutes

### Meeting of 24 April 2009 @ Maritime Museum Southbank

Meeting opened 19:30 by Chairman Michael Cooper VK4MX.

**Attendance:** (9)  
(Committee) Les VK4S0 (Treasurer), Michael VK4MX (President)  
(Members) Bill VK4TWS, Bruce VK4TRS, Colin VK4ACG, Don VK4DS, Peter VK4COZ, Stuart VK4MSL, Kevin VK4WA

**Visitors:** None

**Appologies:** Kevin VK4ZR, Keith VK4XAK, Harry

**Meeting addressed by Michael VK4MX**

**Minutes:** Read by Michael VK4MX

### **Matters arising from Minutes:**

**Repeater** Les said that we were not able to buy the discounted repeater but was able to get a good deal on an another model — which we bought.

### **Reports.**

**Treasurers report** Presented by Les VK4S0 ([copy attached](#)) Proposed by Les VK4S0 seconded Col VK4ACG. — *Accepted.*

**Station Managers** 2m net is averaging about 10 call-ins, reported by Don VK4DS. 1 to 2 call-ins most Monday evenings on the 10m net, reported by Les VK4S0.

### **Correspondence:**

- Incoming**
- Amateur Radio April 2009
  - Silicon Chip April 2009
  - Insurance Certificate (downloaded)
  - Several bookings for Barcfest
  - Bank Statement from Bank of Queensland
  - CQ Magazine March 2009
  - TARC Magazine

- Outgoing**  
**General Business**
- Receipts for Barcfest booking payments

**Club Repeater** Thanks for Kevin VK4UH for setting up new repeater. Bruce VK4TRS, has volunteered to be the club's station Manager. Thanks Bruce.

**BarcFest** It was also discussed that the new repeater should be displayed at BarcFest. Different locations of the repeater will need to be investigated after BarcFest. Les VK4SO gave a report on BarcFest. All going well.

Any Other Business None

Meeting closed with thanks from Michael VK4MX at 20:30

— Michael VK4MX President, April 09

## Brisbane Amateur Radio Club

### Financial report for April 2009

<b>Account Balance</b>	(1st February)	<b>\$6722.17</b>
<b>Income</b>		
<hr/>		
Total income	Barcfest Bookings	\$267.00
		\$267.00
<b>Expenditure</b>		
<hr/>		
	Purchase of Repeater, PSU, change-over switch and fittings	\$???.??
<b>Total expenses</b>		<b>\$???.??</b>
<hr/>		
<b>Account Balance</b>		<b>\$???.??</b>

At time of writing total cost of repeater is unknown, so the net balance is unknown.

— Les Parker VK4SO Treasurer

# ESA launches Herschel Space

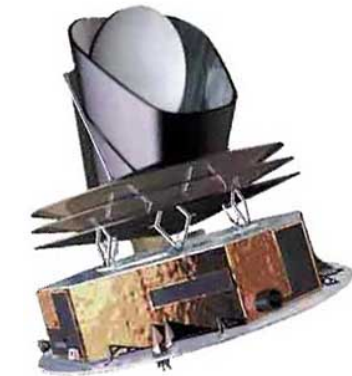
## Observatory and Planck Satellite

The [Herschel Space Observatory](#) and [Planck Satellite](#) were both launched Thursday by an [Ariane 5ECA rocket](#) at around 1pm (UTC) by the [European Space Agency](#) (ESA) from the [Guiana Space Centre](#). The two telescopes valued at €1.9 billion (£1.7bn) were launched from [Kourou, French Guiana](#), a department of France in South America.

“The technology onboard these satellites is unique, and the science these satellites will do is fantastic,” said [Jean-Jacques Dordain](#) director-general at the ESA, “This is the result of many years’ hard work by thousands of scientists and engineers across Europe.”

Herschel was released 26 minutes after launch to continue on its trajectory. Two minutes later, the Planck observatory separated. The Planck telescope is a survey telescope using [Cosmic Microwave Background \(CMB\) measurements](#) of the microwave portion of the electromagnetic spectrum.

“It [Planck] will allow us to pin down all the basic characteristics of the [Universe](#) with very high accuracy - its age, its contents, how it evolved, its geometry, etc.” said Dr Jan Tauber, project scientist at ESA.



The larger space telescope is named after [William Herschel](#) who discovered the planet [Uranus](#) in 1781. The Herschel telescope will use [infrared](#) radiation and its main reflector mirror at a diameter of 3.5 meter (11.5 ft) is one-and-a-half-times larger than that on the [Hubble Telescope](#).

The Heterodyne Instrument for the Far Infrared (HIFI) will also be able to detect carbon, water and oxygen in star-forming areas of space and examine the chemical composition of comets. The Photodetector Array Camera (PACS) and Spectrometer and the Spectral and Photometric Imaging Receiver (SPIRE) will correlate the images. The Herschel will also be equipped with heat detecting instrumentation. The Herschel space telescope will be operational for three to five years.

“These space missions are outstanding feats of engineering. Herschel is the largest telescope we have ever put into space and the instruments on Planck will operate at just a tenth of a degree above absolute zero,” said [Lord Drayson](#), the United Kingdom’s science minister, “This is really cool science happening at mind-blowingly low temperatures, helping to answer some of the basic questions about the history of the universe.”

“Herschel is going to help us understand much, much better how stars form right now and how they have been forming throughout billions of years of cosmic history” said Göran Pilbratt, Herschel’s project scientist at ESA, “We’re going to see the [\[star\] embryos](#), the ones that are not born yet. We’re going to see right into the [wombs](#) where stars are born.”

— Wikinews, 15th May 2009



Figure 2: File photo of [Ariane \(rocket\)](#) launched from the [Guiana Space Centre](#) on 10 August 1992.

# NOAA: Mild Solar Storm

## Season Predicted

Although its peak is still four years away, a new active period of Earth-threatening solar storms will be the weakest since 1928, predicts an international panel of experts led by [NOAA's Space Weather Prediction Center](#) and funded by NASA. Despite the prediction, Earth is still vulnerable to a severe solar storm.

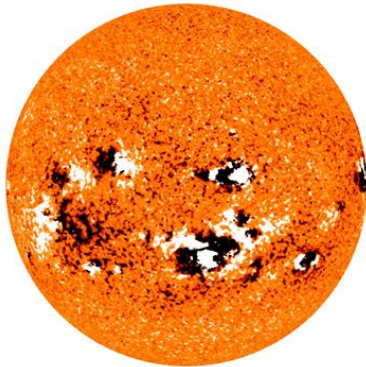


Figure 3: Solar storm.  
(Credit: NOAA)

Solar storms are eruptions of energy and matter that escape from the sun and may head toward Earth, where even a weak storm can damage satellites and power grids, disrupting communications, the electric power supply and GPS. A single strong blast of “solar wind” can threaten national security, transportation, financial services and other essential functions.

The panel predicts the upcoming Solar Cycle 24 will peak in May 2013 with 90 sunspots per day on average. If the prediction proves true, Solar Cycle 24 will be the weakest cycle since number 16, which peaked at 78 daily sunspots in 1928, and ninth weakest since the 1750s, when numbered cycles began.

The most common measure of a solar cycle’s intensity is the number of sunspots—Earth-sized blotches on the sun marking areas of heightened magnetic activity. The more sunspots there are, the more likely it is that solar storms will occur, but a major storm can occur at any time.

“As with hurricanes, whether a cycle is active or weak refers to the number of storms, but everyone needs to remember it only takes one powerful storm to cause huge problems,” said NOAA scientist Doug Biesecker, who chairs the panel. “The strongest solar storm on record occurred in 1859 during another below-average cycle.”

The 1859 storm shorted out telegraph wires, causing fires in North America and Europe, sent readings of Earth’s magnetic field soaring, and produced northern lights so bright that people read newspapers by their light.

A recent report by the National Academy of Sciences found that if a storm that severe occurred today, it could cause \$1-2 trillion in damages the first year and require four to 10 years for recovery, compared to \$80-125 billion that resulted from Hurricane Katrina.

The panel also predicted that the lowest sunspot number between cycles — or solar minimum — occurred in December 2008, marking the end of Cycle 23 and the start of Cycle 24. If the December prediction holds up, at 12 years and seven months Solar Cycle 23 will be the longest since 1823 and the third longest since 1755. Solar cycles span 11 years on average, from minimum to minimum.

An unusually long, deep lull in sunspots led the panel to revise its 2007 prediction that the next cycle of solar storms would start in March 2008 and peak in late 2011 or mid-2012. The persistence of a quiet sun also led the panel to a consensus that the next cycle will be “moderately weak.”

## SOLAR CYCLE 24 SUNSPOT NUMBER PREDICTION

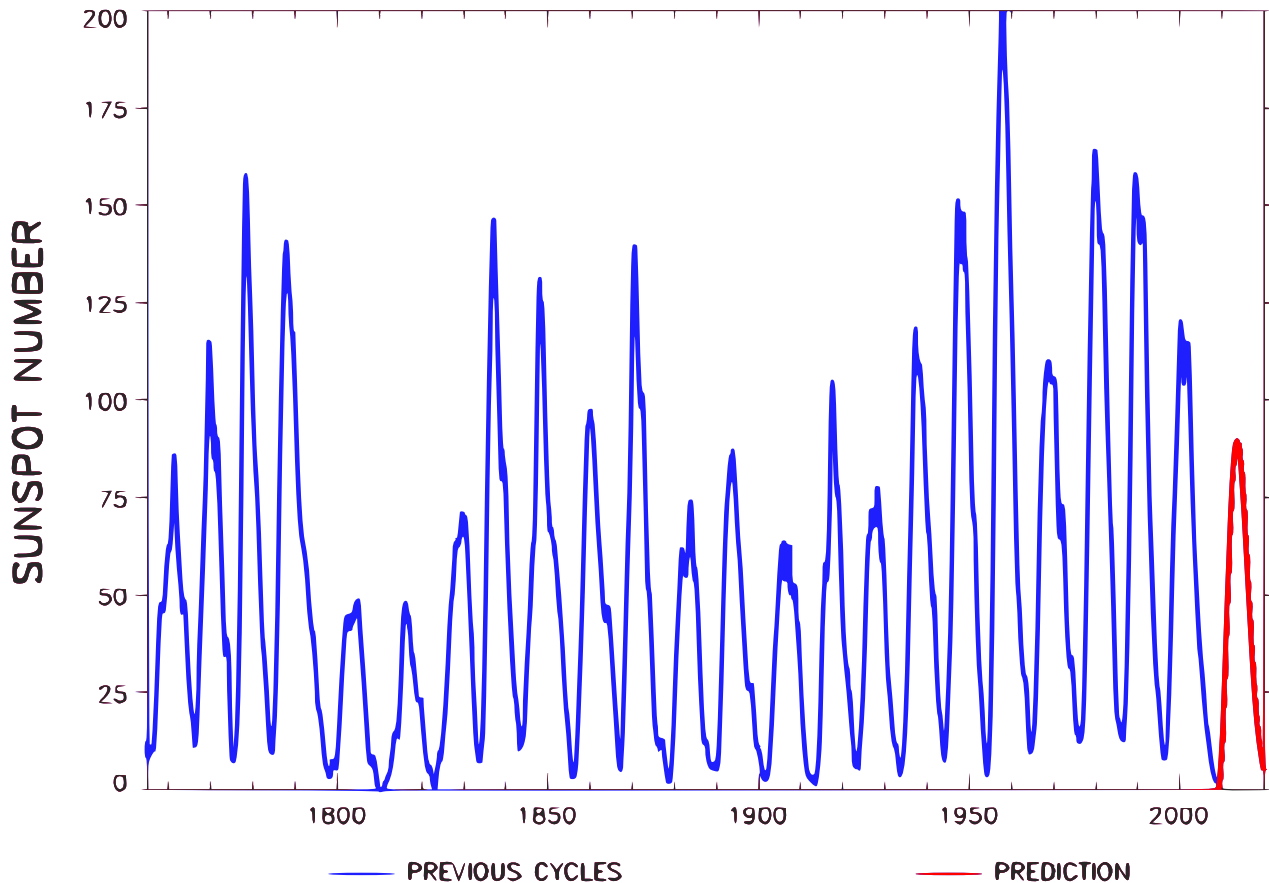


Figure 4: Sunspot predictions (Credit: NOAA)

NOAA's Space Weather Prediction Center (SWPC) is the nation's first alert of solar activity and its effects on Earth. The Center's space weather experts issue outlooks for the next 11-year solar cycle and warn of storms occurring on the Sun that could impact Earth. SWPC is also the world warning agency for the International Space Environment Service, a consortium of 12 member nations.

As the world economy becomes more reliant on satellite-based communications and interlinked power grids, interest in solar activity has grown dramatically. In 2008 alone, SWPC acquired 1,700 new subscription customers for warnings, alerts, reports, and other products. Among the new customers are emergency managers, airlines, state transportation departments, oil companies, and nuclear power stations. SWPC's customers reside in 150 countries.

"Our customer growth reflects today's reality that all sectors of society are highly dependent on advanced, space-based technologies," said SWPC director Tom Bogdan. "Today every hiccup from the sun aimed at Earth has potential consequences."

NOAA understands and predicts changes in the Earth's environment, from the depths of the ocean to the surface of the sun, and conserves and manages our coastal and marine resources.

— National Oceanic and Atmospheric Administration, 8th May 2009

# Digital Modes: Past & Present

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Amateur radio over the years has been a major testing ground for various means of communications. Not only did this include the sending of voice, but also text and images, were also transmitted across the airwaves by radio enthusiasts, in many cases furthering the development of communications standards.

## Modulation Basics

Firstly, it is worth looking at the anatomy of a digital mode. What is it about a radio transmission that makes it *digital*. Let's first look at how signals are modulated.

Normally when transmitting a signal over the air, the variations in the modulating signal (e.g. from a microphone) is used to cause variations in either the amplitude, frequency and/or phase of a signal. Four common types are in use:

### Amplitude Modulation

AM has existed in various forms since 1870 where it was used in an early form of frequency division multiplexing on early telephone lines (known as "undulatory currents"). It was first demonstrated as a means of wireless transmission in 1906. In this mode, the modulating signal  $x(t)$  alters the amplitude, giving the time-domain signal:

$$s(t) = [A + M.x(t)] \cos(2\pi f_c t) \quad (1)$$

where  $A$  is the amplitude of the signal,  $M$  is the modulation index (range:  $0 \dots 1$ ),  $f_c$  is the carrier frequency.

If we adjust the modulation index,  $M$ , we can produce all forms of double-sideband AM. Single sideband is produced by either filtering the output, or by means of a Hartley modulator. In this scheme, a second AM carrier,  $90^\circ$  is modulated by a copy of  $x(t)$  that has also been shifted  $90^\circ$  out of phase by means of the Hilbert Transform.

### Frequency Modulation

FM was first described in Edwin Armstrong's paper, "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation", which was first published in 1936. Here, as the name suggests, it's the frequency we change:

$$s(t) = A \cos [2\pi (f_c + \Delta f.x(t)) t] \quad (2)$$

The  $\Delta f$  term is the frequency deviation, and is what separates wideband FM from narrowband FM. If we define  $f_m$  as being the maximum frequency component of  $x(t)$ , we can define the modulation index as  $h = \Delta f / f_m$ . Wideband FM is when  $h \gg 1$ , narrowband is when  $h \ll 1$ .

## Phase Modulation

In addition to the frequency... we can also adjust the phase of the carrier. Both FM and PM are forms of *angle modulation* and are closely related.

$$s(t) = A \cos [2\pi f_c t + \Delta\phi x(t)] \quad (3)$$

## Quadrature Amplitude Modulation or Amplitude-Phase Modulation

QAM is a combination of AM and PM. It is mainly used with digital communications, and provides a useful visualisation of many digital modes. In the analogue domain, it was used as a means of delivering stereo AM in some regions. The physical structure of the signal is in fact, two AM carriers,  $90^\circ$  out of phase:

$$s(t) = [A + M.x(t)] \cos(2\pi f_c t) + [A + M.y(t)] \sin(2\pi f_c t) \quad (4)$$

In this case,  $x(t)$  is our “in-phase” component,  $y(t)$  is our “quadrature” component. These two signals are typically represented as being the X and Y co-ordinates on a cartesian plot, this point moves around according to the modulating signals.

We can also define  $x(t) = r(t) \cos(\phi(t))$  and  $y(t) = r(t) \sin(\phi(t))$ , giving rise to the name, Amplitude-Phase Modulation. If we hold  $r(t)$  constant, we get Phase Modulation, and holding  $\phi(t)$  constant gives us amplitude modulation.

## Digital Modulation

Digital signals are by definition, signals that are discrete in both amplitude and time. The ‘1’s and ‘0’s people are used to seeing is just one representation that is commonly used... and it works well to illustrate the discrete nature of a digital signal’s amplitude, particularly in purely binary systems.

Modes such as Morse code are discrete in amplitude... the key is either pressed down, or it is released. Theoretically speaking, Morse is also discrete in time, the time unit being the length of a morse “dit”. (In practice, this is dependant on the operator, some being more accurate with their timing than others.)

In digital systems, we consider the waveform in units of symbols. The amplitude, frequency and phase of a carrier is held constant by the transmitting station, for a fixed period of time – thus displaying one *symbol* to those receiving the signal, before changing the parameters quickly, and showing a second “symbol”.

All digital modulation schemes describe at least two different symbol types. Usually, the number of symbols is defined by the number of bits represented by a single symbol – by changing parameters more gradually, we can pack more bits into a symbol, and therefore send data faster, at the cost of noise resistance.

## Bits and Symbols

Amplitude Shift Keying (ASK) is the earliest form of digital modulation. It is exactly like AM above. The other forms of modulation are used here too... they are known as Frequency Shift Keying (FSK),

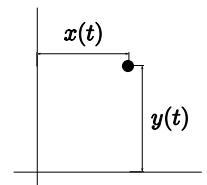


Figure 5: Cartesian representation of a QAM signal

Phase Shift Keying (PSK) and Amplitude-Phase Keying (also called Quadrature Amplitude Modulation, same as in analogue).

Normally for ASK, the modulation index is set  $M = 1$  and the unmodulated carrier amplitude is held constant at  $A = 0$ .

The simplest example is morse code. In morse, we have two symbols:

- $m(t) = 1$ , yielding  $s(t) = \cos(2\pi f_c t)$
- $m(t) = 0$ , yielding  $s(t) = 0$

This is also known as Binary Amplitude Shift Keying. In a digital mode, we could double our data throughput by adding two more symbols...

- $m(t) = 0.33$
- $m(t) = 0.66$

Sending of data is simply a matter of grouping pairs of bits, and assigning each combination to a symbol. Such a table may look like this:

Bit combination	Symbol
00	$s(t) = 0$
01	$s(t) = 0.33 \cos(2\pi f_c t)$
11	$s(t) = 0.66 \cos(2\pi f_c t)$
10	$s(t) = 1.00 \cos(2\pi f_c t)$

This is what's called 4-level ASK, or 4ASK. Modulation schemes are normally described in terms of the number of symbols... e.g. 4PSK (also called Quadrature PSK or QPSK) is PSK with 4 different phase angles, 16QAM is QAM with 16 different amplitude level combinations (4 levels for in-phase, and 4-levels for the quadrature component).

Notice I didn't label them as 00, 01, 10, 11... this is a process known as Gray-coding, and helps with noise resistance. Suppose some weak interference was received with the amplitude  $i(t) = 0.33 \cos(2\pi f_c t)$  on top of  $s(t)$ . If the data to be transmitted was "01", the remote station would hear an amplitude of 0.66 instead of 0.33. A level of 0.66 corresponds to the symbol representing "11", and thus a single-bit error would be generated.

If we used the normal binary numbering... that signal level would be interpreted as "10" instead, generating a double-bit error.

The other end reverses this process, looking at the amplitude of the signal and deducing what the two bits were based on this mapping table. The same principle is used for all the modes.

There's no theoretical roof limit on the number of bits per symbol... the only limitation is the noise characteristics of the band in use. 8 symbols is usually about the limit for ASK and PSK, and 64 symbols being the limit for QAM in most wireless applications. Systems such as 256QAM and above are normally reserved for very quiet radio links or for wired communications.

## Compatible constellations

Most digital modes (except FSK) are implemented using the In-phase/Quadrature-phase scheme used in QAM. When you look at the resultant constellations for various schemes, it can be seen that a number of them are mathematically identical.

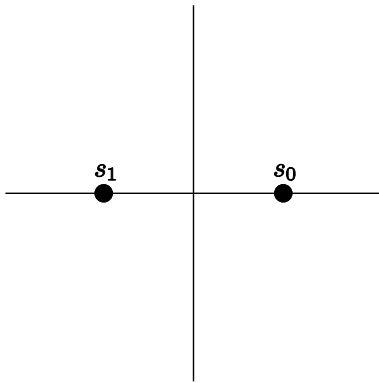


Figure 6: BASK/BPSK constellation

Compare binary phase shift keying, to binary amplitude shift keying. If we use ASK with a bi-polar  $x(t)$  (i.e. we represent logical '0' bits as a -1 signal level), we get two symbols:  $s_1(t) = \cos(2\pi f_c t)$  and  $s_0(t) = -\cos(2\pi f_c t)$ .

If we compare this to BPSK, we could have  $s_1(t) = \cos(2\pi f_c t)$  and  $s_0(t) = \cos(2\pi f_c t + 180^\circ)$ . Trigonometric identities tell us that  $\cos(\theta + 180^\circ) = -\cos(\theta)$ , so in fact these two schemes are identical.

Likewise for 4QAM and QPSK (4PSK)... In 4QAM, we often define the four symbols in terms of combinations of  $x(t)$  and  $y(t)$ , where both variables are set to either 1 or -1. This is identical to QPSK, using the phase angles of  $45^\circ$ ,  $135^\circ$ ,  $225^\circ$  and  $315^\circ$ .

### Synchronisation

Digital logic is a lot like stand up comedy – it's all about timing. Screw it up in either case, and nobody laughs. In digital modes, we're concerned with three levels of synchronisation.

**Phase Synchronisation** affects both QAM and PSK, and is the process by which we try to synchronise a local oscillator with the incoming signal. The aim is to try to deduce a known constant phase error, which can be factored into the demodulation algorithm.

The way this is normally achieved, is to pump out a stream of zeros or ones – the receivers simply measure the phase offset compared to their own local oscillators and factor this in.

**Symbol Synchronisation** affects all digital modulation schemes, and is the process by which we try to determine where each symbol starts and ends. This is a continual process requiring regular adjustment since in practice, all systems will exhibit a degree of timing jitter.

In many systems, a fixed pattern is sent out of alternating zeros and ones. The receivers simply look for the points at which the symbols change state, then use that to synchronise a local data clock.

**Frame Synchronisation** groups bits together in the binary stream of bits, and allows the receiver to locate the start and end of each byte, character or other data unit.

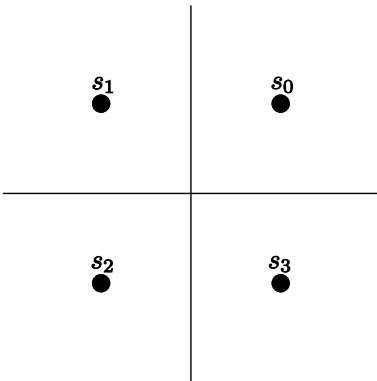


Figure 7: BASK/BPSK constellation

### Baud Rates

The baud rate is defined as the number of state changes in a signal, per second. In this context, that translates to the number of symbols. The faster you change symbols, the more bandwidth you require. The band conditions have an impact on this too – multipath propagation tends to cause a delayed copy of the signal to become superimposed on the original signal, causing what is known as inter-symbol interference which results in data corruption.

The raw data rate of a symbol is defined as  $\text{rate} = \text{baud} \times \text{bits\_per\_symbol}$ . A 50-baud BPSK signal equates to a 50 bit per second data channel, where as QPSK using the same baud rate will yield 100 bits per second.

## Data Encoding

Over this layer, we then come to the field of representing information in terms of bits. This is known as source encoding, and can take a number of forms.

**Variable-length** encoding schemes represent information in terms of words (groups of bits) that can be any length... the bit pattern determines the length of each word. Hamming codes are a means of generating variable-length codes.

**Fixed-length** encoding schemes are the most basic, and simply group every N bits into a single word. This is the most common scheme.

The data stream may be further encoded through the use of error detection codes, and forward error correction... which aims to provide redundant data which allows the receiver to detect, and possibly correct, errors in the incoming data. The important thing to remember is **errors will occur...** thus the system needs some kind of strategy for handling this.

## Common digital modes

Having looked at the basics, we can now explore a number of common systems.

### Morse Code

The earliest form of electronic telecommunications, radiotelegraphy using morse code dates back to the very first experiments with radio communications. If we consider this in the context of digital communications, the system can be seen as binary-ASK as seen earlier.

The data sent in this system is source encoded using a variable-length encoding scheme which is normally interpreted by ear, consisting of “dahs” (three consecutive ‘1’s separated by zeros) and “dits” (a single ‘1’ separated by zeros). There is no forward error correction in this system.

Symbol synchronisation is achieved when the receiver hears the length of a “dah” versus the length of a “dit” (or gaps of this length)... and comparing the time periods.

Frame synchronisation consists of consecutive zeros. A single zero represents the end of one “dah” or “dit” and the start of the next one. Three zeros represent the boundary between two consecutive letters. Six zeros represent the boundary between two consecutive words.

### RTTY

Radio-teletype is probably one of the first truly digital systems. It uses a fixed length encoding scheme. Several character encoding schemes are commonly used. Baudot was the first character encoding system, named after its inventor, Émile Baudot which was a 5-bit scheme.

This was replaced by an updated scheme developed by Donald Murray in 1901... this improved “Baudot” code is what most people mean when they discuss Baudot. This was later improved by the Western Union and ITA2 encoding schemes.

In recent times, ASCII (a 7-bit character set developed for the personal computer) has also seen use on this mode.

Each character (whether it be 5 or 7 bits long) was surrounded by start and stop bits. The “0” symbol was transmitted for the period of one bit to signify the start of transmission, followed by the data bits. The end of a character was signified by a “1” symbol lasting 1, 1.5 or 2 bit periods in length.

The data was modulated using binary-FSK or binary-ASK with a baud rate between 45 and 300.

## MFSK8 and MFSK16

Multiple-Frequency Shift Keying is an extension on traditional Frequency Shift Keying... instead of sending one tone at a time... you send multiple, the presence or absence of a given tone. That is, it is in fact multiple binary-ASK carriers in parallel.

The standard originated in the form of the Piccolo mode developed for the UK government in 1962. MFSK8 and MFSK16 were developed for amateur use by Murray Greenman ZL1BPU. An in-depth technical discussion is available on Murray's website. The scheme employs forward error correction.

<http://www.qsl.net/zl1bpu/MFSK/>

## PSK31 and PSK63

These are both modes employing Phase-Shift Keying. The data is sent using the Varicode scheme, which is a variable-length encoding scheme. Lowercase letters are allocated shorter length codes to improve efficiency.

The data channel is basic... Binary Phase Shift Keying or Quadrature Phase Shift Keying modulates the raw varicode at a baud rate of 31 or 63 baud. Filtering of the signal smoothes out the transitions and thus reduces the bandwidth to about 1Hz/baud.

There is no error correction in this scheme.

## HamDRM and Digital SSTV

Digital SSTV uses a mode otherwise known as HamDRM. HamDRM is a derivative of the Digital Radio Mondiale format used by shortwave broadcasters. It is based on QAM, and uses the Reed Solomon forward-error correction scheme.

Multiple QAM subcarriers are used in transmission with two pilot signals which help the receiver lock-in on the incoming signal. The mode is capable of transmitting just about any digital data file, but is primarily used to transmit pictures in the JPEG2000 format.

Almost all implementations are based on the HamDRM.dll library which is based on code from the DReaM receiver project.

- <http://code.google.com/p/hamdrm-dll/>
- [http://apps.sourceforge.net/mediawiki/drm/index.php?title=Main\\_Page](http://apps.sourceforge.net/mediawiki/drm/index.php?title=Main_Page)

## Packet Radio

This is more a network protocol than a digital mode. Packet radio defines the physical medium over which the AX.25 data link layer runs. A number of higher-level protocols are then transmitted over this stack including TCP/IP and APRS.

The data transmission used binary-FSK at 300 baud on HF, or 1200-9600 baud on VHF. This technical decision was based on the use of surplus Bell 103 and 203 modems which were frequently employed to implement the physical layer of the protocol stack.

## D-Star

This is a relative newcomer, and is already stirring up controversy. It was developed by the Japan Amateur Radio League in 2001. It works purely on the higher bands, 2m, 70cm, 23cm and 10GHz. It is a network protocol stack, designed as an alternative to Packet radio.

The system uses either Gaussian Minimum Shift Keying (a variant of binary FSK) QPSK or 4-FSK achieving a data rate of 4.8kbps in voice mode, or 128kbps in data mode. When transmitting voice, 2.4kbps of the data is used to transmit the voice signal, with 1.2kbps forward error correction, leaving a data channel 1.2kbps wide for arbitrary data.

On the backbone (10GHz), GMSK is used at a data rate of 10Mbps.

The voice data is encoded using the proprietary AMBE (Advanced Multi-Rate Excitation) vocoder, which is sold in hardware form by Digital Voice Systems Incorporated. Software-based implementations of the codec are forbidden by the licensing terms, requiring users to purchase hardware from DVSI directly. This fact is probably one of its most limiting factors.

As yet, the only supplier of D-Star equipment is Icom. Kenwood do produce some D-Star radios for the Japanese market, but as yet, no such units are available for purchase elsewhere.

## 802.11

Not really an amateur digital mode, but it is sometimes used by amateurs. 802.11 is a wireless computer networking standard which operates on either infra-red (very rare) or in the 2.4GHz and 5GHz ISM bands.

BPSK, QPSK and QAM are used in the modulation, with multiple carriers employed in the newer standards. 802.11a also implemented forward error correction in the form of the Viterbi algorithm.

## Conclusion

The above is by no means an exhaustive list of digital modes, nor is it a highly in-depth analysis of each mode. Modes such as Hellschreiber I have deliberately not covered, since these are really analogue modes implemented via digital signal processing techniques.

Digital modes are just one facet of radio communications, and one in which technology is moving forward at a very rapid rate. It also is one which people can experiment with at relatively low cost, in most cases only needing a modern computer loaded with appropriate DSP software. Scope is also there to homebrew modes which may one day bring on a new wave of enthusiasm. Time will tell what happens in this arena... whatever occurs, it'll be interesting to watch.

— Stuart Longland VK4MSL, 19th May 2009.