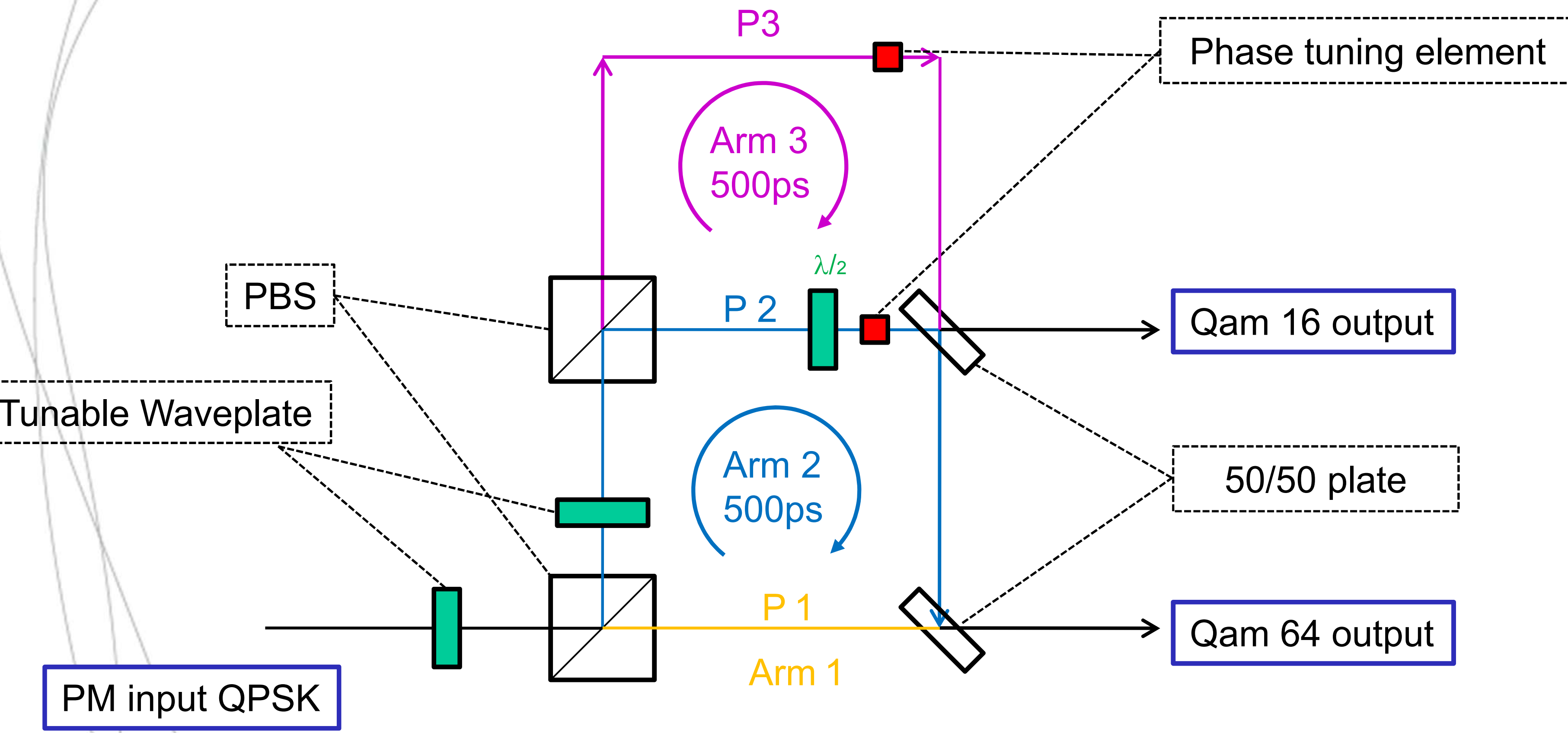
Quadrature Amplitude Emulator : QAME

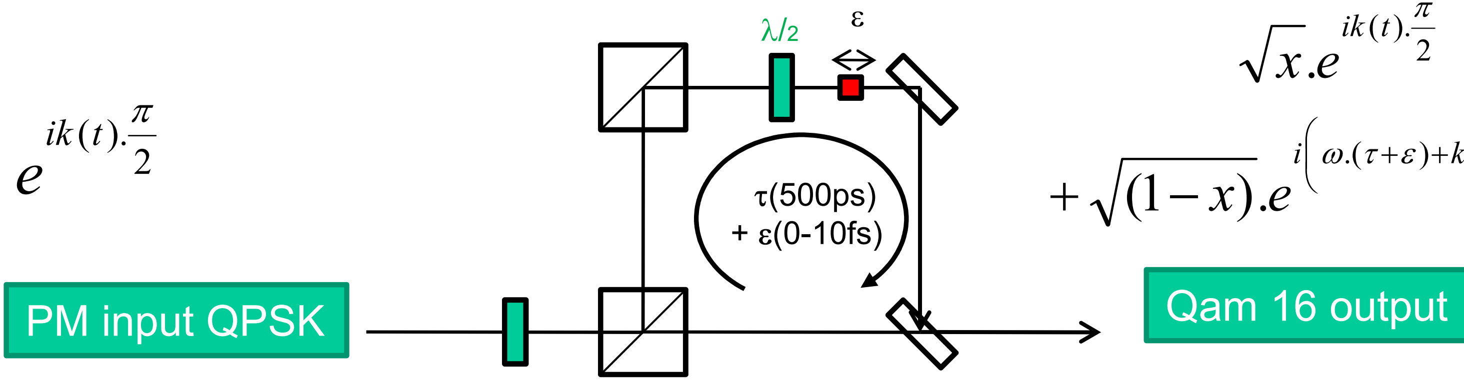
Principle drawing



Principle mathematics (case QAM16)

- Case QAM 16

$$e^{ik(t).\frac{\pi}{2}}$$



$$\sqrt{x}.e^{ik(t).\frac{\pi}{2}} + \sqrt{(1-x)}.e^{i\left(\omega.(\tau+\varepsilon)+k(t+\tau+\varepsilon).\frac{\pi}{2}\right)}$$

- Input $e^{ik(t).\frac{\pi}{2}}$
  - » Where **k(t) is an integer** that changes every T seconds.
    - T=1/F where F is the modulation frequency (typ T= 40 GHz, and k is [0,1,2,3] (QPSK signal)

- Output $\sqrt{x}.e^{ik(t).\frac{\pi}{2}}+\sqrt{(1-x)}.e^{i\left(\omega.(\tau+\varepsilon)+k\left(t+\tau+\varepsilon\right).\frac{\pi}{2}\right)}$

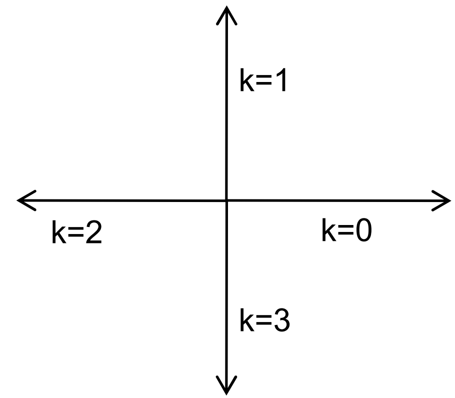
  - **x** is the splitting ratio,
  - $\omega=2\pi$.f, where **f** is the **optical frequency** (e.g 193.400 THz),
  - τ is the delay introduced by the interferometer. **τ=500ps**,
  - ε is the additionnal delay introduced by the **phase tuning element**.

    0< ε <10fs, and so does not change the value of k(t+τ), but **enables $\omega.(\tau+\varepsilon)$ to be a multiple of 2π**.

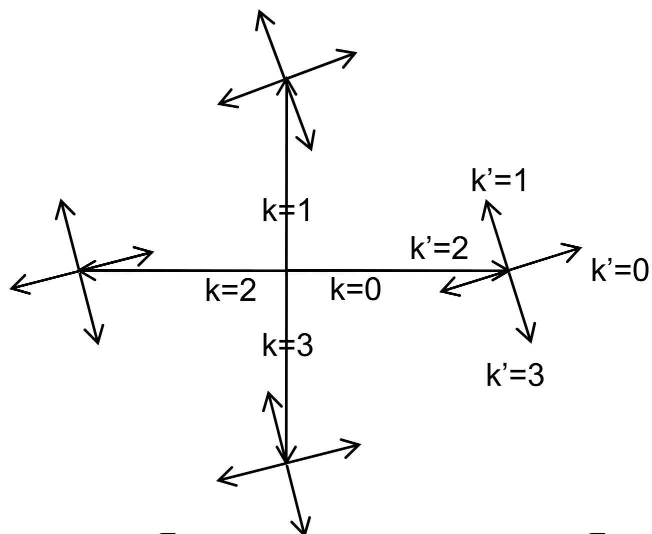
  - **The value of 500ps** enables the device to work with **modulation frequencies that are even and integer** in GHz (e.g f=10, 12,…, 24 ,26,…,38,40 etc.) Then we have
    - A delay of 5 symbols @10GHz ,
    - 10 symbols@20 GHz ….
  - We can note **k'(t)=k(t+τ)** for simplifing.

constellation

- If we represent the electric field in amplitude and phase we have:



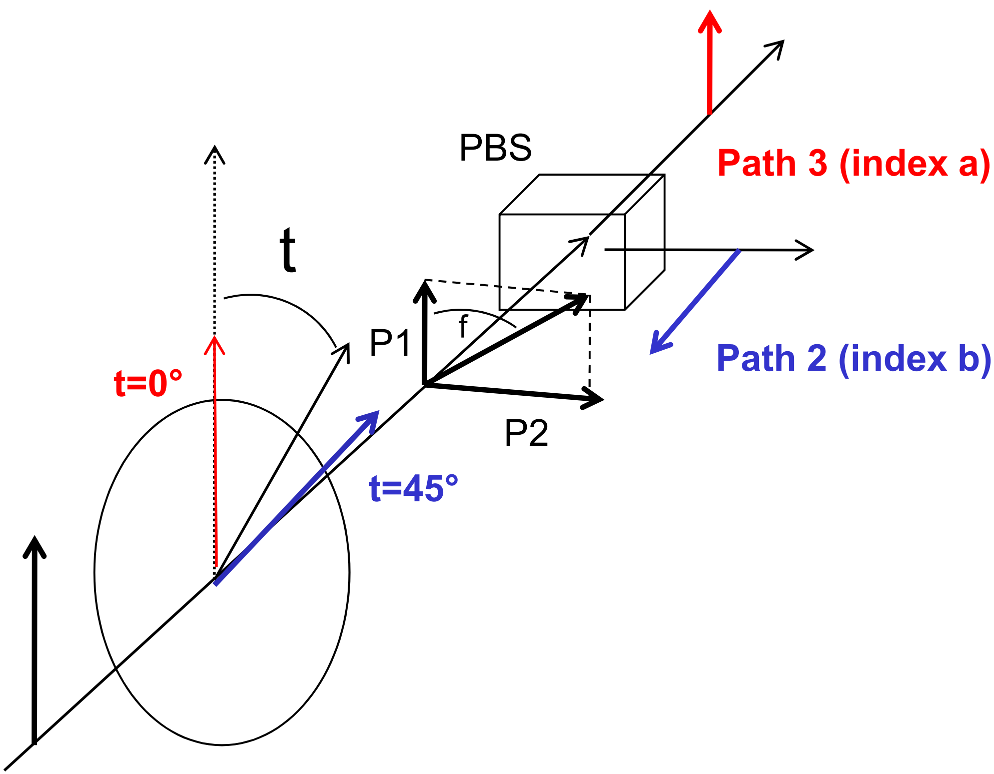
$$e^{i.k(t).\frac{\pi}{2}}$$



$$\sqrt{x}.e^{i.k(t).\frac{\pi}{2}}+\sqrt{(1-x)}.e^{i.k'(t).\frac{\pi}{2}}$$

How to adjust power splitter? (case QAM16)

- Tunable coupler is based on a phase plate tunable between 0° and 45°
  - **When t=0° (all power on Path3: index a) -> i=a**
  - **to 45° (all power on Path2: index b). -> i=b**
  - The index **i** indicates the phase plate angle **t**.



$$t = 45 \times \frac{(i-a)}{(b-a)}$$

$$i = \frac{t \times (b-a)}{45} + a$$

- The angle of the polarization f is the double of the angle of the phase plate

  f=2xt

- The ratio of the power between arm2 (P2) and arm3 (P3)

  P2/P3=(tan(f))^2

- If relative power on arm 2 is **P2= x** then power on arm3 is **P3=1-x**.
- tan(2.t)=tan(f)=sqrt(x/(1-x)),

$$i=\frac{1}{2}\times\arctan\left(\sqrt{\frac{x}{1-x}}\right)\times\frac{(b-a)}{45}+a$$

- Example P2=2.P3 (or x=1/3) ,

  a=100

  b=1688

  then f=54.7°, t=27.4° and **i=1066**

Features

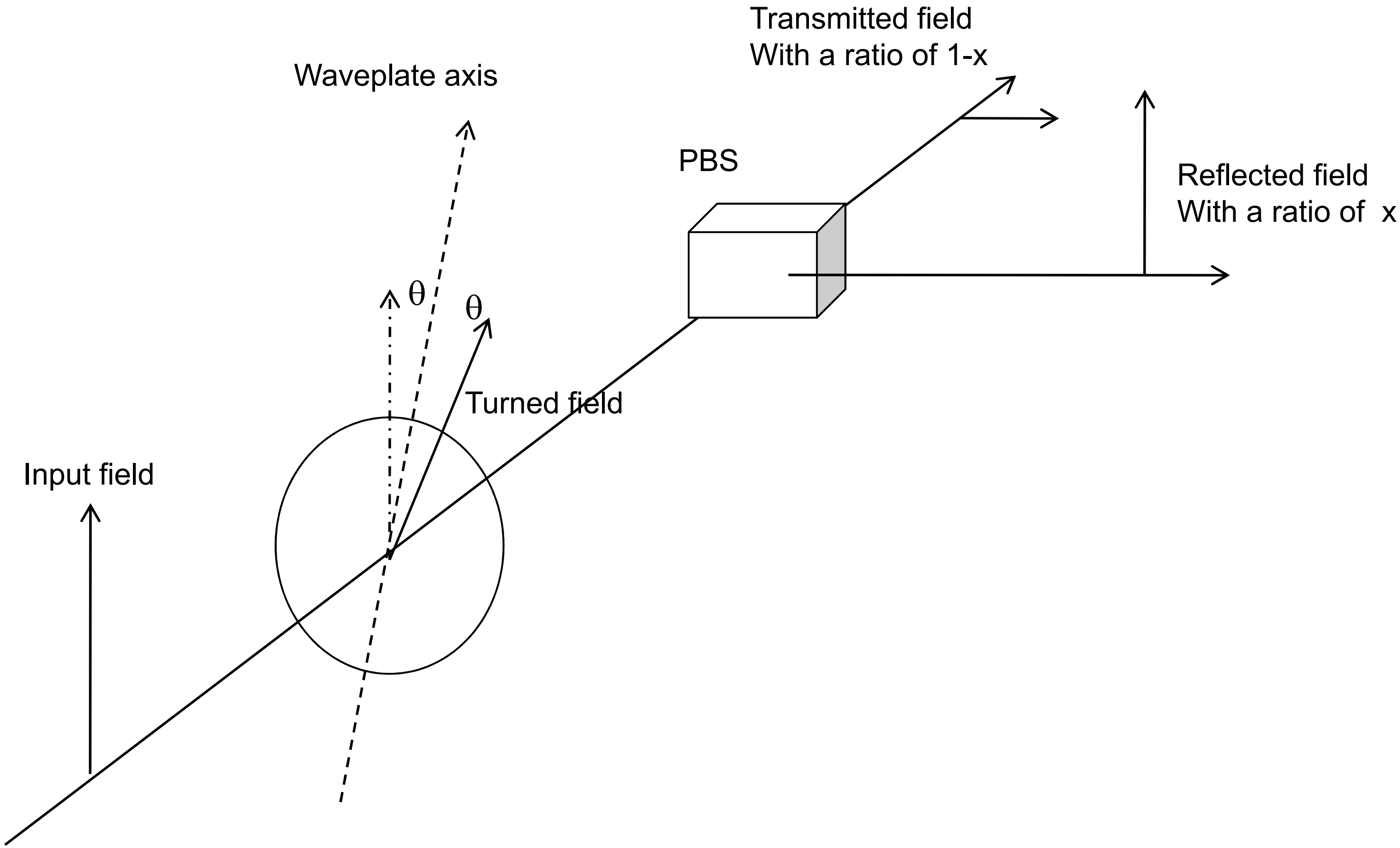
- Good 90°stability
- Low excess IL (< 3dB)
- Complete 3-path power balancing
- Options available
  - » Fixed ratio component (factory settings of debalancement and no tunable element)
  - » Shutter on one arm

Applications

- QAM16 emulation
- QAM64 emulation
- QPSK emulation

Related products

- Coherent receiver (COH24 & COH28)
- PDM emulator (PDME)
- Polarizer
- Variable Optical Delay Line (VODL)


Waveplate axis
Transmitted field
With a ratio of 1-x
PBS
Reflected field
With a ratio of x
θ
θ
Turned field
Input field